DOCTORAL DISSERTATION

GALILEO CREATION AND COSMOGONY

A Study on the Interplay between Galileo's Science of Motion and the Creation Theme

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È chiaro che il pensiero dà fastidio
anche se chi pensa è muto come un pesce
anzi è un pesce
e come pesce è difficile da bloccare
perché lo protegge il mare
Com'è profondo il mare

LUCIO DALLA, *Com'è profondo il mare* (1977)

Non 'mbrischiare a calia ca 'nzudda
(*Calabrian saying*)

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Abstract

(English)

Galileo: Creation and Cosmogony. A Study on the Interplay between Galileo's Science of Motion and the Creation Theme. *The relationship between science and theology in Galileo's work is usually studied with reference to the Copernican letters and the so-called 'Galileo affair,' ended with Galileo's abjuration in 1633. This dissertation tackles the same subject, but from a different angle. Galileo's approach to the creation theme does indeed allow us to inquiry into the relationship between science and theology while keeping Biblical exegesis and Galileo's trial on the background. The dissertation is divided into two parts: (1) "Creation," and (2) "Cosmogony." In the first part, a series of primary sources are considered (Benedetto Castelli's letter to Galileo of April the 1st, 1607; a few unpublished folios from the* reportationes *of Muzio Vitelleschi's course on natural philosophy held at the Roman College in 1589-90; some passages of Galileo's* Juvenilia*) which help us gauge, albeit indirectly, Galileo's attitude toward the possibility of demonstrating* creatio de novo *(the beginning of the world) and* creatio ex nihilo *(the existential dependence of creatures on God). Although some initial supporters of Galileo sought to demonstrate* creatio de novo *through his definition of motion, he never welcomed their attempt. He probably agreed with Castelli that the demonstration of* creatio de novo *was beyond the reach of his science and, in general, of human knowledge (a position that, for the sake of convenience, I have referred to as 'agnosticism'). As regards creation out of nothing, at Galileo's time this notion was usually treated in light of a metaphysical understanding of the relationship between God and creatures – a relationship which entailed an understanding of God as* primum ens *(first being). This notion is also used in the* Juvenilia, *namely, a series of pages reporting standard arguments of Scholastic philosophy, which Galileo copied from other sources. I have interpreted the total absence of the idea of God as* primum ens *in the original writings of Galileo as a sign that Galileo was not interested in the problem of* creatio ex nihilo, *nor did he consider its metaphysical solution. In the second part, I have argued that Galileo was interested in the cosmogony problem, namely, he tried to understand how God imposed order on the primeval chaotic universe. Cosmogony was refuted in the Aristotelian tradition on the basis that motion and gravity cannot be conceived of outside the orderly framework of the universe. In this view, mechanics leans on cosmology, and vice versa. Galileo separates the two, but through cosmogony he tries to reconcile his cosmological views (initially geocentric, then heliocentric) with his understandings of motion and gravity. Thanks to Copernicus, he is able to 'mathematize' the cosmogony problem. Thus, the solution to this problem becomes an important scientific task, one that allows Galileo to advocate the relevance of his science on a universal scale.*

Reflecting on the origins of the world becomes an astrophysical task which can help us grasp the order of the world.

(Italian)

Galileo: creazione e cosmogonia. Uno studio sull'interazione tra la scienza del moto di Galileo e il tema della creazione. *Il rapporto tra scienza e teologia nell'opera di Galileo viene solitamente studiato facendo riferimento alle lettere copernicane e alla cosiddetta 'affaire Galileo,' conclusasi nel 1633 con l'abiura di Galileo. Questa dissertazione affronta lo stesso argomento, ma da un punto di vista diverso. L'approccio di Galileo al tema della creazione ci dà infatti l'opportunità di indagare il rapporto tra scienza e teologia lasciando sullo sfondo l'esegesi biblica e il processo a Galileo. La dissertazione è divisa in due parti: (1) "Creazione" e (2) "Cosmogonia." Nella prima parte vengono prese in considerazione una serie di fonti (la lettera di Benedetto Castelli a Galileo del 1º aprile 1607; alcune carte inedite delle* reportationes *del corso di filosofia naturale di Muzio Vitelleschi tenutosi nel 1589-90 presso il Collegio Romano; alcuni passi degli* Juvenilia *di Galileo) che ci aiutano a valutare, seppur indirettamente, l'orientamento di Galileo in merito alla possibilità di dimostrare la* creatio de novo *(l'inizio del mondo) e la* creatio ex nihilo *(l'esistenziale dipendenza delle creature da Dio). Sebbene alcuni iniziali sostenitori di Galileo cercassero di dimostrare la* creatio de novo *attraverso la sua definizione di movimento, egli non accolse il loro tentativo. Probabilmente era d'accordo con Castelli sul fatto che la dimostrazione della* creatio de novo *era al di là della portata della sua scienza e, in generale, della conoscenza umana (una posizione che, per comodità, ho definito 'agnosticismo'). Per quanto riguarda la creazione* ex nihilo, *ai tempi di Galileo questa nozione era solitamente trattata alla luce di una concezione metafisica della relazione tra Dio e le creature – una relazione che implicava una concezione di Dio come* primum ens *(primo essente). Questa nozione è usata anche negli* Juvenilia, *cioè una serie di pagine che riportano argomenti standard della filosofia scolastica che Galileo copiò da altre fonti. La totale assenza dell'idea di Dio come* primum ens *negli scritti originali di Galileo è stata da me interpretata come un segno di disinteresse da parte di Galileo verso il problema della* creatio ex nihilo *e verso la sua soluzione metafisica. Nella seconda parte ho sostenuto che Galileo si interessò al problema della cosmogonia, vale a dire che egli cercò di capire come Dio diede ordine a una primordiale situazione di caos universale. Nella tradizione aristotelica, l'idea di cosmogonia era confutata in base all'impossibilità di concepire movimento e gravità al di fuori di un universo strutturato secondo un ordine. Da questo punto di vista, la meccanica si sorregge sulla cosmologia, e viceversa. Galileo separa le due, ma attraverso la cosmogonia egli cerca di conciliare le sue convinzioni cosmologiche (inizialmente geocentrica, poi eliocentrica) con le sue concezioni di movimento e gravità. Grazie a Copernico, egli riesce a 'matematizzare' il problema cosmogonico. Pertanto, risolvere questo problema diventa un'importante sfida scientifica, tale da permettere a Galileo di sostenere la* *rilevanza della sua scienza su scala universale. Il compito di riflettere sulle origini del mondo si connota come un problema astrofisico che può aiutarci a comprendere quale sia il vero ordine del mondo.*

(Dutch)

Galileo: Schepping en Kosmogonie. Een Studie over de Wisselwerking tussen de Bewegingswetenschap van Galileo en het Scheppingsthema. *De relatie tussen wetenschap en theologie in het werk van Galileo wordt meestal bestudeerd aan de hand van de Copernicaanse brieven en de zogenaamde 'Galileo-affaire,' die eindigde met Galileo's afzwering in 1633. Dit proefschrift behandelt hetzelfde onderwerp, maar vanuit een andere invalshoek. Galileo's benadering van het scheppingsthema stelt ons inderdaad in staat onderzoek te doen naar de relatie tussen wetenschap en theologie zonder de Bijbelse exegese en het proces van Galileo op de voorgrond te plaatsen. Het proefschrift is verdeeld in twee delen: (1) "Schepping" en (2) "Kosmogonie." In het eerste deel wordt een reeks primaire bronnen behandeld (de brief van Benedetto Castelli aan Galileo van 1 april 1607; enkele niet-gepubliceerde folio's uit de* reportationes *van Muzio Vitelleschi's cursus over natuurfilosofie die in 1589-90 werd gehouden op het* Collegio Romano*; enkele passages van Galileo's* Juvenilia*) die ons helpen om, zij het indirect, de houding van Galileo te peilen ten opzichte van de mogelijkheid om* creatio de novo *(het begin van de wereld) en* creatio ex nihilo *(de existentiële afhankelijkheid van schepselen van God) aan te tonen. Hoewel sommige aanvankelijke aanhangers van Galileo probeerden* creatio de novo *aan te tonen op basis van zijn definitie van beweging, verwelkomde hij hun poging nooit. Hij was het waarschijnlijk met Castelli eens dat de demonstratie van* creatio de novo *buiten het bereik lag van zijn wetenschap en, in het algemeen, van menselijke kennis (een standpunt dat ik gemakshalve 'agnosticisme' heb genoemd). Wat betreft schepping uit het niets, in de tijd van Galileo werd dit begrip gewoonlijk behandeld in het licht van een metafysisch begrip van de relatie tussen God en zijn schepselen – een relatie die een begrip van God als* primum ens *(eerste wezen) met zich meebracht. Dit begrip wordt ook gebruikt in de* Juvenilia*, een reeks pagina's met standaardargumenten uit de scholastische filosofie die Galileo uit andere bronnen heeft gekopieerd. Ik heb de totale afwezigheid van het idee van God als* primum ens *in de originele geschriften van Galileo geïnterpreteerd als een teken dat Galileo niet geïnteresseerd was in het probleem van* creatio ex nihilo*, en dat hij ook niet nadacht over de metafysische oplossing ervan. In het tweede deel heb ik betoogd dat Galileo geïnteresseerd was in het kosmogonieprobleem, namelijk dat hij probeerde te begrijpen hoe God orde oplegde aan het oorspronkelijke chaotische universum. Kosmogonie werd in de aristotelische traditie weerlegd op grond van het feit dat beweging en zwaartekracht niet kunnen worden opgevat buiten het ordelijke raamwerk van het universum. In deze visie leunt mechanica op kosmologie, en vice versa. Galileo scheidt de twee, maar door kosmogonie probeert hij zijn kosmologische opvattingen (eerst* *geocentrisch, dan heliocentrisch) te verzoenen met zijn opvattingen over beweging en zwaartekracht. Dankzij Copernicus is hij in staat het kosmogonieprobleem te 'mathematiseren.' De oplossing voor dit probleem wordt dus een belangrijke wetenschappelijke taak, een die Galileo in staat stelt om de relevantie van zijn wetenschap op universele schaal te bepleiten. Nadenken over de oorsprong van de wereld wordt een astrofysische taak die ons kan helpen de echte orde van de wereld te begrijpen.*

Introduction

When we wonder about the place of religion and theology in Galileo's scientific work, the first thing that suddenly pops up in our minds is Galileo's trial, or at least a more or less popular idea of it. Those who know a little more about Galileo would also think about the so-called Copernican letters, while the most erudite would remind us of the *libertas philosophandi in naturalibus* that Galileo sought to defend. Only a very few, though, would think of Galileo as a cosmogonist who used his science of motion to understand how God arranged the universe. An even smaller group would know that some of the initial supporters of Galileo's doctrine of motion tried to demonstrate that the world had a beginning in time, that is, it was created by God *de novo*. It is likely that Galileo did not support their attempt. On the contrary, he consciously avoided to touch upon theological problems which concerned creation and that exceeded the reach of his science. In the first part of this dissertation (chapters I-III), I have examined a letter by Benedetto Castelli that in my view stresses this point. Castelli seems to argue that the question of whether the world had a beginning does not fall within the purview of natural philosophy. I believe that this epistemological view concerning science and theological issues deserves to be historicized. One of the main purposes of my dissertation is indeed to show that there is an interesting story to be told about Galileo's approach to God's creation. It is possible to revive this story by taking distance from the usual narratives about Galileo and religion, the one that focuses on the *clash* – in all its declinations, especially juridical and exegetical – between Galileo and the church, or the one that lies much emphasis on the role of counterfactual *imagination* in Galileo's scientific thought.[1]

The narrative of this dissertation is perhaps convoluted, and sometimes it departs too much from Galileo. But I hope that Galileo and non-Galileo scholars will forgive me for daring cross different paths. In my defense, I would say that, if I took the risk of going off topic, it was because the creation theme is as multidisciplinary and complex today as it was in the past. In order to grasp Galileo's approach to creation, it is beneficial to have at least a rough idea of how the notion of creation had developed up to his time, and how it was treated by his contemporaries, especially the natural philosophers (for the major part Aristotelians) whom he directly confronted.

This kind of methodological approach convinced me to divide the dissertation

[1] On the historiographical origin of the 'warfare' account of the relationships between science and faith, cf. the Introduction to Lindberg-Numbers (1986), pp. 1-18. For the thesis that "the theological imagination prepared for the scientific," see Funkenstein (1986).

into two main parts: (1) "Creation," and (2) "Cosmogony." The problems related to creation required to be solved by appealing to a variety of conceptual tools – some of them involved metaphysics, while others disregarded it. Although the distinction between creation and cosmogony is terminologically anachronistic, I have tried to show that at Galileo's time the two concepts were conceptually separated, as they occurred in the form of two distinct philosophical problems.

First of all, there was the question of the possibility of demonstrating whether the world had a beginning in time. In order to understand the different solutions to this problem, it is worth noticing a difference which has been too often neglected by Galileo scholars, namely, the difference between *creatio de novo* and *creatio ex nihilo*. This difference (which I have tried to highlight in the first part of the dissertation) concerns a specific understanding of creation with respect to time and duration. It had gone through a long period of philosophical development before reaching Galileo's time. If we fail to notice that creation was not only understood as an 'unprecedented' beginning of the world, we might risk to advance and endorse opinions that are attractive but unfounded from a strictly historical point of view. I am thinking, for example, of Pietro Redondi's suggestive claim that "Galileo's theological commitment was essential to his scientific journey. That is to say, Galileo's physics required God." To support this opinion, Redondi has claimed, *inter alia*, that Galileo's scientific thought was indebted to Augustine's reflections on time.[2] In my view, this claim is based on an arguable reading of Augustine. For this reason, I devoted a full chapter (chapter IV) to *creatio ex nihilo* and its role in Augustine's rethinking of the notion of eternity. The ideas of *creatio ex nihilo* and eternity did actually continue developing after Augustine: at Galileo's time they were approached in light of notions that were perhaps more indebted to Aquinas's metaphysics than to Augustine's reflections on time. In Aquinas's metaphysics, God as *primum ens* (chapter V) is an important notion also used to demonstrate *creatio ex nihilo*. The same notion can be found in Galileo's *Juvenilia*, a sort of repertory of standard arguments in scholastic philosophy. The fact that Galileo does only resort to the idea of God as *primum ens* in the *Juvenilia* (i.e., in a writing that he copied from other sources) might suggest to us that Galileo's own understanding of God falls outside the metaphysical framework within which the relationships between God and creatures were usually thought at his time.[3] Also, this

[2] Cf. Redondi (1998). Kenneth J. Howell has partially leveraged on Redondi's claims to argue for "a closer continuity between [Galileo's] science and his interpretation of Scripture" (Howell (2002), p. 187).

[3] It was already too late when I had read the little book where Heinrich C. Kuhn makes the opposite claim on the basis of Galileo's annotations to Cremonini's *Disputatio de coelo*. According to Kuhn, these annotations show that Galileo was Janus-faced, as it were: "Da una parte c'è la faccia del rigorista, dell'«antimetafisico» […]. Dall'altra parte abbiamo la faccia di un ricercatore, che insiste sul fatto che lo scopo della filosofia della natura non è quello di salvare i fenomeni, ma conoscere le cose come sono veramente…abbiamo la faccia di un ricercatore che dichiara esplicitamente conoscibili le essenze e sostanze in base ai loro

might suggest to us that Galileo was simply not interested in the problem of creation *ex nihilo* and its metaphysical solution.

Galileo was mainly interested in cosmogony, namely how God imposed order upon an initial situation of chaos in the universe. In the second part of the dissertation I have tried to show that the cosmogony problem considered by Galileo was rooted in a tradition that originated with Aristotle, where cosmogony is denied on the basis of a particular understanding of natural motion and gravity (chapters VI-VII). I have emphasized the 'scientific' character of this problem, and I have devoted a whole chapter to the notion of gravity, paying particular attention to the Aristotelian tradition (chapter VIII).

One of my objectives was also to show that in the Renaissance an ancient and more Platonic view of gravity was revived, especially thanks to Copernicus. This view does not exclude cosmogony; on the contrary, it requires that God imposed an order on the primeval chaos. However, I have been careful to notice that Galileo's interest in cosmogony precedes his adherence to Copernicanism. In fact, Galileo's first cosmogony is geocentric (chapter IX). My thesis is that, even before he became Copernican, he had started to rethink natural motion and gravity independently of their cosmological role. They had already been *decosmologized*, as it were. This means that it was *not* a certain idea of gravity that compelled Galileo to endorse the geocentric view in his early writings on motion. Also, for Galileo this meant that the notion of gravity alone could be used to determine whether the world is geocentric or not. The tautological connection between gravity – i.e., the natural motion of heavy bodies – and the geocentric view is explicitly denounced by Galileo in the *De motu antiquiora*. But while he breaks the 'Aristotelian circle' between mechanics and cosmology, he also opens a *gap* between the two.

In my view, Galileo resorted to cosmogony in order to *bridge* this gap. Initially, he used cosmogony to show that, contrary to what Aristotelians thought, a science based on Archimedes' hydrostatics and on the Atomists' extrusion theory does not contravene the order or *ratio* with which natural phenomena occur in the cosmos. Afterwards, when Galileo was already fully Copernican, the bridging role of cosmogony became even more evident (chapter X). His new science of motion and the possibility of establishing, thanks to Copernicus, the relative distances between planets, allowed Galileo to reformulate cosmogony into a problem that could be

accidenti… la faccia di un filosofo della natura speculativo, per cui Dio conserva il mondo mediante costante azione e costante creazione…" (Kuhn (1993), pp. 23-24, but see also 20-21). After considering these passages, Oreste Trabucco has succinctly commented that "sull'esilità di tali conclusioni mi sembra superfluo insistere" (Trabucco (2001), p. 933). I agree with Trabucco, but I would also suggest that it is perhaps more appropriate to think that Galileo was not the author of those notes, than to think that for his entire life he hid one of his 'faces.' Has it really been ascertained that those notes were written by Galileo?

mathematically solved. Cosmogony was therefore regarded by Galileo as a crucial problem: a scientific solution to this problem would have shown that Galileo's mechanics could be successfully applied to the heliocentric universe. Accordingly, the Copernican system would also have been scientifically substantiated.

It may be that I have overestimated the role of cosmogony in Galileo's scientific works. This is another risk that I have deliberately taken. For taking such a risk can be beneficial: it can help us reappraise a long-debated historiographical question concerning the Platonic origin of Galileo's reflections on cosmogony. Once it has been accepted that cosmogony is an important part of Galileo's scientific thought, something that cannot be narrowed down to a mere Platonic exercise, the following question becomes more pressing: why did Galileo link his heliocentric cosmogony to Plato? As is known, Galileo's cosmogony cannot be easily traced back to that of Plato in the *Timaeus*. The suggestion I have advanced in this regard is that Galileo's heliocentric cosmogony is the *source* of his understanding of Plato's cosmogony, not the other way around. It may be, then, that Galileo made a reference to Plato's cosmogonic 'myth' in order to dissimulate an otherwise strong – too strong at the time – Copernican claim. Of course, this suggestion is based on the assumption that Galileo regarded cosmogony as a scientific problem that needed to be solved scientifically, that is, independently of what an *auctoritas* like Plato said about it. As I have tried to show in the last part of this dissertation, I think that there are good reasons to accept this assumption.

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One of the theses of this dissertation is that Galileo's approach to the creation theme was not metaphysical. But what does 'metaphysical approach' mean? What is it? My answer to this question relies heavily on Gary Hatfield's essay *Metaphysics and the New Science*. Hatfield argues that when metaphysics is loosely understood as a set of non-empirical presuppositions, or even unconscious assumptions about reality, it is impossible to single out a thinker of the seventeenth century who did not have a metaphysics. All thinkers were metaphysicians in that they all had presuppositions.[4] However, Hatfield notices that in the seventeenth century metaphysics was a science – it was actually *the* science of presuppositions and first principles. As such, it involved a series of technical notions and a particular kind of argumentative styles. Metaphysical notions and techniques of argumentations can be historically determined. This, in

[4] Cf. Hatfield (1990), pp. 93-94.

turn, can help to notice when certain presuppositions were *used* as metaphysical principles, and when they were not used as such. This way of historicizing metaphysics can allow us to distinguish "metaphysical from nonmetaphysical attitudes and styles of argumentation", and "to discern a type of nonmetaphysical (and yet nonetheless philosophical) voice in the rise of modern science that has not heretofore been adequately recognized, a voice that speaks especially in the work of Galileo."[5]

My dissertation corroborates Hatfield's conclusion, although it does it *exclusively* with respect to a specific issue which concerns the creation of the world. I have deliberately applied Hatfield's methodology to this particular issue. I have not intended to make generic conclusions about the role of metaphysics in Galileo's scientific discourse.

On the one hand, by focusing on a notion such as God as *primum ens*, and by showing how it was used in the seventeenth century, I have tried to show that '*primum ens*' was indeed an essential part of argumentative strategies aimed at solving a highly metaphysical problem about creation. Since Galileo was aware of this notion, he *consciously* avoided to use it and he *deliberately* ignored the metaphysical kind of discussions on creation. This choice was not a common one among the natural philosophers of his time.

On the other hand, it is undeniable that Galileo's cosmogonies require God. For instance, his heliocentric cosmogony is pivoted around the idea of God as a geometer and "Architect." However, this idea, which may be rightly regarded as a metaphysical presupposition, is not *used* by Galileo as a metaphysical justification to cosmogony. God does not have a foundational role in Galileo's cosmogony. The principles upon which his heliocentric cosmogony is grounded are the law of fall and the so-called proto-inertia. Of course, one may argue that these two principles have metaphysical foundations; hence Galileo's cosmogony has metaphysical foundations, too. But this is not the issue I have addressed in my research. My goal has been to understand *what kind* of problem cosmogony was for Galileo. Was it a metaphysical one, namely one whose solution requires arguments and notions proper to the metaphysics of his time? Or was it a non-metaphysical one? As I said above and as I have tried to show in the dissertation, in my view Galileo regarded cosmogony as a non-metaphysical problem. Apart from the absence of the notion of *primum ens*, Galileo's approach to cosmogony is typical of those geometers and engineers who were asked to solve practical problems.

[5] *Ibid.*, p. 96.

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In almost every chapter I have given ample room to Aristotelian authors such as Muzio Vitelleschi, Benedictus Pererius, Francesco Buonamici, and Girolamo Borro. In some way or another, they are all connected with Galileo.

Personally, I am not a supporter of the so-called ‘continuity thesis’ – I believe that the question concerning the continuity/revolution of modern science is ill-posed and ideologically flawed (as I have argued *passim* in the dissertation). If I have paid a great deal of attention to Aristotelian authors is because I am convinced that Galileo’s natural philosophy can be properly understood only against the backdrop of Renaissance Aristotelian natural philosophy (or better, as Charles B. Schmitt would perhaps say, Aristotelian natural philosoph*ies*). Especially in the beginning of his scientific path, Galileo’s discourse was influenced by the philosophical agenda set out by Aristotelians. He addressed their same problems, although he advanced new solutions. Such a proximity to the philosophical environment enlivened by Aristotelian natural philosophy may have stimulated Galileo and contributed to making him a (non-Aristotelian) natural philosopher.

But I must confess that my interest in early modern Aristotelianism goes well beyond Galileo: the birth of modern science fascinates me as much as the slow and gradual disappearance of Aristotelian natural philosophy. In general, I am interested in the early modern period and the late Renaissance because they offer several case studies of different kinds of coexistence between the emerging new science and the wonderfully faceted one of the Aristotelians. One way to approach this coexistence is to focus on transversal themes. This is what I have tried to do in this dissertation by focusing on the creation theme.

I have already treated a few of the subjects of this dissertation in my MA thesis, which was awarded the 2019 SISFA (Italian Society for the History of Physics and Astronomy) prize for best thesis.[6] However, I have tried to improve my initial considerations, and not a few times I have changed my mind about them. I cannot exclude that tomorrow, after researching further, I will also change my mind on many of the things I wrote here, in this dissertation.

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[6] Cf. Malara (2016) and Malara (2020c).

As I said, this dissertation may (rightly) appear to be convoluted and difficult to follow (also because it has not been proof-read by a native speaker). However, I have tried to organize it in such a way that each chapter can be read independently of one another. The only exception does perhaps concern the first three short chapters, which I suggest to read together and in their order of appearance. Each part is composed of five chapters including an *intermezzo*. The *intermezzi* (chapter IV and VIII) are not essential to the main theme, but they are useful in order to avoid simplistic approaches to the problem of creation and to the notion of gravity in relation to cosmogony.

I should like to add a few personal considerations concerning the structure and the style of my dissertation. When I started writing it, I knew that I was not writing a book. At most, this dissertation may be regarded as a preparatory sketch, a draft that contains some suggestions for further and more thorough studies, which one day might be developed into a book. At any rate, I think it is important for the reader to know that I have sometimes used writing styles which might seem to be pretentious (e.g., in the beginning of chapter I and at the end of chapter III). Also, if I will actually have the chance and time to turn this dissertation into a book, I will try to reorganize it along a structure similar to that of Julio Cortázar's *Rayuela* (known to the English readers as *Hopscotch*). These choices about writing styles and narrative structures stem from my personal take on the work of the historian and on history, in particular intellectual history.

Marie-Dominique Chenu once wrote that "the task of the historian is to construct and not simply to recover."[7] I believe this is true. I have assumed that my task as a PhD student was chiefly to *construct* a solid and possibly original historical *narrative*. In order to do so, I have applied a methodology which lies much emphasis on the direct scrutiny of primary sources. Such a methodology has helped me figure out the contents of my narrative, but it did not help much when I had to lay out the structure of my work. Gradually, I realized that the usual and linear manner of organizing academic texts is not the most ideal (at least not for me) to tell a story that is stratified into an impressive number of layers. What you may earn in clarity (which is not tantamount to accuracy) by using a chronologically and/or thematically linear narrative, you may lose it in depth and contextualization. Footnotes are useful to reduce losses of this kind, but there might be alternative tools, other complementary ways of writing about history while maintaining academic accuracy and keeping the reader more actively involved.

Novels can be an essential source of inspiration in this regard and with respect to writing style, too. In this dissertation, I have experimented the use of a sort of fiction writing style every time I thought it was suited to introduce or recapitulate

[7] Cf. Chenu (1997), pp. XIX.

aims, concepts, characters, or simply to restate a point that I had already made through one or more chapters (see, e.g., the closing paragraph of chapter III). As for the structure, the *intermezzi* are a first attempt to develop a collateral kind of narrative whereby accounting for secondary themes related to the main one. Hopefully one day I will be able to develop further on this narratological aspect.

My experimental attitude does also come from the belief that history is something other than its narratives, however they are. In my view, the purpose of historical narratives, such as the one I have advanced in this dissertation, is to serve as a stimulus for a dialogue among historians. This may be banal, but I imagine the space of history to be placed within a perimeter that historians continuously redefine by means of proper arguments and criticisms (unfortunately, one cannot become a historian overnight). This kind of constructivism requires more than one (trained) mind, and it is so far the best way to avoid both historical denialism and mythologies based on political ideologies or personal beliefs. Within such a perimeter, history is a social effort that benefits society, especially the political dimension of society. It is itself a historical product, and as such it should always be critically reconsidered lest the past dry out into a stereotype.

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I should like to express my most sincere gratitude to Luca Bianchi, Elio Nenci, and Maarten Van Dyck. Their suggestions have stimulated my curiosity and enriched my research, while their criticisms have helped me see mistakes and flaws in my arguments that otherwise I would have never noticed. I must say that I am glad I could count on their advice.

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PART ONE

CREATION

I.
ANNO 1607: GALILEO AND CASTELLI

§1.
GALILEO IN 1607

Padua, 1607. Springtime. Not far from the Basilica of Saint Anthony there is a house with a tidy garden on the outside. Inside, Galileo is sitting at his desk. A heap of letters lies in front of him. He is using some of the letters to write his defense against Baldassarre Capra. As he writes, a frown of concentration creases his face. Unexpectedly something distracts him. One of the letters has not been opened yet. It arrived in April, when Galileo was for a short period in Venice, and it made a long journey before reaching his desk. The letter was written that year at Cava de' Tirreni. To be precise, it was the first of April when Benedetto Castelli wrote it. In a blink of an eye, Galileo grabs the letter, opens it and reads it… Here, though, the narrative ends abruptly.

Castelli's letter has come down to us.[1] It is an important testimony of the interaction between Galileo's science of motion and questions on God's existence and the beginning of the world. We can read Castelli's letter, just like Galileo did. Yet we do not know if Galileo replied to it, and we lack enough pieces of information to figure out what Galileo's reaction to and interest for the arguments in Castelli's letter might have been. In this and the next two chapters, I shall try to cut through this fog of history, as it were.

But first things first. In 1607, Galileo was a professor of mathematics at the University of Padua. Fifteen years earlier, he moved from the Grand Duchy of Tuscany to the Republic of Venice, after having spent three years – from the winter of 1589 to the fall of 1592 – teaching mathematics at the University of Pisa.[2] In 1607,

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[1] The letter was published for the first time in 1883 in Antonio Favaro's essay *Galileo e lo studio di Padova* (Le Monnier). Here, I will refer to the latest edition of this essay, which was published in 1966 (Antenore) in two volumes. The transcription of Castelli's letter is included in the second volume (cf. Favaro (1966), II, pp. 202-203). This transcription is slightly different than the one Favaro had later included in the National Edition (cf. OG, X, *Castelli to Galileo*, 1 April 1607, pp. 169-171). The transcription of the National Edition is to be preferred over the first one. For instance, Favaro initially read "Ticone" (Favaro (1966), II, p. 202) instead of "Theo[dosio]" (OG, X, *Castelli to Galileo*, 1 April 1607, p. 170, l. 1), in a passage where Castelli refers to the *Sphaerics*, namely a book written by Theodosius of Bithynia. In another passage Favaro read "trova" (Favaro (1966), p. 202) instead of "tronca" (OG, X, *Castelli to Galileo*, 1 April 1607, p. 170, l. 44). In this case, the meaning of Castelli's argument clarifies that the correct reading is "tronca" (more on this *infra*, §7). For these reasons, I will always cite Castelli's letter from the National Edition.

[2] On Galileo's moving from Pisa to Padua, see Favaro (1966), I, pp. 25-50, and Camerota (2004), pp. 78-

Galileo was a 43-year old man and a teacher of mathematics since almost half of his life.[3]

At that time, he had published only two books under his own name. Both of them are about a measuring instrument known as 'geometric compass.' The first book is entitled the *Operations of the Geometric and Military Compass* (*Operazioni del compasso geometrico militare*, 1606).[4] It is a manual on how to use a multi-functional compass that was ideated by Galileo to facilitate and allow a wide range of measurements and calculations – it was especially useful for military purposes. With the aid of Marcantonio Mazzoleni, Galileo began to produce and sell his compass.[5] He probably hoped that by selling the compasses he would have been able to sustain the increasing mundane costs that his modest salary as a professor of mathematics could barely cover.[6] Also, he probably thought that the compass could help him tighten his connection with the Grand Duchy of Tuscany. Indeed, Galileo dedicated the book to the Prince Cosimo de' Medici, hoping to enter the graces of Cosimo's father, the Grand Duke Ferdinando I de' Medici, in order to hasten his return to Tuscany.[7]

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[3] Galileo began to teach mathematics when he was very young, even before he was appointed professor at the University of Pisa. Favaro suggested that Galileo gave private lessons of mathematics in Florence and Siena between 1587 and 1588 (cf. Favaro (1966), I, pp. 19-20) in order to help his father's financials. There are documents attesting that Galileo did indeed teach mathematics to the Benedictine Epifanio Parini (born Sebastiano) at the Abbey of Passignano, near Florence, in 1588 (cf. OG, Appendix IV, p. 23).

[4] Cf. OG, II, pp. 363-424. For the English translation by Stillman Drake, see Galilei (1978).

[5] On Galileo's compass, see Favaro (1966), I, pp. 165-192, Drake (1977), Valleriani (2010), pp. 27-41.

[6] Galileo's father Vincenzo Galilei died in 1591. As Galileo was the eldest son, from that moment he had to take care of the economic situation of his relatives. Probably in 1591, Galileo's sister Virginia married Benedetto Landucci. As was customary at the time, Galileo and his brother Michelangelo had to provide Landucci with Virginia's *dote*. But Michelangelo's instable carrier eventually put the entire burden of responsibility for payments on Galileo's shoulders. In 1593 Galileo was still in debt with Landucci, and the latter threatened him with jail (cf. OG, X, *Giulia Ammannati Galilei to Galileo*, 29 May 1593, p. 61). It is probably for this reason that in 1593 Galileo took out a loan from Jacopo and Bardo Corsi (cf. OG, XIX, pp. 571-573). In the following years, Michelangelo's wandering throughout Europe as a musician, and the wedding of Galileo's other sister Livia in 1601 (cf. OG, Appendix IV, p. 37), put Galileo in an even more difficult economic position. Although his salary as a professor increased during his stay in Padua, and despite the fact that in Padua he could count on better pays from private lectures, Galileo had to look for other sources of income. In 1598 he hired Mazzoleni, whose task was to build Galileo's instruments for sale, such as the military and geometric compass (cf. Favaro (1966), I, p. 161). But it appears that this was not enough to lighten Galileo's financial burden. Galileo had to loan money again in 1602. It was only thanks to the aid provided by Giovanfrancesco Sagredo and Sebastiano Venier that Galileo could repay his debt (cf. OG, X, *Sagredo to Galileo*, 28 December 1602, pp. 100-101). For a detailed account of Galileo's financial situation in Padua, see Camerota (2004), pp. 110-113. Some information on Galileo's financial troubles is also in Favaro (1966), I, pp. 35, 41.

[7] The compass and the telescope are regarded as crucial "instrument of credit" by Mario Biagioli (cf. Biagioli (2006), pp. 1-19, *passim*). Galileo returned to Tuscany in 1610. However, he was wont to spend his summers in Florence even before his official return to Tuscany. In 1605, Galileo had indeed been invited by the Grand Duchess Christina of Lorraine to spend his summers at the Villa Pratolino (cf. OG, X, p. 156), where he introduced the Prince Cosimo to mathematics, and taught him how to use the geometric and military compass (cf. Camerota (2004), p. 115).

Unfortunately, the compass did not yield enough earnings;[8] and the book, rather than facilitating Galileo's repatriation, caused him some troubles, instead. As is well known, Galileo's book was plagiarized, and he was forced to write – probably between May and June 1607 – a second book against the false charges of Baldassarre Capra (*Difesa contro alle calunnie ed imposture di Baldessar Capra*, 1607).[9]

Although he had published but two books on a measuring instrument, in 1607 Galileo was more than an ingenious inventor and unlucky 'entrepreneur,' so to speak. His two works on the geometric compass represent the tiny tip of an enormous iceberg. Since his time as a professor at Pisa, Galileo had indeed grown interest in several philosophical topics, including problems on motion which he was wont to discuss with colleagues, disciples, acquaintances, and friends. By 1607, Galileo had written pages that for the moment he preferred to either publish pseudonymously, or keep closed in the drawer.

If we could open that drawer, among a youthful work on the hydrostatic balance (*La bilancetta*),[10] and some notes on Aristotelian natural philosophy and logics (mss. Gal 46 and 72),[11] we would also find: two lectures on the size and depth of Dante's *inferno* held at the Academy of Florence between 1587 and 1588 (*Due lezioni all'Accademia Fiorentina circa la figura, sito e grandezza dell'Inferno di Dante*);[12] a commentary on Ptolemy's *Almagest* (now lost);[13] some early writings on motion (*De motu*

[8] Galileo probably began to sell his compasses in 1599, and in 1602 he had to undertake another loan to sustain a still difficult financial situation (cf. *supra*, nt. 6).

[9] Cf. OG, II, pp. 513-599. According to Michele Camerota, Galileo's defense against Baldassarre Capra was published in August, just before Galileo sent a copy to Prince Cosimo (cf. Camerota (2004), p. 129, and OG, X, *Galileo to Cosimo de' Medici*, 24 August 1607, pp. 177-178). I would add that internal evidence seems to suggest that Galileo wrote the *Defense* between May and June. In the preface (*a i lettori*), Galileo says that Capra translated the *Operations of the Geometric and Military Compass* into Latin "ed alcune cose frivolissime aggiungendovi, lo ristampa *tre mesi sono*…" (OG, II, p. 533, my emphasis). A few pages later, Galileo also says that Capra's plagiarism was published "li 7 marzo del 1607" (*ibid.*, p. 539). This means that Galileo wrote the preface of the *Defense* three months after the beginning of March, that is, around the end of May-beginning of June 1607.

[10] Cf. OG, I, pp. 215-228. For a recent study on this early writing of Galileo, see Mottana (2017).

[11] Large parts of ms. Gal. 46 were transcribed and entitled *Juvenilia* by Favaro, who included them in the first volume of the National Edition (cf. OG, I, pp. 15-177). More information *infra*, §5-6. Ms. Gal. 27 was only partially transcribed by Favaro (cf. OG, IX, pp. 280-281, where Favaro lists the titles of the questions discussed in the manuscript, and pp. 291-292, where Favaro reports a sample of the questions). The complete transcription of ms. 27 was made by William F. Edwards and published for the first time in 1988 (cf. Galilei (1988)). In 1992 it was published William A. Wallace's English translation of the same manuscript (cf. Wallace (1992)). Recently, another transcription of ms. 27 has been edited by Mario O. Helbing in the fourth appendix to the National Edition of Galileo's works. The composition date of ms. 46 and ms. 27 is still a debated issue among Galileo scholars, although there is general agreement that they were written before Galileo moved to Padua in 1592.

[12] Cf. OG, IX, pp. 29-57, and Galilei (2011b).

[13] The existence of this commentary is documented by Galileo himself in his early treatise on local motion (cf. OG, I, p. 314).

antiquiora);[14] a compendium of Sacrobosco's *Sphere* (*Trattato della sfera ovvero cosmografia*);[15] two versions, one longer than the other, of a treatise on how machines truly work (*Le mecaniche*);[16] a treatise on the rudder (now lost);[17] two writings on military architecture (*Breve istruzione dell'architettura* and *Trattato di fortificazione*);[18] many drawings and theorems concerning the study of motion (ms. Gal. 72);[19] and interesting works and notes on solid geometry (*Theoremata circa centrum gravitatis solidorum* and *Postille ai libri De Sphaera et Cylindro di Archimede*).[20]

In the same drawer, we would also find other fascinating material that probably Galileo was too afraid to publish. Thanks to a letter exchange with Jacopo Mazzoni and Johannes Kepler, we know that in 1597 Galileo had "come to the opinion of

[14] Cf. OG, I, pp. 251-419. References to the literature on the *De motu antiquiora* will be provided *infra*, chapter IX.

[15] Cf. OG, II, pp. 211-215. On this treatise, see the recent studies by Roberto De Andrade Martins and Walmir Thomazi Cardoso (Martins-Cardoso (2008), Martins (2010), and Martins-Cardoso (2017)). Interesting remarks on this treatise can be also found in Valleriani (2010), pp. 89-91. Valleriani assumes that Wallace "convinci[n]gly showed that Galileo's text *La sfera* was probably compiled using Clavius' homonym text as fundamental work" (*ibid*., p. 90, nt. 31). However, Martins and Cardoso have now provided good reasons to question Wallace's claim. They have indeed argued how difficult it is to ascribe a precise source to Galileo's *Trattato della sfera*. In particular, Martins has convincingly shown that, between the sixteenth and the seventeenth century, some of the customary issues concerning the *Sphere* were addressed in a similar way by different commentators of the *Sphere*, who used to borrow data and sentences from other commentaries: "Clavius sacó su tabla del libro de Peucer (o de Reinhold). Pifferi sacó su tabla de Clavius. Probablemente Galileo sacó su tabla de Clavius, o de Peucer, o de Reinhold, o de un manuscrito de Pifferi. [...] Este ejemplo muestra como los autores de aquel tiempo componían sus obras: en gran parte, copiando directamente partes de otros libros, sin citarlos, y quizás introduciendo errores. Galileo no fue una excepción a la pràtica de su tiempo" (Martins 2010, pp. 379-380; a similar claim was already made in Cardoso-Martins (2008)). Recently, I have suggested to call '*bricolage*' this kind of writing technique, as it was referred to by Claude Lévi-Strauss and Umberto Eco (cf. Malara (2019)). Cardoso and Martins have also pointed out striking similarities between Galileo's *Sphere* and that of Alessandro Piccolomini (cf. Cardoso-Martins (2017)).

[16] Cf. OG, II, pp. 155-191. An English translation by Stillman Drake is included in Galilei (1960). For a critical edition, see Galilei (2002).

[17] According to Camerota, some letters written by Giovanni Ciampoli between 1624 and 1625 suggest that Galileo wrote a "trattato sul timone" when he lived in Padua (cf. Camerota (2004), p. 86, and Ciampoli's letters in OG, XIII, pp. 295, 246-247, 254; Camerota also refers to an interesting fragment in OG, VIII, p. 609).

[18] Cf. OG, II, pp. 15-146. On Galileo's courses on fortifications, see Valleriani (2010), pp. 71-89. See also Pellicanò (2000) for an attempt to contextualize Galileo's *Fortificazioni*. However, it must be noted that Antonio Pellicanò fails to consider an important part of the secondary literature on Galileo's early writings. He thinks that on Galileo's *Juvenilia* "esiste una particolare quanto *taciuta* controversia, a parte il fatto che il Favaro li ha pubblicati in parte..." (*ibid*., p. 31, nt. 1, my emphasis). Even assuming that the title *Juvenilia* refers to both ms. 46 and ms. 27, the controversy on the *Juvenilia* have publicly started since at least the 1970s (cf. Crombie (1975), Wallace (1977), Wallace (1981), Carugo-Crombie (1983), Wallace (1984), Carugo (1987)).

[19] This important manuscript can be viewed online (cf. https://teca.bncf.firenze.sbn.it/ImageViewer/servlet/ImageViewer?idr=BNCF0003760961#page/1/mode/2up (last accessed 19 Nov 2019). For a recent study of the manuscript, see Büttner (2019).

[20] Cf. OG, I, pp. 187-208 [= *Theoremata*], 233-242 [= *Postille*].

Copernicus since many years" (*in Copernici sententiam multis ab hinc annis venerim*).[21] In the letter to Kepler, we read that by 1597 Galileo had already written many refutations of the arguments against the Copernican system ("*multas conscripsi et rationes et argumentorum in contrarium eversiones*"), but he preferred to hide them, fearing mockery. Also, in the same letter, Galileo argues that heliocentrism enabled him to explain some terrestrial phenomena otherwise incomprehensible ("*ac tali positione multorum etiam naturalium effectuum caussae sint a me adinventae, quae dubio procul per communem hypothesim inexplicabiles sunt*").[22] Thus, it may be that by 1607 Galileo had already laid out his first theory of tides based on the Earth's double rotation.[23]

All things considered, even though Galileo was not granted yet the title of philosopher, in 1607 he was already more than an esteemed professor of mathematics.[24] His interests were sundry, and his researches on natural philosophy had led him to important results. A letter written in 1602 to Guidobaldo del Monte shows that by the very beginning of the seventeenth century Galileo held the so-called isochronism and the law of chords.[25] In that period, he shared with Paolo Sarpi some interest about the properties of magnets;[26] he worked on the construction of a thermoscope;[27] and he was appointed as 'print supervisor' (*censore sopra le stampe*) of the *Academia dei Ricovrati*.[28] Also, in 1604 he was in possession of the correct law of fall, although he linked it to a false principle according to which velocity of fall is proportional to the distance fallen.[29] A few years later, in 1607, he probably began to reject this principle, until he eventually replaced it with the proportionality between velocity and time.[30]

[21] OG, X, *Galileo to Kepler*, 4 August 1597, pp. 67-68. The letter has been studied in detail by Massimo Bucciantini (cf. Bucciantini (2003), pp. 49-68). As for the letter to Mazzoni, cf. OG, II, *Galileo to Mazzoni*, 30 May 1597, pp. 197-202.

[22] OG, X, *Galileo to Kepler*, 4 August 1597, p. 68.

[23] On this, see Drake (1970), pp. 200-213; Drake (1978), pp. 36-38. While Drake linked this theory to some of Sarpi's observations dating 1595, Camerota has noticed that Galileo could have already known of a similar theory from Andrea Cesalpino's *Quaestiones peripateticae* published in 1571. Cesalpino was one of Galileo's teachers in Pisa (cf. Camerota (2004), pp. 98-99).

[24] In 1604, Vincenzo Gonzaga, Duke of Mantua, asked Galileo to become his court mathematician. Galileo would have accepted if only the pay had been higher (see Camerota (2004), p. 116, and OG, X, *Galileo to Vincenzo Gonzaga*, 22 May 1604, pp. 106-107).

[25] Cf. OG, X, *Galileo to Guidobaldo del Monte*, 29 November 1602, pp. 97-100. On this letter, see Büttner (2019), pp. 61-73, *passim*.

[26] Cf. OG, X, *Sarpi to Galileo*, 2 September 1602, pp. 91-93. See Favaro (1966), I, pp. 237-243.

[27] Cf. Favaro (1966), I, pp. 193-212: Camerota (2004), pp. 130-132.

[28] Cf. OG, XIX, pp. 207-208, and Lazzarini (1992), p. 165.

[29] "Ripensando circa le cose del moto, nelle quali, per dimostrare li accidenti da me osservati, mi mancava principio totalmente indubitabile da poter porlo per assioma, mi son ridotto a una proposizione la quale ha molto del naturale e dell'evidente […]. Et il principio è questo: che il mobile naturale vadia crescendo di velocità con quella proportione che si discosta dal principio del suo moto…" (OG, X, *Galileo to Sarpi*, 16 October 1604, p. 115). On the "spontaneity" of thinking in terms of space traversed, rather than in terms of time elapsed, see Koyré (1966).

[30] See Camerota (2004), pp. 144-148. Camerota provides compelling evidence that Galileo realized and corrected his initial mistake between 1607 and 1609.

Furthermore, it must be noted that, starting from the fall of 1604, Galileo had a series of correspondences with figures such as Ilario Altobelli and Leonardo Tedeschi, who kept him informed about a sensational discovery: the observation of a new star in the theretofore incorruptible sky.[31] Shortly after, Galileo wrote or perhaps co-authored, or simply inspired, three books: the *Dialogue of Cecco di Ronchitti of Brugine concerning the New star* (*Dialogo de Cecco di Ronchitti da Bruzene in perpuosito de la stella Nuova*, 1604);[32] Astolfo Arnerio Marchiano's *Discourse on the New Star* (*Discorso sopra la Stella Nuova comparsa l'Ottobre prossimo passato*, 1605);[33] the *Considerations of Alimberto Mauri on some places of the discourse of Lodovico delle Colombe about the star which appeared in 1604* (C*onsiderazioni d'Alimberto Mauri sopra alcuni luoghi del discorso di Lodovico delle Colombe intorno alla stella apparita* [*nel*] *1604*, 1605).[34] When it came to controversies on natural philosophy, Galileo apparently preferred to work under cover, alias Cecco di Ronchitti, Astolfo Arnerio Marchiano, and Alimberto Mauri.

So, Galileo was after all honest when in 1597 he told Kepler about his fears of going public against the Aristotelians. And this is another hint suggesting that by 1607 Galileo's drawer was perhaps deeper and fuller than one may think.

§2.
CASTELLI IN 1607. THE *EPISTULAE CAVENSES*

Benedetto Castelli's letter adds something interesting to this already faceted picture. In this letter dated April 1st 1607, it is written that according to Galileo "motion is nothing but the mutation of something with regard to another one" (*il moto non sia altro che una matatione di una cosa in relatione a un'altra*), and that "a motive cause is necessary to start the motion, but the lack of obstacles is sufficient to continue it" (*a*

[31] Cf. OG, X, *Altobelli to Galileo*, 3 November 1604, pp. 116-117, *Altobelli to Galileo*, 25 November 1604, pp. 118-120, *Tedeschi to Galileo*, 22 December 1604, pp. 122-132, *Altobelli to Galileo*, 30 December 1604, pp. 132-133.

[32] Cf. OG, II, pp. 307-334. According to Favaro, this work was written by Girolamo Spinelli with Galileo's help, although there is no certainty about the extent of Galileo's contribution (cf. *ibid.*, p. 272, and Favaro (1881), pp. 195-237). However, Matteo Cosci has convincingly argued that Galileo is the real author of this dialogue (cf. Cosci (2018)). For the English translation by Drake, see Galilei (1976).

[33] This work is not included in the National Edition of Galileo's works. Marialaura Soppelsa has hypothesized that Arnerio was "portavoce o eventuale schermo mimetico dello stesso Galilei" (Soppelsa (1974), p. 27). Soppelsa has also noticed interesting parallels between Arnerio's *Discorso* and Galilei's lessons on the *nova* (cf. *ibid.*, p. 32, nt. 19). Recently, Matteo Cosci has suggested that Astolfo Arnerio Marchiano is but a pseudonym of Galileo (cf. Cosci (2020)). I wish to thank Matteo Cosci, who kindly allowed me to read the draft of his paper before it was published. I have already communicated to Cosci my objections against a *direct* attribution to Galileo.

[34] This work, too, was not included by Favaro in the National Edition. Probably because Galileo assured Ludovico delle Colombe that he was not the author of the *Considerations* (cf. OG, X, *Lodovico delle Colombe to Galileo*, pp. 176-177). For the English translation by Drake, see Galilei (1976), pp. 73-130.

principiar il moto è ben necessario il movente, ma a continuarlo basta non aver contrasto). In other words, Castelli's letter bears important evidence that by 1607 Galileo held the relativity of motion, along with an idea that today sounds very similar to our concept of inertia.[35]

But this is not all. There are other elements that make this letter particularly interesting. The letter, for instance, provides some useful details of an otherwise unknown period of Castelli's life.[36]

In 1607 Castelli was in the Kingdom of Naples (ruled by the King of Spain, Philip III of Habsburg), at the Benedictine Abbey of La Trinità della Cava, not far from Salerno.[37] He moved there from the Abbey of Santa Giustina, in Padua,[38] where between 1603 and 1604 he had met Galileo, who gave him and another Benedictine, Girolamo Spinelli, private lectures on mathematics.[39] It is likely, however, that even before meeting Galileo, Castelli had received some rudimentary education in the field of geometry, arithmetic, and perhaps astronomy. In the monastery of San Faustino in Brescia, Benedetto Castelli (born Antonio) was probably initiated to the study of these disciplines, although he was chiefly taught theology.[40]

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[35] Cf. OG, X, *Castelli to Galileo*, 1 April 1607, p. 170. This and further references to the English translation of this letter are from Rachel Bindman (cf. Redondi (1998), pp. 180-181). Sometimes, I have slightly modified Bindman's translation.

[36] On Castelli's life, see OG, XX, pp. 412-413; Masetti Zannini (1961); Drake (1971); Shore (2014). See also Piccinali (2019) for some information on Castelli's family.

[37] For more information on the seventeenth-century Italian states, see Sella (1997), pp. 1-18.

[38] The histories of S. Giustina Abbey and Cava Abbey were intertwined since 1492. In 1392, pope Boniface IX raised Cava to the rank of city; accordingly, the Abbey became a Cathedral headed by a bishop. From that moment, the rules and customs of the Benedictines became to decline gradually. But in 1482 the Abbey was given *in commendam* to cardinal Oliviero Carafa, who decided to restore the Benedictine traditions. To this end, in 1492 he entrusted the Abbey to a group of diligent Benedictine monks based in S. Giustina Abbey. In 1497, pope Alexander VI ended the commandery, suppressed the bishopric, and sanctioned the perpetual union between the Abbey of Cava and the community of S. Giustina (cf. Cerasoli (1929), pp. 191-194; from 1504 – when the Abbey of Monte Cassino was included in the community of S. Giustina, the latter became known as the 'community of Monte Cassino,' or simply the Cassinese community). When Benedetto Castelli was assigned to the Trinity Abbey at Cava, the latter was still administrated by the monks of S. Giustina.

[39] Cf. Favaro (1966), I, p. 150.

[40] Luca Piccinali has carried out an important study on Castelli's studies in Brescia and Padua (cf. Piccinali (2018), pp. 49-121). While highlighting that the Benedictines had access to interesting works concerning mathematics and astronomy, Piccinali has also noticed "come la maggior parte dei testi fosse di carattere religioso, dai testi sacri ai Padri della Chiesa per arrivare sino a san Tommaso e ai testi di autori ecclesiastici cinquecenteschi. Questo per sottolineare che almeno da quando Castelli aveva dieci anni (1588) la sua educazione gli fu sempre e solo impartita da ecclesiastici su libri per la maggior parte di argomento religioso" (*ibid.*, p. 115). Furthermore, according to Massimo Bucciantini, the Abbey of S. Giustina "era considerato il centro culturale dell'ordine benedettino cassinese, in cui, tra l'altro, erano forti gli influssi della tradizione ne[o]platonica, e dove le discussioni sul ruolo e il grado di certezza delle matematiche si intrecciavano a quelle sui rapporti tra matematica e teologia, tra simbologia cristiana e figure e simboli geometrici" (Bucciantini (1992), p. 173).

The letter of April 1607 is the oldest survived testimony of the connection that Galileo and Castelli established in Padua. The two must have soon tightened an amicable relationship, as it appears that before leaving Padua Castelli promised Galileo to keep him informed about his conditions ("*stato mio*"). Indeed, the letter begins with Castelli apologizing because he was unable to immediately fulfil his promise ("*debito mio*"), given that he was delayed by certain "current troubles" (*correnti turbolentie*).[41] Castelli then says that at Cava he lectures on Euclid, and this gives him the occasion to list the progress he has made in the study of mathematics.

After his departure from Padua, he studied Euclid's *Elements*, from book VII till the 40th proposition of book X; then, given some serious intricacies encountered in that proposition, he leapt to book XI, and continued without interruptions through book XII, eventually addressing book XIII to the very end of the *Elements*. Shortly after, he dealt with Ptolemy's *Almagest*, but he could not go over the "first corollary" (*primo corollario*) of chapter XII,[42] about which he asks Galileo for "some enlightenment" (*qualche lume*). Lastly, Castelli undertook the study of the *Sphaerics* by Theodosius of Bithynia, along with the first seven propositions of Archimedes' *On Floating Bodies*.[43] As regarding proposition VIII, Castelli writes that he prefers to wait until Galileo's treatise *On the Center of Gravity of Solid Bodies* is published.[44] He is convinced that this

[41] "Per le correnti turbolentie son stato necessitato a mancar del debito mio, con non dar conto a V.S. del stato mio: hora, con l'occasione del nostro Capitolo Generale, prima li faccio profonda riverenza, dandoli aviso che il stato mio è assai megliore di quello a che io sto di continuo preparato; poi vivo al servitio di questo mio prelato [*viz.* Lorenzo Pacifico of Antwerp: cf. Cerasoli (1929), p. 214], che non manca di honorarmi…" (OG, X, *Castelli to Galileo*, 1 April 1607, p. 169).

[42] It must be noted that the chapters of the *Almagest* have no corollaries. In Renaissance editions, Ptolemy's text was often accompanied by Theon of Alexandria's exposition. Sometimes, Theon's exposition is reported at the end of certain chapters and labelled as 'scholium' ("σχόλιον ex Theone": Ptolemy (1549), p. 83). But in other cases, Theon's exposition is entirely reported at the end of every chapter (see Ptolemy (1605)). Probably Castelli refers to chapter XII of the first book, which was usually entitled *De circumferentijs inter Aequinotialem, et circulum obliquum* (cf. Ptolemy (1549), p. 117, and Ptolemy (1556), p. 71). However, in Ptolemy (1605), at page 160, the same title refers to chapter XIII.

[43] Archimedes' *On Floating Bodies* refers to the circumference and the sphere (cf. Archimedes (1565), pp. 1*r*-1*v*: "PROPOSITIO I. Si superficies aliqua plano secetur per idem semper punctum; sitque sectio circuli circunferentia, centrum habens punctum illud, per quod plano secatur: sphaere superficie erit. […] PROPOSITIO II. Omnis humidi consistentis, atque manentis superficies sphaerica est; cuius sphaerae centrum est idem, quod centrum terrae…"). No wonder, then, that Castelli studied Archimedes along with Theodosius's *Sphaerics*. Also, according to Johannes Vögelin, Theodosius's *Sphaerics* were essential to understanding Ptolemy's works: "… tres Sphaericorum Theodosij libr[i], sine quibus, nemo idoneus magnae compositionis Ptolomei auditor esse posse" (Theodosius (1529), preface without pagination).

[44] Proposition VIII is about a solid body lighter than the fluid, and in the form of a segment of a sphere. Once immersed in the fluid, the solid will always maintain or regain a symmetric position such that its axis is perpendicular to the fluid's surface (cf. Archimedes (1565), p. 6*r*: "PROPOSITIO VIII. Si aliqua magnitudo solida levior humido, quae figuram portionis sphaerae habeat, in humidum demittatur, ita ut basis portionis non tangat humidum: figura insidebit recta, ita ut axis portionis sit secundum perpendicularem. Et si ab aliquo inclinetur figura, ut basis portionis humidum contingat; non manebit inclinata si demittatur, sed recta restituetur"). This proposition comes without proof, which is supplied by Commandinus in his Latin edition (cf. *ibid.*, pp. 6*r*-6*v*). However, Castelli believes that the proposition can be better understood after

treatise is indispensable to this matter.[45]

The first paragraph of the letter ends with a curious note on Castelli's effort to make his pupils acquainted with Galileo's "rare virtues" (*rare virtù*).[46] In 1607, at Cava de' Tirreni, Castelli is already proselytizing.

Let us pause the reading for a moment. Castelli's letter has already provided enough interesting elements to ponder upon. Not much is known about Castelli's life between 1607 and 1610, when he returned to his birth city, Brescia. Even less is known about his stay at the Abbey of Cava. The beginning of the letter, however, can help us shed some light on this period of his life.

Given the amount of studies Castelli had undertaken since he left Galileo in Padua, and given the apologies for the delay in sending news to Galileo, it seems safe to assume that at least a month had elapsed between Castelli's arrival at Cava and the first of April, when he wrote and sent the letter. Also, we know as a fact that at the end of October 1607 Castelli was still at Cava. Indeed, in October 24th he sent another letter from Cava to the Benedictine Ermagora Basadelli in Padua.[47] In this letter, Basadelli is asked to inform Galileo about Castelli's observations of a comet and to get back to Castelli with some news about Galileo.[48]

Ermagora Basadelli is an important character of this story, although he has been unfortunately but understandably – given the scarcity of information about him – neglected in Galileo historiography.[49] There is no doubt that Basadelli met Galileo

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the publication of Galileo's *Theoremata circa centrum gravitatis solidorum*. Galileo began this treatise when he was very young (cf. OG, I, pp. 181-182), and kept working on it when he was in Padua (cf. *ibid.*, pp. 182-185). As is known, Galileo relinquished publishing the treatise after he had found out that Luca Valerio had already found a satisfactory solution to determine the center of solid bodies (cf. OG, VIII, p. 313). Now, given that Castelli is convinced that Galileo would soon publish the treatise, it seems likely to assume that in 1607 Galileo had not yet come across Luca Valerio's work, which was published for the first time in 1604, and a second time in 1661, ninteen years after Galileo's death.

45 "… [L]eggo poi una lettione d'Euclide, del quale io già ho visto il 7°, 8°, 9° et sin alla quarantesima del X°, et di lì, suffocato dalla moltitudine (per confessar il peccato mio) de' vocaboli, profondità delle cose e difficultà di demonstrationi, mi son trasferito al'XI, XII, e XIII, de' quali ho visto tutto quello che dalle viste propositioni dependeva. Dopoi ho datto l'assalto a Tolomeo, ma son restato intricato al primo corollario del capitolo duodecimo: se V.S. mi vole favorire con darmi qualche lume, infilzarò quest'obligo con gli altri. Ho datto di piglio alli Elementi Sferici di Theo[dosio], et insieme ho cavati gli piedi dalle sette prime propositioni di Archimede *De iis que vehuntur in aqua*: all'ottava, starò aspettando in luce il trattamento suo *De centro gravitatis solidorum*, il quale alla detta materia mi pare necessario" (OG, X, *Castelli to Galileo*, 1 April 1607, pp. 169-170).

46 "Gli miei discepoli adorano le rare virtù, et a' nostri secoli uniche, di V.S., delle quali spesso ne faccio quella che io posso mentione" (*ibid.*, p. 170).

47 Favaro published a partial version of this letter (cf. OG, X, *Castelli to Basadelli*, 24 October 1607, pp. 183-184). For the integral version, see Castelli (1988), pp. 35-37.

48 "Mi farete favore darmi nova del mio Sig.r caro Galileo, e, se è possibile, communicateli questa mia, acciò se S.S. con più esatta osservatione havesse notata la sudetta apparenza, me ne dia copia: e scrivetegli che io tengo desiderio di servirlo, conforme a' segnalati e grandi meriti suoi" (OG, X, *Castelli to Basadelli*, 24 October 1607, p. 184).

49 Favaro simply calls him "Don Ermagora da Padova." Bucciantini identified him as Ermagora

and gave him the October letter from Castelli.[50] There is no trace, however, of Basadelli's replies to Castelli. This fact should not be underestimated. Ermagora Basadelli is already mentioned in the first letter that Castelli sent to Galileo in April. At the end of this letter, Castelli invites Galileo to address his replies to Basadelli, who at that time was in Rome. Castelli is sure that Galileo's letters would arrive safely only through Basadelli.[51] Yet there is no trace of any of the letters that Basadelli probably sent to Castelli. This means that Galileo's replies to Castelli through Basadelli, if there were any, are also not extant. Although there is no certainty that Galileo did actually reply to the missives from Cava, in my view there are sufficient reasons to believe that he answered at least to the first *Cavensis epistula*, and that he did it through Basadelli. Before trying to understand Galileo's reception of Castelli's first letter from Cava, it is important to ascertain that Galileo most likely read and reply to that letter.

Three reasons in favor of this conclusion may be argued *ex silentio*:

1) in the letter of October 24, Castelli is content to have some news about Galileo: "You will please give me some news about my dear Signor Galileo..." (*Mi farete favore di darmi nova del mio Sig.^{r} caro Galileo*), says Castelli to his confrere Basadelli.[52] Had Castelli not heard from Galileo since the time of the first letter from Cava – which dates almost seven months earlier than the second one – he would have most probably mentioned, in the October letter, his unsuccessful attempt to contact Galileo in the past months;

Basadelli (cf. Castelli (1988), p. 37), although he did not provide additional biographical information. Basadelli was surely a Benedictine monk of the community of S. Giustina, as he is listed among the Cassino abbots of S. Faustino Maggiore from 1649 to 1651 (cf. Guerrini (1931), p. 99; Bucciantini cites the same source, but p. 19 (cf. Castelli (1988), p. 37), where unfortunately I was not able to find any reference to Basadelli). Basadelli is the annotators of mss. BUP 200/1, 1172, 1364, and 1800. The latter contains Cesare Cremonini's *expositiones* on diverse topics. In ms. BUP 1364, f. 50*r*, Basadelli writes: "anno 1632 in monasterio Sancti Fortunati de Bassano." In the record card of ms. BUP 1172, Lavinia Prosdocimi wrote that Basadelli entered the Benedectine order in Padua, at the Abbey of S. Giustina, on December the 8th in 1599. Prosdocimi took this information from ASP, "Corporazioni religiose soppresse. S. Giustina," b. 85, entry 555. Also, the name "Basadellus Hermagoras" is recorded in *ManusOnLine* with two variants: (1) "Hermagoras Patavinus abbas Sancti Nicolai in Littore"; (2) "Hermagoras Patavinus" (the source, in both cases, is Bossi (1983), pp. 32, 79). The first variant indicates that Basadelli had also been the abbot of the Monastery of San Nicolò al Lido, Venice.

[50] Cf. OG, X, p. 184, nt. 2: "[La lettera] fu infatti comunicata a Galileo che la trattenne e annotò sul tergo di essa, che corrisponde alla car. 22: 'D. Ben.^{to}'." See also Castelli (1988), p. 37, nt. 4.

[51] "[S]e V.S. si degnerà di scrivermi, potrà indirizzare le lettere in Roma a D. Hermagora da Padoa in monte Cavallo, che l'haverò sicure" (OG, X, *Castelli to Galileo*, 1 April 1607, p. 171). From this passage, we can notice that Castelli expected to receive more than one reply from Galileo *via* Basadelli. It must be noted that three years later Castelli asks again Galileo to send his letters through an interposed person, because from Brescia – where Castelli was – there was no ordinary mail to Florence (cf. OG, X, *Castelli to Galileo*, 27 September 1610, p. 436). It is likely that Castelli asked Galileo to send his letters *via* Basadelli for the same reason, as from Cava de' Tirreni there was no ordinary mail service to Padua.

[52] OG, X, *Castelli to Basadelli*, 24 October 1607, p. 184.

2) also, when Castelli sent his first letter from Cava, he was missing from Padua since at least one month, perhaps more. He was therefore feeling sorry to have waited so long before letting Galileo know about his conditions at Cava. Now, had Castelli received no answer from Galileo after almost seven months, in October he would have been worried to reassure Galileo, *via* Basadelli, of his good conditions at Cava. But in the October letter Castelli is not concerned about it. Hence, Galileo and Castelli must have had an exchange of letters (perhaps more than one), between April and October, of which we are now in the dark;
3) if (1) and (2) are plausible, they might also explain why Castelli, in the October letter, does not ask Basadelli to notify Galileo that he had received his clarification on chapter XII of the *Almagest*, about which Castelli had asked for "some enlightenment" in April. It seems likely to assume that Galileo replied through Basadelli to the April letter, and that Castelli thanked his master with another letter, now lost, but certainly anterior to October 24.

Another reason may be inferred from the role of Ermagora Basadelli:

4) at the end of October 1607 Basadelli was in Padua. Castelli knew it, and sent him a letter which is almost entirely addressed to Galileo.[53] In that period, Galileo was also in Padua. Supposedly, Castelli knew this too. Why, then, did he not send the letter to Galileo directly, as he did in April? An answer might be that, having received no reply from Galileo to the April letter, this time Castelli thought it safer to send his letter to Basadelli. Or perhaps, since both Basadelli and Galileo were in Padua, Castelli just wanted to kill two birds with one stone, so to speak. Yet the reasons above suggest to take another scenario into account. It seems likely that by October 1607 Basadelli was already operating as a designated intermediary in Castelli and Galileo's letter exchange. It might be, then, that Galileo received the April letter from Castelli, and then he decided to address his reply to Basadelli, as suggested by Castelli himself at the end of the same letter. If this is the case, we must acknowledge that Ermagora Basadelli had a pivotal role in the first correspondence between Galileo and Castelli. Although Basadelli is the formal recipient of the October letter, it may well be that the real recipient of that letter is Galileo.

[53] Although we do not know much about Basadelli's interests, it is likely that Castelli's astronomical observations are directed to Galileo, as well as the following words: "Solo sospiro la ampiezza dell'orizzonte vostro, ma molto più la vostra conversatione, con la quale volentieri ragionerei di presenza e di questo e di molte altre cose, che con non poche fatiche vado alla giornata guadagnando" (OG, X, *Castelli to Basadelli*, 24 October 1607, p. 184). In this case, two third of the letter would be directed to Galileo.

A further reason for arguing that Galileo replied to Castelli's April letter may rest on a hypothesis concerning the time of Castelli's departure from Padua:

5) during the summer of 1606 Galileo went to Florence for a few months. October 17 he was back to Padua, where he got ill. As far as we know, he had to deal with a serious illness that lasted several months, probably until the end of January 1607.[54] In the letter of April 1607, however, Castelli is not concerned about Galileo's health conditions. Perhaps he did not know that Galileo was ill; or, on the contrary, he knew that he had recovered. Taking both cases as plausible, it seems safe to assume that: (*a*) Castelli left Padua in 1606, before October 17; or (*b*) he moved to Cava the year after, between the end of January and the beginning of March 1607, when Galileo had already healed. Assuming that Galileo read Castelli's April letter at about the end of April-beginning of May,[55] until that time he had had no news from his dear disciple since about (*a*) seven or (*b*) one/two months. Considering Galileo's concern for Castelli, as witnessed by Castelli himself, it is unlikely that Galileo ignored the April letter.

[54] The first symptoms began in summer, when Galileo was in Tuscany: "Il male, che mi cominciò la notte avanti la partita da Pratolino et che mi ritenne poi otto giorni presso indisposto in Firenze, dopo avermi concedute tante forze che mi potessi condurre a Padova, due giorni dopo il mio arrivo qua, rompendo ogni tregua, mi assalì et fermò in letto con una terzana…" (OG, X, *Castelli to the Grand Duchess Christina*, 8 December 1606, p. 164). That Galileo came back to Padua the 17th of October can be inferred from the following passage written by Galileo the 27th of that month: "Tornai di Firenze dieci giorni or sono, e trovai tre lettere di V.S. Ill.ma e due compassi inviatimi, le quali lettere da' miei di casa erano state trattenute, perché per tre settimane innanzi li avevo scritto che non mi scrivessero più…" (*ibid.*, *Galileo to unknwon*, 27 October 1606, p. 162). In the same letter, Galileo says that he is still suffering from the illness that he got in Florence. Galileo was apparently very sick, if it is true – as he says to Curzio Picchena – that he was visited by Tommaso Menadoi from Rovigo (the Grand Duchess asked for information about him: cf. *ibid.*, *Picchena to Galileo*, 25 January 1607, p. 167) and Hieronimus Fabricius from Acquapendente, two important practitioners of the time: "L'Ecc.mo Minadoi da Rovigo è da me benissimo conosciuto, anzi, in questa mia lunga malattia mi ha visitato insieme con l'Ecc.mo S. Aqquapendente, stimandolo io tra i migliori medici che oggi siano in questa città" (*ibid.*, *Galileo to Picchena*, 9 February 1607, p. 168).

[55] Castelli sent the letter on the first of April, which in 1607 fell on Sunday. Before reaching Padua, the letter had to go through Naples, as there was no ordinary mail service from Cava. From Naples, then, it had to reach Rome, where it was sent to Venice. Ordinary mail from Naples was sent every Wednesday to Rome; from Rome to Venice every Saturday; from Venice to Padua every day (cf. Codogno (1608), pp. 335, 355). Best case scenario, Castelli's letter was sent from Naples to Rome on Wednesday the 4th of April. From Rome, then, it was sent to Venice on Saturday the 7th. That same day, Galileo moved from Padua to Venice, in order to prepare his case against Baldassarre Capra, which was presented to the Riformatori of the Studio on Monday the 9th (cf. OG, II, p. 538, and OG, X, pp. 171-172). Assuming that a letter had to travel for 5/6 days before arriving in Venice from Rome, Castelli's letter would have probably arrived in Padua on the 13th of April, which was Good Friday in 1607. So, taking into account some delay due to holidays, Castelli's letter most likely arrived in Padua after Easter, when Galileo was in Venice, fully engaged against Capra (cf. OG, II, p. 539). He probably read Castelli's letter when he went back to Padua, around the end of April.

There are, I believe, enough reasons to argue that Galileo replied to Castelli's first letter from Cava. We cannot exclude that Galileo was even genuinely interested in the most philosophical part of the letter. But before addressing this part, we should resume the reading of Castelli's letter.

§3. CASTELLI'S COMPLAINT

Maurice Clavelin coined the expression '*copernicianisme silencieux*' to denote Galileo's Copernicanism during the years in Padua that preceded the publication of the *Sidereus Nuncius* (1610).[56] The expression points in part at the fact that Galileo hesitated many years before he dared defend his Copernican ideas in public. And yet in private, with friends and trustworthy colleagues, like Mazzoni and Kepler, his silence had broken since at least 1597. In this regard, it must be noted that the letter sent that year by Galileo to Mazzoni – where the opinion of the "Pythagoreans and Copernicus" is regarded as "much more likely [*assai più probabile*] than the other of Aristotle and Ptolemy"[57] – was also in Gian Francesco Pinelli's library.[58] It is therefore likely that Pinelli read it, and there is no reason to exclude that other thinkers gravitating around his library did the same.[59] More than silent and private, then, Galileo's Paduan Copernicanism was whispered loudly enough to be heard by a semi-public (or semi-private) audience. The historiographical label 'silent Copernicanism' should therefore be handled with care, as it does not tell us anything by itself about the state of Galileo's Copernicanism in Padua (did Galileo considered the heliocentric system to be more than a plausible hypothesis already in 1597?), and because it may conceal the real extent of the circulation of Galileo's Copernican opinions.

But what about Galileo's science of motion before 1610? Was it also a '*science silencieuse*,' since nothing of it was published during Galileo's stay at Padua? I believe that especially in this case, the adjective 'silent,' as evocative as it may be, does not fit well. True, in Padua Galileo had not published any of his accomplishments concerning the study of motion. However, this does not mean that his "doctrine of motion" – as it is called by Castelli in the first letter from Cava – was only known by a very small and intimate group of people. It is noteworthy that, in the first letter from Cava,

[56] Cf. Clavelin (1995), p. 157.

[57] "… [L]a opinione de i Pitagorici e del Copernico circa il moto e sito della terra; la quale sendo da me stata tenuta per *assai più probabile* dell'altra di Aristotele e di Tolomeo…" (OG, II, *Galileo to Mazzoni*, 30 May 1597, p. 198, my emphasis).

[58] Cf. Favaro (1966), I, pp. 221-222, and OG, II, pp. 195-196. Clavelin did not raise the problem, or the question at least, about the circulation of Galileo's letter to Mazzoni.

[59] Pinelli's library was visited by many thinkers, including Galileo (cf. Bucciantini (2003), pp. 30-37).

Castelli finds it ridiculous that *some people* used to leverage on Galileo's doctrine of motion to prove God's existence:

> Then from the doctrine of Your Lordship that a motive cause is necessary to start the motion, but the lack of obstacles is sufficient to continue it, it makes me want to laugh when *they magnify* [*esaltano*] such a doctrine as though it made the existence of God known to me. So, if it is true that motion is eternal, then I could begin to be atheistic and say that we don't need God – what a wicked blasphemy![60]

Who is Castelli arguing against? Who are those people that, being aware of Galileo's latest findings on motion, claim that it is possible to demonstrate God's existence? And why does Castelli, a man of God, disagree with them? None of these questions has been carefully addressed by Galileo scholars.

Massimo Bucciantini has argued that the context of Castelli's letter clarifies that Castelli's complaint is not directed against Galileo's supporters; rather, it is directed against Aristotle, who claimed that the world is eternal. In the passage quoted above Castelli is therefore trying to show that, contrary to Aristotle's doctrine of motion, Galileo's doctrine can be reconciled with (or, at least, does not contrast with) the Christian belief in the temporal beginning of the world. Thus, Bucciantini regards Castelli's first letter from Cava as an attempt to refute Aristotle's doctrine from a "logical-scientific" standpoint, as well as to recognize the superiority of Galileo's doctrine of motion from a "metaphysical-theological" standpoint. In the passage above, it seems indeed that Aristotle's opinion of the eternity of the world leads to the blasphemous assertion that God does not exist.[61]

Bucciantini's interpretation is very interesting. However, it clashes against many difficulties. As we shall see in chapter III, it is true that part of Castelli's letter is devoted against Aristotle's arguments for the eternity of the world. Yet in the passage

[60] "Dalla dottrina poi di V.S., che a principiar il moto è ben necessario il movente, ma a continuarlo basta il non aver contrasto, mi vien da ridere quando *esaltano* questa dottrina come quella che mi faccia venir nella cognitione dell'esistentia di Dio; conciosiacosaché se fusse vero che il moto fosse eterno, io potrei doventar ateista e dire che di Dio non havemo bisogno, bestemia scelerata" (OG, X, *Castelli to Galileo*, 1 April 1607, p. 170, my emphasis).

[61] As Bucciantini puts it, Castelli's letter "contiene, infatti, sotto forma di saggio, un esame approfondito delle concezioni sul movimento di Galileo e di Aristotele. Si tratta di un serrato confronto a tutto campo, che dal piano logico-scientifico si sposta, con sicurezza, su quello metafisico-teologico. Sistema contro sistema, dunque, filosofia contro filosofia; e il bilancio è tutto a favore del Maestro: l'impossibilità di conciliare la concezione aristotelica dell'eternità del mondo con la tesi cristiana della creazione – e, quindi, l'accusa rivolta alla concezione dell'eternità del movimento di fare a meno dell'operato di Dio – sanciscono la piena superiorità della scienza galileiana *de motu* rispetto a quella aristotelica" (Bucciantini (1992), p. 174; see also *ibid.*, pp. 174-175, nt. 8 and 9)

quoted above Castelli is clearly stating – as testified by the deictic expression "*such* a doctrine" (*questa dottrina*) – that the position of certain supporters of Galileo is hazardous from a "metaphysical-theological" standpoint. Also, Castelli knew that Aristotle's proof of the first motive cause, which can be interpreted as a proof of God's existence, is grounded in the eternity of motion. So, even "if it is true that the world is eternal," Aristotle's doctrine gives Castelli no reason to become "atheistic and say that we don't need God." On the contrary, Aristotle's argument for God's existence holds good if the world is eternal.

It is clear that Castelli's complaint cannot be easily interpreted from the perspective of a black-and-white divide between the heterodox eternalism of Aristotle's natural philosophy, on the one hand, and the orthodox anti-eternalism allegedly involved in Galileo's doctrine of motion, on the other hand. For now, suffices it to notice that Castelli is complaining against unknown supporters of Galileo's doctrine of motion, as it has been already suggested by Libero Sosio and Pietro Redondi.[62]

Redondi has argued that, according to Castelli, "enthusiasts who took God to be the initial source of an inertial rectilinear motion were also wrong."[63] He then linked the discussion in Castelli's letter with "the problem of time as discussed by Augustine against the Manichees."[64] Although this link is more a brilliant association of ideas than a serious attempt to understand the actual historical and philosophical roots of Castelli's argument, I believe that Redondi's observation can however help us realize that a controversy was going on among some first-hour "enthusiasts" of Galileo's doctrine of motion. Interestingly, this controversy was about the possibility of proving God's existence by demonstrating that the world had a temporal beginning. This demonstration was apparently obtained by leveraging on the new conceptual tools of Galileo's mechanics. In sum, Castelli's letter gives us enough elements to outline a hitherto neglected historical narrative, one where unknown supporters of Galileo are keen to apply, in 1607 (!), Galileo's doctrine of motion to theological issues.

In the current state of knowledge, it is impossible to single out the identity of the 'enthusiasts' against whom Castelli argues. It is known, however, that Galileo sometimes shared some of his findings on motion with his private pupils. In order to date an important fragment of ms. Gal. 71, Michele Camerota has suggested to

[62] Cf. Galilei (1970), p. 28, nt. 1; Redondi (1998), pp. 180-183. David Wootton has welcomed Redondi's interpretation of the letter but has used it to argue that Galileo was most likely the one who Castelli argues against in the letter (cf. Wootton (2010), pp. 240-250). I do not agree with this hypothesis. Let us in fact suppose that Wootton is right: why, then, did Castelli not argue directly against Galileo? And why did Galileo never attempt, later, to demonstrate God's existence (which is actually what Castelli complains about in the letter)? Did Castelli convince Galileo?

[63] *Ibid.*, p. 181.

[64] *Ibid.*

consider a letter written in April 1611 by Daniello Antonini to Galileo.[65] Antonini was a private disciple of Galileo in Padua. In his letter he recalls when, probably during a private lesson, Galileo told him the "proposition: *mobile secundum proportionem distantie, a termino a quo movetur velocitatem acquirens, in instanti movetur*."[66] Not only does this letter show that Galileo had rejected, while he was still in Padua, the assumption that velocity of free fall motion is proportional to the distance fallen, but it also shows that Galileo introduced his private students to the latest novelties of his study of motion.

Without going too far, Castelli's letter is a further evidence in this regard. As a disciple of Galileo, Castelli knew that his master held the relativity of motion along with a certain idea of inertia (which is only arguably associable with an "inertial *rectilinear* motion,"[67] since Castelli does not specify its trajectory). It is possible, then, that in the April letter of 1607 Castelli argues against other private pupils of Galileo – pupils who, just like Castelli himself, were told of a new theory of motion directly from their master.

This, of course, is a purely conjectural hypothesis. But it seems to be confirmed by the manner in which Castelli refers to his opponents. He does not think it necessary to spell out their names. Probably Galileo already knew who Castelli was talking about; he was perhaps aware that his doctrine of motion was exploited in matters of faith by someone he knew.

At any rate, despite the uncertainty about the real identity of Castelli's opponents, the first letter from Cava provides important evidence about the 'state of debate' on Galileo's mechanics during, and perhaps before, 1607. The letter shows that Galileo's accomplishments in natural philosophy were discussed and differently used in Padua. Also, it is worth noting that Galileo's accomplishments are regarded as a "doctrine" by Castelli. This seems to suggest that by 1607 Galileo's study of motion was already a well-developed form of knowledge, a *scienza nova*.[68]

Also, Castelli's letter shows that, from its very beginning, Galileo's doctrine of motion "involved a theological drift," as noticed by Redondi.[69] However, I am

[65] Cf. Camerota (2004), pp. 146-148.

[66] OG, XI, *Antonini to Galileo*, 29 April 1611, p. 85.

[67] Redondi (1998), p. 181.

[68] It must be recalled that, before moving to Florence in 1610, Galileo had to finalize three books on local motion which were for the major part ready: "Le opere che ho da condurre a fine sono principalmente [...] tre libri *De motu locali*, *scienza interamente nova*, non avendo alcun altro, né antico né moderno, scoperto alcuno de i moltissimi sintomi ammirandi che io dimostro essere ne i movimenti naturali et ne i violenti, onde io la posso ragionevolmente chiamare *scienza nova* da me ritrovata sin da i suoi primi principii..." (OG, X, *Galileo to Vinta*, 7 May 1610, pp. 351-352, my emphasis). As for the term "*nova*," Paolo Rossi noticed (also thanks to Thorndike) that "[n]el titolo di centinaia e centinaia di libri scientifici pubblicati nel corso del Seicento ricorre il termine *novus*" (Rossi (2017), p. 85 (nt. 15 for the reference to Thorndike)).

[69] Cf. Redondi (1998), p. 181.

convinced that Castelli seeks in his letter to convince Galileo not to follow that drift. The scholars who studied Castelli's letter have in my view misunderstood Castelli's aim and arguments. They overlooked or simply downplayed Castelli's *agnostic* position as regards the possibility of demonstrating that the world had a beginning.

II.
CREATIO DE NOVO AND ITS (IN)DEMONSTRABILITY

§4.
Agnostic Reasons

Umberto Eco – So, between philosophy and faith, you picked faith.

Thomas Aquinas – No, I have always held that they should agree. My problem was to show that, even from the point of view of philosophy, it was impossible to think of the eternity of the world. As always, I could not philosophically prove to the pagan and the fool – who says in his heart *Deus non est* [*Psalm* 53:2] – that the world was created; instead I had to prove to pagans and fools, and by means of philosophical arguments, that it was an error to think the opposite.

Eco – So?

Aquinas – I had already dealt with this problem in the *Summa Theologiae*, but insufficiently. So, I tried to think about it honestly and logically, without being influenced by my faith, and I reached a shocking conclusion. I believe in a created world because I am told so by revelation. But from a philosophical standpoint it is impossible to prove that the world is not eternal.

This imaginary interview was recorded by Umberto Eco at the Fossanova Abbey on the seventh of March 1274, just before Aquinas died.[1] It is more than a sample of accurate historical fiction. Eco knows very well his interviewee, and Aquinas seems to know his interviewer. Both have the ability to chitchat on serious philosophical issues in a rather colloquial language. When Aquinas is asked about philosophy and faith, he raises the problem of "creation." This term is vague, as it might not mean that the world was once created in time. But a little after Aquinas specifies that he is talking about the temporal beginning of the world: "from a philosophical standpoint it is

[1] Eco (2012), *Intervista a Tommaso d'Aquino*, p. 1190: "*I* – Quindi tra filosofia e fede, sceglievate fede / *T* – No, ho sempre sostenuto che esse avrebbero dovuto andare d'accoro. Il mio problema era di mostrare che anche dal punto di vista della filosofia pensare all'eternità del mondo ea impossibile. Come sempre non potevo dimostrare filosoficamente al pagano o all'insipiente (che dice in cuor suo *Deus non est*) che il mondo era stato creato, ma dovevo dimostrare a pagani e insipienti, con argomenti filosofici, che era errato pensare il contrario. / *I* – Allora? / *T* – Me n'ero già occupato nella *Summa Theologiae*, ma in modo insufficiente. Così ho cercato di ragionare secondo onestà e secondo logica, senza farmi influenzare dalla mia fede, e sono arrivato a una conclusione sconvolgente. Io credo a un mondo creato perché me lo dice la rivelazione, ma filosoficamente non si può dimostrare che il mondo non sia eterno." The English translation is mine.

impossible to prove that the world is not eternal."

Although Aquinas regards this conclusion as "shocking" in the interview forged by Eco, it must be noted that the same conclusion had been held by Aquinas from the time of his early commentary on the *Sentences*.[2] If Eco had met Aquinas ten years before, and had him asked about the possibility of demonstrating that the world had a beginning, Aquinas would have probably repeated his *respondeo* included in the *Summa Theologiae*, part I, question 46, article 2:

> I answer that by faith alone do we hold, and by no demonstration can it be proven, that the world did not always exist… Hence that the world had a beginning is an object of faith, but not of demonstration or science.[3]

Aquinas's position as regard the demonstrability of the beginning of the world is often referred to as 'agnostic.' Aquinas's agnosticism states the impossibility of demonstrating the articles of faith, such as the Trinity and the creation *de novo* of the world. These truths are beyond the reach of philosophy and cannot be demonstrated by the natural light of reason. Thus, they came from Revelation and must be held by faith.

But the reasons behind Aquinas's agnosticism do not stem from strictly epistemological considerations. Firstly, it is the faith in God that does inevitably belittle the faith in human reasoning when it comes to the beginning of the world. Indeed, there cannot be demonstration of what has not happened by necessity; but the world was freely created *de novo* by God; hence there cannot be demonstration of *creatio de novo*. This conclusion, pertaining to our epistemological boundaries, evidently clings onto a theological conception of God as a free being.[4] Secondly, and as a consequence, when one seeks to demonstrate *creatio de novo*, by so doing he is also risking to rely an article of faith on unreliable sophisms. This would jeopardize faith, which might appear laughable to the infidels:

> Hence, that the world had a beginning is an object of faith, but not of

[2] Cf. *In Sent.*, II, d. 1, q. 1, a. 2, *resp.* Perhaps Eco meant to refer to the fact that Aquinas did only later, in his *De aeternitate mundi*, defend a stronger thesis according to which it is possible that the world was created from eternity (cf. Wippel (1984), pp. 191-214).

[3] "Respondeo dicendum quod mundum non semper fuisse, sola fide tenetur, et demonstrative probari non potest […]. Unde mundum incoepisse est credibile, non autem demonstrabile vel scibile." English translations from the *Summa Theologiae* are always taken, and sometimes slightly modified, from the Fathers of the English Domenican Provence's version made available online (http://www.newadvent.org/summa/ (accessed 19 Nov 2019)).

[4] "Similiter etiam neque ex parte causae agentis, quae agit per voluntatem. Voluntas enim Dei ratione investigari non potest, nisi circa ea quae absolute necesse est Deum velle, talia autem non sunt quae circa creaturas vult, ut dictum est" (*S. th.*, I, q. 46, a. 2, *resp.*).

> demonstration or science. And it is useful to consider this, lest anyone, presuming to demonstrate what is of faith, should bring forward reasons that are not cogent, so as to give occasion to unbelievers to laugh, thinking that on such grounds we believe things that are of faith.[5]

Aquinas's remark is partially polemic, and it must be placed within its own historical context. At Aquinas's time, there were theologians who claimed that the beginning of the world can be demonstrated by natural reason alone.[6] Aquinas is not the first to condemn this counterproductive way of reconciling reason and faith. Before him, Moses Maimonides had already criticized the *mutakallimûn*'s attempt to demonstrate what should be held by faith alone.[7] It is fair to say with David B. Burrell that, while "Avicenna gave the impetus to Aquinas's project of adapting the received philosophy of the Greeks to the larger project of elaborating a universe created and redeemed by the one God," it is Maimonides who "gave that project its critical shape."[8] That is, Maimonides and Aquinas agree on the extent to which the encounter between reason and faith, philosophy and religion, can be considered fruitful, and when it must be considered harmful, instead. Obviously, 'fruitful' and 'harmful' are to be taken with respect to faith.

§5.
MUZIO VITELLESCHI'S 'ANTI-AGNOSTICISM.'
A NEW CASE STUDY ON THE BULL *APOSTOLICI REGIMINIS* (1513)

The question as to whether it is possible to demonstrate the beginning of the world was not at all settled in the Renaissance. Also, controversies on the unicity of the intellect and immortality of the soul were often debated by thinkers whose take on the matter has been sometimes poorly labelled as 'Averroistic' or 'Alexandrian.'[9] These controversies drew the attention of local ecclesiastic authorities at first, and soon they

[5] "Unde mundum incoepisse est credibile, non autem demonstrabile vel scibile. Et hoc utile est ut consideretur, ne forte aliquis, quod fidei est demonstrare praesumens, rationes non necessarias inducat, quae praebeant materiam irridendi infidelibus, existimantibus nos propter huiusmodi rationes credere quae fidei sunt" (*ibid.*).

[6] Bonaventura is the classic example in this regard. On this issue, see Cyril Vollert's introduction in Aquinas-Siger of Brabant-Bonaventure (1965), pp. 1.17; Bianchi (1984), pp. 115-141 *et passim*; Dales (1990), *passim*.

[7] Cf. Gillson (2015), pp. 197-198; Vollert's introduction in Aquinas-Siger of Brabant-Bonaventure (1965), pp. 11-12, 15; Dunphy (1983); Bianchi (1984), p. 121, nt. 25; Burrell (1993), pp. 70-71; Dobbs-Weinstein (2003), pp. 128-131, 134-135.

[8] Burrell (1993), p. 70.

[9] On the difficulties involved in these labels, see Hasse (2007) and Blum (2007).

reached the pope's ears, who decided to officially intervene with a doctrinal statement on the issues at stake.[10]

Pope Leo X promulgated the bull *Apostolici regiminis* in 1513, at the eighth session of the Fifth Council of the Lateran. The bull can be divided into three main sections: in the first, the theories of the mortality of the rational soul is condemned, while its immortality is declared to be true; in the second, prescriptions are given for teaching opinions that are contrary to faith, such as the mortality of the soul and the eternity of the world; in the last section, clergy students educated in grammar and logic are forbidden to partake courses of philosophy or poetry, except as part of their final formation in theology or canon law.[11]

The very existence of this bull gives us some clue about the Church's interference with public teaching and education in the sixteenth century. However, it does not tell us anything about the actual impact that the bull had on the teaching of philosophy in colleges and universities. Did the bull actually restrict the freedom of philosophy teachers? Furthermore, the text of the bull includes some ambiguous expressions which should be studied through the interpretations produced by the historical actors of the time. For instance, the bull asks teachers to make all efforts (*omni conatu*) in order to show the truth of Christian religion, which they must teach persuasively and "*pro posse*" while refuting with all their strength the arguments against it (*pro viribus excludere atque resolvere*). Does this mean that professors were demanded to *demonstrate* the mortality of the soul and the beginning of the world? Also, how should the *pro posse* clause be interpreted? Does it mean that teachers must persuade about the Christian truth "so far as *it* is possible," or "as best *they* can"? Does the clause refer to an *objective* difficulty, or a *subjective* one on the part of the teacher?[12]

Scholars have addressed these questions by drawing particular attention to controversies on the mortality/immortality of the soul, especially with respect to the aftermath of the bull in the Italian academic milieu.[13] There now seems to be general agreement that the bull did not demand to *demonstrate* the immortality of the soul.[14]

[10] The bishop of Padua, Pietro Barozzi, published a first *edictum* on May 4, 1489 (cf. Grendler (2002), pp. 283-289).

[11] Cf. the original Latin text has been recently included in Constant (2002), pp. 377-379. For an English translation by Norman P. Tanner, see *Decrees of Ecumenical Councils* (1990), I, pp. 605-606.

[12] On these issues, see Bianchi (2008), pp. 121-124.

[13] Cf. Martin (1995); Grendler (1996); Constant (2002); Grendler (2002), pp. 189-193.

[14] With the remarkable exception of Eckhard Kessler, who argued that the bull establishes that "individual immortality could be demonstrated philosophically and consequently had to be defended by all philosophers" (Kessler (1988), p. 495). There may be another exception. Indeed, Grendler claims that "the bull further demanded that philosophers demonstrate philosophically the truths of Christianity 'so far as this [was] possible'" (Grendler (2002), p. 290). This, however, is a rather awkward request, given that two are the possible cases: either the truths of Christianity can be demonstrated, or they cannot. For this reason, Grendles argues that the clause 'as far as possible' (*pro posse*) "seemingly acknowledged that not everyone agreed that all truths of Christianity could be demonstrated philosophically. It was an escape clause" (*ibid.*).

Thus, the *Apostolici regiminis* left an ample margin of maneuver to philosophers and for the teaching of philosophy, as it "freed natural philosophy from all but *nominal* theological constraints."[15] However, what I want to stress here is that this conclusion is usually based on the study of published books dwelling on the soul's mortality/immortality issue – like Pietro Pomponazzi's famous *Tractatus de immortalitate animae* (1516) – and then it is applied to the teaching of philosophy also pertaining to the question of the duration of the world.

A quasi-exception from this way of studying the impact of the bull is provided by an essential contribution by Christopher Sander. The latter focuses chiefly on Diego de Ledesma's (1519-1575) effort to include the bull's precepts into his "pedagogical guidelines" for the Roman College, which eventually resulted in the seventeen propositions of the *Decretum borgianum*.[16] After pointing out Ledesma's influence on Franciscus Toletus's (1532-1596) commentary on the *De anima* (1574), and on some parts of the *Ratio studiorum* (1586), Sander concludes that the *Apostolici regiminis* had a certain impact on the teaching of Jesuit philosophy professors such as Toletus.[17]

Although Sander considers important teaching guidelines, his study of the bull's impact on the Jesuit teaching of philosophy is still surveyed *indirectly*: in the first place, by showing that the bull influenced the elaboration of documents – either official, like the *Ratio studiorum*, or unofficial, like Ledesma's *Decretum borgianum* – that laid out a set of rules for the Jesuit didactic; in the second place, by attesting the impact of such documents on published works whose authors – like Toletus – taught philosophy in a Jesuit college.

This *modus operandi* or methodology has a twofold merit: on the one hand, it shows how the bull *Apostolici regiminis* was integrated into the Jesuit teaching guidelines and rules; on the other hand, it shows to what extent Jesuit professors abided by these rules in their published writings. Toletus, for instance, who wrote before the *Ratio studiorum* had been issued, could claim that the immortality of the soul cannot be demonstrated through philosophical arguments, notwithstanding Ledesma's contrary opinion in the *Decretum borgianum*.[18] This shows to us that the *Apostolici regiminis* did not compel Toletus to demonstrate the mortality of the soul. It is only after the officialization of the *Ratio studiorum*, where the immortality of the soul is said to be demonstrable by natural reason, that Jesuit teachers are prevented from holding the

However, this does not detract anything from the fact that the statement 'demonstrate as far as possible' is extremely awkward, to say the least. It is not by chance, I believe, that the bull uses the verb *persuadeo*, not *demonstro*. This fact should not be overlooked.

[15] *Ibid.*, my emphasis.

[16] Cf. Sander (2014), pp. 48-56.

[17] Cf. *ibid.*, pp. 56-60.

[18] Cf. *ibid.*, p. 59.

indemonstrability of the soul's immortality.[19]

However, Sander's methodology does also have a limit. Even by considering Ledesma's guidelines, the *Ratio studiorum*, and Jesuit commentaries on Aristotle's works, one can but *guess* how the *Apostolici regiminis* affected the Jesuit lectures on natural philosophy. Also, we are still in the dark about the bull's impact on the other matter, that is, the eternity of the world.

For these reasons, I should like to suggest a different, though complementary, way of studying the impact of the bull, which consists in looking *directly* at the lectures of philosophers. Some of these lectures have come down to us in the form of so-called *reportationes*.[20] Here, I shall present a particular case study provided by Muzio Vitelleschi's (1663-1645) *reportationes* on natural philosophy, where the *Apostolici regiminis* is cited almost *verbatim* with respect to the controversy on the eternity of the world.

Vitelleschi's reportationes on the *De caelo* and the *De generatione et corruptione* are conserved in the Archive of the Pontifical Gregorian University, in Rome (codex APUG, F.C. 392). The lectures therein recorded were held at the Roman College during the academic year 1589-1590.[21] As far as I know, the manuscript has only received the attention of two scholars: William A. Wallace, and Corrado Dollo. They considered Vitelleschi's *reportationes* an important document in relation with Galileo's *Juvenilia*, namely a series of hand-written folios where classic issues of scholastic natural philosophy are discussed in the medieval form of *quaestiones*. According to Antonio Favaro, the editor of the National Edition of Galileo's works, those folios are nothing but the transcription of customary lectures on natural philosophy. Thus, Favaro entitled them *Juvenilia*. He had valid reasons to believe that Galileo transcribed those lectures in 1584, when he was a young student at the University of Pisa. However, Alistair C. Crombie, Adriano Carugo, and William A. Wallace, have called into question Favaro's dating, after they had found out that some parts of the *Juvenilia* and another similar manuscript on logic (i.e., ms. Gal. 27) seem to be taken from books and *reportationes* of the professors of the Jesuit Roman College.[22]

Vitelleschi's *reportationes* play an important role in this regard. Indeed, according to Wallace these *reportationes* are strikingly similar to the *Juvenilia*; thus Galileo must have copied the *reportationes* of lectures that were held in the Roman College between 1588 and 1590. Leaning on these textual similarities, Wallace put forth his own version of the continuity thesis which seamlessly links, *via* the Jesuit philosophers of the Roman College, the medieval contributions to science and logic with Galileo's

[19] "… [N]aturali lumine demonstrari potest, et iam demonstratum est, Animam rationalem esse immortalem…" (*Ratio studiorum* (1591), p. 122)

[20] On the 'genre' of the *reportatio*, see Hamesse (1997).

[21] Cf. Villoslada (1954), p. 329.

[22] For an introduction to these issues, cf. Malara (2019), pp. 2-5.

scientific methodology.[23]

While Wallace focused on Vitelleschi's *reportationes* in order to show that the *Juvenilia* originated with the Roman College, Dollo took this origin for granted, but showed the hiatus separating the *Juvenilia* and the *reportationes* from the rest of Galileo's original production. In so doing, Dollo attempted to refute the conclusions drawn by Crombie, Carugo, and Wallace, who identified the sources of Galileo's science in a series of Jesuit writings.[24]

Thanks to this scholarly debate, a large part of Vitelleschi's *reportationes* was transcribed by Dollo. To be more specific, Dollo transcribed the second part of the *reportationes*, which concerns Aristotle's *De generatione et corruptione*, and includes an interesting treatise on the elements.[25] Other short passages concerning the *De caelo* had already been transcribed by Wallace in his papers and books.[26]

The parts I shall refer to here have never been transcribed. They are situated almost at the beginning of the manuscript, under the heading *Quid de mundi origine senserit Aristoteles. Disputatio prima* ("What Aristotle thought about the origin of the world. First disputation," ff. 5*r*-6*v*) and *An lumine naturali cognosci possit mundum fuisse a Deo creatum in tempore. Disputatio secunda* ("Whether it is possible to recognize by natural reason that the world was created in time by God. Second disputation," ff. 6*v*-9*r*). These are the first disputations discussed in the section of the manuscript entitled *De mundo tractatio prima* ("First treatise on the world").

Wallace did also provide some biographical information about Vitelleschi. Here, it suffices to recall that Vitelleschi entered the Society of Jesus in 1583; five years later, he started a course of logic at the Roman College, followed by a course on natural philosophy in 1589-90, and one on metaphysics in 1590-91. In 1615, he was elected General of the Society, after having spent some years as professor of theology and prefect of studies.[27]

It must be noted that, although Wallace delivered a paleographical commentary of the *Juvenilia*, he did not carry out an evenly useful paleographical commentary of the Jesuit *reportationes* he had consulted. Concerning Vitelleschi's *reportationes*, I agree with Dollo that they were written by different "hands."[28] Most likely, students were put in charge of transcriptions. This would explain the presence of blunders, which can also be found in the part where the *Apostolici regiminis* is cited. I would add that some errors of transcription show that the *reportationes* were copied from another

[23] Cf. Wallace (1981), pp. 303-319.
[24] Cf. Dollo (2003), pp. 87-128.
[25] Cf. *ibid.*, Appendix II, pp. 331-386.
[26] Cf. Wallace (1981), pp. 213-214, 257-259, 267, 280-281; Wallace (1984), p. 86.
[27] Cf. Wallace (1977), pp. 18-19; Wallace (1984), pp. 66-68.
[28] "La scrittura corrente, di più mani, si serve delle normali abbreviazioni e contrazioni" (Dollo (2003), p. 331).

manuscript. Hence, the extant *reportationes* of Vitelleschi's lectures were not written by students taking notes in the classroom.

Now, Vitelleschi's *reportationes* and Galileo's *Juvenilia* can help us gauge the role played by the *Apostolici regiminis* in the controversy on the eternity of the world. Did the bull prevent philosophers from endorsing the agnostic position held by Aquinas? At Galileo's time, was a natural philosopher demanded to demonstrate, as far as possible or as best he could, that the world had a beginning? An answer to these questions can also help us interpret Castelli's first letter from Cava.

I shall consider the *Juvenilia* in the next section. For the time being, my aim is to provide a brief account of Vitelleschi's position about the possibility of demonstrating that the world had a temporal beginning, and see whether the bull affected his philosophical standpoint in this regard.

The first thing to consider is that Vitelleschi had to abide by the *Ratio studiorum*. As we have seen, in the *Ratio studiorum* it is written that the immortality of the soul can be demonstrated; however, the *Ratio studiorum* is silent on how to settle the dispute on the demonstrability or indemonstrability of the beginning of the world. The only instruction in this regard is included in a general observation about the teaching of Aristotle's unorthodox doctrines:

> The professor of philosophy shall not depart from Aristotle, unless he finds some doctrine contrary to the common teaching of the schools or, more serious still, contrary to the true faith. If he does find such contrary doctrines in Aristotle or any other philosopher, he shall be at pains thoroughly to refute them [*ea strenue refellere studeat*] as the Lateran Council prescribes.[29]

In his lectures on Aristotle's natural philosophy, Vitelleschi is demanded to refute Aristotle's claims that clash with the truth of Christian religion. But before doing that, he must first ascertain that Aristotle did actually hold impious opinions, such as the eternity of the world. Only after having ascertained this, Vitelleschi can then juxtapose Aristotle's opinion with the truth of faith, while also showing "by natural light of reason" that Aristotle's opinion is wrong. This way of proceeding is suggested to him by the bull *Apostolici regiminis*:

> In this difficulty regarding the origin of the world we cannot be mistaken. In

[29] "Philosophiae professor ab Aristotele non recedat, nisi quid incidat a doctrina, quam academiae ubique probant, alienum; multo magis, si orthodoxae fidei repugnet; adversus quam, si qua sunt illius aliusve philosophi argumenta, ea strenue refellere studeat iuxta Lateranense Concilium" (*Ratio studiorum* (1591), p. 176). English translation from Farrell (1970), p. 40, also quoted in Sander (2014), p. 47.

> fact, the divine faith (which can include no falsehood) openly teaches us what is to be upheld in this matter. Therefore, in this treatise we first follow the decree of the Lateran Council under [the superintendence of] Julius II and Leo X, which is given in section VIII: [1.] we will reveal Aristotle's mistakes; [2.] then we will place the truth of faith side by side with Aristotle, and at the same time we will show by natural reason that it is possible to prove Aristotle wrong, so that it appears how easily a man, although very sharp-sighted in other matters, without the light of faith yet went blind in a not too obscure matter. Eventually, we will disprove all the things that Aristotle and others said against the truth. However, I omit other philosophers' opinions, especially those of Plato, whose opinion on the origin of the world is a major controversy amongst Platonists… Our duty here is only to clarify and refute Aristotle's mistake [*Nobis solus Aristotelis error aperiendus et confutandus est*].[30]

Aperire et confutare. So, Vitelleschi begins by *clarifying* that Aristotle regarded the eternity of the world as a philosophical truth.

There have been thinkers who argued that Aristotle used the eternity of the world just as a dialectical argument to show that his predecessors' opinions on the origin of the world were insufficiently grounded.[31] Other interpreters, like Albert the Great, have gone so far as to argue that Aristotle's opinion on the origin of the world can be reconciled with what is taught us by faith, namely that the world was created.[32] However, Vitelleschi refutes these interpretations, and shows that for Aristotle the world is eternal.[33]

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[30] "In hac difficultate de mundi origine nos errare non possumus, divina enim fide, cui falsum subesse non potest, apertissime docemur quid in hac re sentiendum sit. Primum ergo in hac tractatione sequentes [sumus] decretum Lateranensis concilij sub Iulio 2° et Leone X°, quod habetur sessione octava. Aristotelis errorem aperiemus, tum veritatem nostrae fidei Aristoteli opponemus, et simul ostendemus naturali lumine Aristotelem posse convinci, ut appareat quam facile fuerit homini, quamvis alioquin oculatissimo, fidei tum luce destituto in re non obscurissima caecutire. Denique quae ab Aristotele et alijs contra veritatem dicuntur dissolvemus. Omitto autem aliorum philosophorum sententias et praecipue Platonis, de quo, quid de mundi origine senserit, controversia maxima est inter Platonicos… Nobis solus Aristotelis error aperiendus et confutandus est" (Vitelleschi, ms. APUG, F.C. 392, ff. 5*r*-*v*).

[31] "S. Thomas prima parte quaest. 46 art. 1, Albertus 8 *Physicorum* tract. 1 cap. 4, Rabi Moses, teste Burlaeo ibidem in textu 15, existimant Aristotelem, dum disputat de mundi aeternitate, non explicare suam sententiam sed tantum velle probare mundum non fuisse genitum eo modo quo volebant antiqui, et ad hoc adduxisse rationes quae nihil concludunt nisi positis illorum antiquorum proprijs. De hoc etiam dubitat Sotus 8 *Physicorum* quaest. 1. Conantur autem probare hoc, primo ex Aristotele ipso, qui primo *Topicorum* cap. 9 refert inter problema[ta] dialectica an mundus sit aeternus necne; secundo, quia Aristoteles 8 *Physicorum* et primo *Caeli* praemittit antiquorum de mundi origine, quas deinde impugnat; tertio, quia ad id probandum affert antiquorum testimonia, quod dialectici est non demonstrantis" (*ibid.*, f. 5*v*). On the use of *Top*. 104b to deny that Aristotle held the eternity of the world, ot to reconcile Aristotle's opinion with that of Plato, see Bianchi (1987), pp. 13-17, 76.

[32] "Denique Albertus, loco notato, refert in libro Aristotelis De natura deorum legi mundi a Deo opifice esse creatum" (Vitelleschi, ms. APUG, F.C. 392, f. 5*v*).

[33] "Ad primum autem argumentum in contrario respondeo illud afferri ab Aristotele exempli gratia, sicut et alia problemata quae ibidem proponuntur, ut an voluptas sit eligenda necne. Adde quod licet

That being established, Vitelleschi can now explain what faith tells us to believe. Calling on the Bible (*Genesis* 1:1 in the reading of Basilius and other interpreters; *Proverbs* 8:22; *John* 1:1 and 17:5) and the Niceno-Constantinopolitan Creed ("Maker of heaven and earth"), Vitelleschi says that "faith teaches us that the world was not from eternity, but it is made and created by God in time" (*nos fides docet mundum non fuisse ab aeterno, sed factum et creatum esse a Deo in tempore*).[34]

Vitelleschi then introduces a controversy: whether it is possible to recognize (*cognosci possit*) by natural light of reason (*naturali lumine*) that the world had a beginning.[35] On this matter, two are the opinions reported by Vitelleschi: (1) the opinion of those who affirm that the beginning of the world can be *recognized* by natural light of reason, but they deny that it can be *demonstrated*;[36] (2) the opinion of those who say that, not only can the beginning of the world be *recognized*, but it can also be *demonstrated* just as other truth of natural philosophy are demonstrated by the natural philosopher.[37]

Aquinas, the masters of Paris (*Parisienses*), Walter Burley, Domingo de Soto, Jean Capreolus, are mentioned by Vitelleschi as supporters of the first of opinion. Vitelleschi specifies that the first opinion is held by all those who believe that God might have produced the world from eternity. Their main reason for holding this is called *fundamentum* by Vitelleschi; it states that the decision to make the world from eternity or in time depends on God's free will. Hence, it cannot be demonstrated that God decided to create the world in time.[38] The second opinion, instead, is held by

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Aristoteles ipse de mundi aeternitate non dubitavit; erant tum variae philosophorum de hac re sententiae, et variae rationes pro utraque parte afferebuntur, dialectice enim est etiam de ijs rebus quae in scientijs scientifice tractantur in utramque partem probabiliter disputare. Denique quisnam pluris faciat longam tractationem quam ex professo instituit Aristoteles 8 *Physicorum* et primo *De caelo*, quam duo illa verba ex primo *Topicorum*. Ad secundum respondeo familiare id esse Aristoteli et omnibus philosophis; valet enim ad propriam sententiam explicandam et confirmandam aliorum primum errorem aperire et refutare. Ad tertium eodem modo dico solere Aristotelem et omnes rationibus necessarijs probabiles et aliorum etiam testimonia adiungere quando praesertim plurimi contrarium sentiunt. Ad quartum facile possem respondere librum illum non esse Aristotelis cum contineat aliquid quod aperte repugnat ijs quae relinquit Aristoteles in libris quos constat esse Aristotelis, et nulla eius libri mentio fiat ab antiquioribus peripateticis; quod si est Aristotelis, exotericus est et populariter scriptus, vel denique dicitur mundus a Deo creatus quia ab eo emanet et dependet sed tamen ab aeterno" (*ibid.*, ff. 6*r*-*v*).

34 "Primum illud ponendum est quod nos fides docet mundum non fuisse ab aeterno, sed factum et creatum esse a Deo in tempore. Probatur ex sacris litteris, Genesis primo: 'In principio Deus creavit caelum, etc.,' hoc est, ut Basilius et alij ittigunt, ab aliquo initio temporis; et Proverbiorum 8: 'Dominis possedit me ab initio, etc.'; Ioannis primo: 'Mundum per ipsum factus est'; Ioannis 17: 'Clarifica me tu pater claritate quam habui prius quam mundus esset'; et denique ex symbolo 'creatorem caeli et terrae'" (*ibid.*, f. 6*v*).

35 "Hoc posito, controversia est an id possit naturali lumine cognosci" (*ibid.*).

36 "Prima sententia concedit quidem naturali cognosci posse et probabilibus rationibus ostendi mundum non fuisse ab aeterno; negat tum posse demonstrari" (*ibid.*).

37 "Secunda sententia dicit naturali lumine non minus posse ostendi mundum de facto fuisse factum in tempore, quam probentur in physica multae res quae censentur demonstrare" (*ibid.*).

38 "Ita S. Thomas prima parte quaest. 46 art. 2° et lib. 2° Contra gentes cap. 38; Parisienses 8 Physicorum quaest. 2ª; Burlaeus ibidem in textu 15; Sotus ibidem quaest. 2ª; Capreolus in 2° dist. prima quaest. prima

those "who believe that the eternity of the world involves contradiction."[39]

As we can see, both opinions states that the beginning of the world is *recognizable* or *acknowledgeable* by natural reason. This means that the real controversy is about its being *demonstrable*. Notwithstanding the agreement on the *recognizability* of the beginning of the world, Vitelleschi includes a small but interesting epistemological remark in this regard:

> It must be noted that it is not so easy to understand what we are able to recognize by natural light of reason. In fact, the certainty that, because of the grace of divine faith, makes us deal with many things without fear of failing, sometimes also makes us ascribe to our natural light of reason what we have actually received from our faith. Also, it is much easier to confirm with new arguments what has been already discovered and known (*res iam inventas et cognitas*), than to discover it for the first time. It happens often that a certain type of light is weak and insufficient for us to see a thing for the first time, especially when that thing is entangled with many mistakes. Now, this should suffice to readily consider what we have already discussed and said.[40]

In sum, it may be that we get acquainted with the truth of something thanks to our faith. However, that same truth can be later recognized by our natural light of reason. This makes it difficult to understand whether we have arrived at the truth by faith or by natural reason alone. But this does not matter. The point is that the truths of faith can be recognized by our human reasoning, although the latter may be too weak to reach them without the *initial* aid of Revelation.

Bearing this in mind, and knowing that all thinkers seem to agree that the beginning of the world can be recognized by natural reason, Vitelleschi states his first proposition:

> In this matter, then, be it a first proposition: that the world was *de facto* created in time can be recognized by the natural light of reason. We will dwell a little longer on this proposition. For a holy decree, that of the Lateran Council (in

conclus. 3[a], et alij qui existimant potuisse a Deo mundum produci ab aeterno quos infra citabo. Fundamentum est quia pendet a libera Dei voluntate" (*ibid.*).

[39] "Est [*viz.* sententia secunda] eorum qui existiment implicare contradictionem mundum fuisse ab aeterno, de quibus infra dicam" (*ibid.*).

[40] "Notandum est non ita facile videri posse quid naturali lumine cognoscere possimus. Certitudo enim illa, qua divinae fidei beneficio versamur in multarum rerum tractatione sine ullo prorsus errandi timore, facit ut eam cognitionem quam fidei lumine assequimur interdum naturali lumini attribuatur. Adde longe facilius esse res iam inventas et cognitas novis rationibus confirmare, quam eas primum invenire; et quod saepe lumen aliquod quod exiguum est nec sufficiens ut rem primo videamus, si praesertim multis erroribus involuta sit. Satis deinde est ut eandem iam propositam et explicatam facile intueamur" (*ibid.*, ff. 6*v*-7*r*).

> the locus cited above), enjoins on each and every philosopher who teaches philosophy, that when they explain to their audience the principles or conclusions of philosophers, where these are known to deviate from the true faith – as the assertion of the eternity of the world – they have to clarify for their listeners the truth of the Christian religion, to teach it perfectly by persuasive arguments, and to apply themselves to the full extent of their energies to refuting and disposing of the philosophers' opposing arguments, since all refutations [*solubilia*] are available.[41]

Two things must be noted: (1) the *Apostolici regiminis* is mentioned with reference to a proposition which is not about the *demonstrability* of the beginning of the world, but pertains to its *recognizability* by natural reason; (2) the *Apostolici regiminis* is cited almost *ad verbum*, as it can be seen in the following comparison, where I have emphasized in italics the similarities between the two texts, and in bold the most striking difference:

Vitelleschi, ms. APUG, F.C. 392, f. 7*r*.	*Apostolici regiminis*
In hac propositione erimus paulo longiores, sanctum enim concilium est decretum illud Lateranensis concilij, loco supra citato, quo *omnibus et singulis philosophis publice philosophiam profitentibus praecipit ut cum philosophorum principia aut conclusiones in quibus a recta fide deviare noscuntur, auditoribus suis explicaveri*[n]*t qualis hac est de mundi aeternitate, eisdem veritatem Christianae religionis manifestam facia*[n]*t et persuadendo* **perfecte** *doceant, et omni studio hujusmodi philosophorum argumenta, cum omnia solubilia existant, pro viribus excludant ac resolvant*.	Insuper *omnibus et singulis philosophis in universitatibus studiorum generalium, et alibi publice legentibu*s, districte praecipiendo mandamus, *ut cum philosophorum principia aut conclusiones, in quibus a recta fide deviare noscuntur, auditoribus suis legerint, seu explanaverint, quale hoc est de* animae mortalitate aut unitate, et *mundi aeternitate*, ac alia hujusmodi, teneantur *eisdem veritatem religionis Christianae* omni conatu *manifestam facere, et persuadendo* **pro posse** *docere, ac omni studio hujusmodi philosophorum argumenta, cum omnia solubilia existant, pro viribus excludere atque resolvere.*

The original expression "*pro posse*" is transformed into "*perfecte*" in the *reportationes*. It is likely that this difference is due to a slip made by the copyist. The passage quoted

[41] "In hac tum rem sit prima propositio: lumine naturali cognosci potest mundum de facto productum fuisse in tempore. In hac propositione erimus paulo longiores, sanctum enim est decretum illud Lateranensis concilij, loco supra citato, quo omnibus et singulis philosophis publice philosophiam profitentibus praecipit ut, cum philosophorum principia aut conclusiones, a quibus a recta fide deviare noscuntur, auditoribus suis explicaverit, qualis hac est de mundi aeternitate, eisdem veritatem Christianae religionis manifestam faciat et persuadendo perfecte doceant, et omni studio hujusmodi philosophorum argumenta, cum omnia solubilia existant, pro viribus excludant ac resolvant" (*ibid.*, f. 7*r*).

does indeed include more than a slip. In one case, the copyist makes a doctrinal mistake, when he writes that it is possible to recognize by natural reason that the world was *de facto* created "from eternity" (*ab aeterno*). This expression is underlined, and the expression "in time" (*in tempore*), also underlined, is added by another hand in the left margin. The second expression is most likely meant to substitute the first one. In fact, affirming that the world was created "from eternity" stands at odds with the precepts of the *Apostolici regiminis*, which is cited immediately after.

At any rate, the sense of Vitelleschi's appeal to the bull is clear: according to Vitelleschi, showing that the beginning of the world is *recognizable* by natural reason amounts to *persuading* his audience that the world had a beginning. In accord with the bull, then, Vitelleschi must devote enough time to show to his students that the beginning of the world can indeed be *recognized* by natural reason.

Vitelleschi resorts to three authorities and four arguments (*rationes*). As for the authorities, he resorts to:

1. the authority of ancient philosophers, who preceded Aristotle and believed that the world had beginning in time;[42]
2. the authority of Mosaic history;[43]
3. the authority of profane history.[44]

Then he lists four arguments, which are rather 'classic.' This means that they were developed in antiquity and in the middle ages, and they were still used as 'stock arguments' in the Renaissance[45]:

1. if the world was eternal, then there should be an actual infinite number of rational souls – but this is impossible, hence the world is not eternal;[46]
2. if the world was eternal, then an actual infinite number of months should be elapsed in a year – but this is impossible, hence the world is not eternal;[47]
3. as written by Pliny, mortal creatures get smaller and smaller, generation after generation. If the world was eternal, mortal creatures should now be incredibly small – but this is not true, hence mortal creatures are not eternal;[48]

[42] Cf. *ibid.*, ff. 7*r*-*v*.

[43] Cf. *ibid.*, ff. 7*v*-8*r*.

[44] Cf. *ibid.*, f. 8*r*.

[45] On this kind of arguments, see Bianchi (1984) and Dales (1990).

[46] "Primum enim si mundus fuisset ab aeterno essent nunc actu infinitae animae rationales" (Vitelleschi, ms. APUG, F.C. 392, ff. 8*r*-8*v*).

[47] "[I]tem fuisset actu elapsi infiniti menses, anni, circulationes caeli, quod esse non potest" (*ibid.*, f. 8*v*).

[48] "Deinde ut ait Plinius, libro 7 [*Hist. Nat.*] cap. 16, in plenum puncto mortalium generi minorem in dies fieri mensuram propemodum observatum, rarosque partibus proceriores, ergo signum est homines et alia non fuisse ab aeterno. Idem argumentum habetur libro 4 Esdrae cap. 5" (*ibid.*).

4. as shown by Aristotle, it is possible to grasp by natural reason that God always employs the best possibility amongst many. From this one gathers that, in order for creatures to know the virtues of the Creator by contemplating the world, the best possibility was to create the world in time, that is, *de novo*.[49]

These arguments and the three authorities cited above show that we can grasp by natural reason that the world had a beginning. They also contribute to persuading us that the world actually (*de facto*) had a beginning.

Vitelleschi can therefore introduce a second proposition:

> Not only can the non-eternity of the world be somehow recognized by natural reason, but the same is also proved, just like in philosophy many things are considered to be proven by the natural philosopher. This is shown especially well by the first of the arguments used in the previous proposition.[50]

According to Vitelleschi, the argument of the actual infinity of the soul is more than *persuasive* – it is *demonstrative*. Hence, Vitelleschi holds that the natural philosopher is able to demonstrate that the world had a beginning. The main reason or *fundamentum* of those who deny the possibility of this demonstration does only tell us that we cannot know why God created the world at some given time:

> To the *fundamentum* in support of the first opinion, I reply: [1.] it is one thing is [to say] that the world was not from eternity but was created in time [*in tempore*]; [2.] it is another [to say] that the world was created at a given time

[49] "Praeterea lumine naturali cognosci potest Deum ex possibilibus Deum facere quod melius est. Quod etiam < … > docet Aristoteles 8 *Physicorum* 56, primo *De generatione animalium* cap. 4. Sed lumine etiam naturali cognosci potest longe melius esse mundum fuisse productum in tempore; ergo minor probatur: tum quia melius sic cognoscimus Deum esse omnipotentem, esse agens liberum, et posse producere non solum quidquid voluerit sed etiam quando et quomodo voluerit. Omnia prout voluerit optime administravit quae omnia negunt saltem plurima ex ijs qui contra sentiunt; tum quia decet ut Deus, qui in omnibus alijs res ceteras antecessat, antecessat etiam aeterna duratione; tum quia creatura melius cognoscit suam imbecillitatem cum per totam aeternitatem nihil fuerit, et melius cognoscit quantum a creatore dependeat, cum sola eius potestate ex nihilo eductam se videat, in nihilum mox reditura si ab eodem vel momento temporis duratur, ex quo ad cuiusdem creaturis sui timorem, amorem ac cultum maxime excitatur, ob quem finem mundum a Deo conditum esse constat. Unde Aristoteles 2 *Physicorum* 24: 'Sumus, inquit, et nos quodammodo finis omnium,' quia omnia sunt propter hominis felicitatem quae in Dei consecutione consistit; quare eo modo produci debuit quo magis ad id posset homines excitari; quod constat esse, si dicamus productum esse in tempore" (*ibid.*).

[50] "Secunda propositio: lumine naturali non solum quomodocumque cognosci potest mundum non fuisse aeternum, sed ita probari ut non melius in philosophia probentur multa quae censentur physico demonstrare. Patet haec propositio praesertim ex prima ex rationibus allatis propositione praecedenti" (*ibid.*).

> [*tali tempore*], neither before nor after. The second [statement] surely depends on the divine will, and therefore can be only known by revelation. It cannot be known demonstratively through natural reason, but it may be somehow inferred inductively from suppositions and histories. The first [statement] does not depend only on God's will. In fact, the world must have been created in time, for the production of the world from eternity implies contradiction.[51]

The problem raised by Vitelleschi is similar to the 'Why not sooner?' question addressed by Augustine. The latter argued that the question 'Why was the world not created sooner?' is devoid of sense, because the world begins *along with* time; thus there is no sooner or later in a situation that does without the world.[52] However, Richard Sorabji has argued that

> it is not quite true to say that we cannot make sense of the 'Why not sooner?' question. We can do so by thinking backwards from the present. Let us suppose for convenience that the solar system is as old as the universe and that both have lasted a million years. The 'Why not sooner?' question can then be put as the question: 'Why did not the universe begin a million and *one* years ago?' To bring this about, God would only need to have tacked on an extra revolution of the earth around the sun at the beginning of the series. To imagine him doing so is not to imagine extra time without extra change; on the contrary, the extra year would have involved an extra revolution of the earth. Why did none occur? Leibniz was to recognise in the eighteenth century that the question could be interpreted in this way.[53]

I believe that this interpretation can help us understand Vitelleschi's argument. The problem he raises can be put as the following questions: 'Why has some given time elapsed from the beginning of the world until now? Why not more? Why not less?' Vitelleschi argues that God's free will makes it impossible for us to provide a demonstrative answer to these questions. Some given time has elapsed until now because God wanted it to be so. At most, one can seek to determine the time of creation by inductive reasoning. That is, by proceeding from effect to cause, one can determine *when* the world was created by God; however, one cannot determine *why* a certain

[51] "Ad fundamentum autem primae sententiae respondeo: aliud esse mundum non fuisse ab aeterno sed productum in tempore; aliud fuisse productum tali tempore et non ante et post. Secundum omnino pendet ex divina voluntate et ideo relevante Deo cognoscitur. Lumine autem naturali demonstrative cognosci non potest, sed ex coniecturis et historijs aliqua ratione colligi. Primum vero non pendet a sola Dei voluntate, nam mundus produci debuit in tempore, ita ut implicet contraditionem fuisse productum ab aeterno" (Vitelleschi, ms. APUG, F.C. 392, f. 9*r*).

[52] Cf. *infra*, chapter IV, §16.

[53] Sorabji (1983), pp. 235-236. For the reference to Leibniz, see *ibid.*, pp. 79-80.

number of years have passed until now.

Unlike Aquinas, Vitelleschi is convinced that God's free decision to create the world *de novo* does not prevent us from *demonstrating* that the world did actually (*de facto*) have a beginning. The eternity of the world is contradictory; hence it would be absurd to deny that the world was created *de novo*. This *reductio ad absurdum* is enough, for Vitelleschi, to demonstrate that the world had a beginning.

In conclusion, it must be noted that Vitelleschi's 'anti-agnosticism' is not motivated by the bull *Apostolici regiminis*. The bull obliges Vitelleschi to refute the eternity of the world and show that the beginning of the world is within the range of natural reason. Vitelleschi's second proposition about the demonstrability of the beginning of the world is neither motivated by nor based on the *Apostolici regiminis*. Vitelleschi is convinced of its demonstrability because he takes the 'actual infinity of souls' argument to be irrefutable. It is not by chance, I think, that Vitelleschi avoids mentioning Aquinas's counterargument.[54]

§6.
Creatio de Novo in Galileo's *Juvenilia*

Today it is generally accepted that Galileo copied the *Juvenilia* from the *reportationes* of Roman College lectures. William Wallace carried out a series of extensive studies in support of this thesis, which made us also better acquainted with the Roman College milieu at Galileo's time. However, I am convinced that the connection between Roman College sources and Galileo's *Juvenilia*, albeit undeniable, must be problematized.

As I tried to show in a paper devoted to a small part of the *Juvenilia*, some of the expressions and arguments used in the *Juvenilia* are customary expressions and stock arguments filled with references to common loci. Thanks to best-selling Roman College textbooks, such as Christoph Clavius's commentary on Sacrobosco's *Sphere* and Benedictus Pererius's *De communibus omnium rerum naturalium princiis et affectionibus*, these expressions and arguments were made available to a wide audience composed also by non-Jesuit philosophers and professors of philosophy. In the *Juvenilia*, there is evidence that some sentences copied from Pererius's *De communibus* are used in a different sense than the original one. This writing technique is usually called *bricolage*, and we cannot in principle exclude that the very same technique was used, for instance, by Galileo's Pisan professors to prepare their lectures.[55]

[54] Cf. *S. th.*, I, q. 46, a. 2, ad 8.

[55] Cf. Malara (2019). On the use of the *bricolage* in the Middle Ages, see Calma (2011).

But what I wish to emphasize here is that, given the complexity of the context briefly outlined, we must consider that textual similarities between two texts may conceal a disagreement in the contents of the very same two texts.

Wallace focused chiefly on the textual agreement between the *Juvenilia* and the Roman College *reportationes*. In one of his papers on Galileo, after comparing a passage of the *Juvenilia* with another one from Vitelleschi's reportationes, Wallace wrote: "What is more striking about these parallels, of course, is that practically every authority and locus cited by Vitelleschi is also in Galileo, usually in abbreviated form."[56] Having drawn attention only to these striking parallels, Wallace did not notice some interesting contrast in their contents.

As regard the controversy on the demonstrability of *creatio de novo*, in the *Juvenilia* there is a proposition that stands in clear opposition to Vitelleschi's anti-agnosticism. The proposition states that, not only God could have created the world *de novo*, but He did actually (*de facto*) created it *de novo*.[57] A little bit further, we read that the second part of this proposition, "since it cannot be demonstrated" (*quandoquidem demonstrari non potest*), is confirmed (*probatur*) "by the authority of Holy Scripture and from the determination of the Lateran Council."[58] This is most likely a reference to the Fourth Lateran Council, which decreed that God "by His own omnipotent power at once from the beginning of time [*ab initio temporis*] created each creature from nothing…" As far as I know, the *Juvenilia* make no reference to the Fifth Lateran Council and the bull *Apostolici regiminis*. So, in a single proposition of the *Juvenilia* we can find a disagreement with the position held by Vitelleschi on the demonstrability of *creatio de novo*, and we can notice the striking absence of reference to the *Apostolici regiminis*, which is cited twice in Vitelleschi's *reportationes*.

Another important element to be considered when approaching the *Juvenilia*, is that there seems to be consistency in the opinions and the terminology used therein.[59] In the proposition cited above, it is said that it cannot be *demonstrated* (from the Latin *demonstro*) that the world had a beginning. However, that the world had a beginning is *confirmed* (from the Latin *probo*) by the authority of the Bible, by that of the fourth Lateran Council, as well as by arguments taken from history and from biblical chronology.[60] These and other arguments, however, are never regarded as

[56] Wallace (1981), p. 214.

[57] "Dico, 5°, hoc primum ens, increatum, infinitum et liberum, potuisse de novo creare mundum, et de facto creasse" (OG, I, *Juvenilia*, p. 26). Concerning the notion of *primum ens*, see *infra*, chapter V.

[58] "Probatur secunda pars conclusionis: primo, quandoquidem demonstrari non potest, authoritate Sacrae Scripturae et ex determonatione Concilii Lateranensis" (OG, I, *Juvenilia*, p. 26). English translation from Wallace (1977), p. 41.

[59] At least some parts of the *Juvenilia* are consistently arranged by readapting sentences taken from Pererius's *De communibus* (cf. Malara (2019)).

[60] "… [P]rimo, quandoquidem demonstrari non potest, authoritate Sacrae Scripturae et ex determonatione Concilii Lateranensis; 2°, quia sequeretur artes et disciplinas infinities ad nos pervenisse; at

demonstrative in the *Juvenilia*. In another part of the *Juvenilia*, creation in time ("*in tempore*") is supported by a series of arguments "which also somehow confirm [*probant etiam aliquo modo*] that the world could not have existed from eternity."[61] The use of *probant* instead of *demonstrant* is consistent with the opinion held before, namely, it cannot be demonstrated that the world is not eternal.

Now, in the current state of knowledge, the only certainty we have is that Galileo transcribed from another (or many other) source(s) what he wrote in his own hand in the *Juvenilia*.[62] This is however enough to regard the *Juvenilia* as a repertory of doctrines, issues, and arguments, that were somehow known to Galileo. Although there is no certainty about the composition year of the *Juvenilia*, they were surely written after 1581 and most likely before 1592.[63] This means that in 1607, when Galileo received Castelli's first letter from Cava, he already had a certain knowledge of the controversy on the demonstrability of *creatio de novo*. He was at least aware of the agnostic position.

hoc repugnat historiae; lege Aristotelem, 2° Met. c. 2.; siquidem scriptorum fide dignorum nemo inventus est, qui mundum ante sex mille annos affirmaret extitisse" (OG, I, *Juvenilia*, p. 26).

[61] "Dico, iam primo, mundum non fuisse ab aeterno, cum et Fides nostra hoc edoceat, quae factum esse in tempore docet. […] Probatur haec conclusio his rationibus, quae probant etiam aliquo modo, mundum non potuisse esse ab aeterno" (*ibid.*, pp. 35-36).

[62] Cf. Favaro's 'Avvertimento,' *ibid.*, pp. 10-13.

[63] Crombie and Carugo showed that in the *Juvenilia* there are passages from the second or third edition (cf. Lattis (1994), p. 231, nt. 9) of Clavius's *Sphere*, which was published in 1581 (cf. Carugo-Crombie (1983)). On the *terminus ad quem*, there is no agreement among historians (for a general overview on this problem, see Malara (2019), pp. 2-4). However, today it is generally assumed that the *Juvenilia* were written when Galileo was in Pisa.

III.
A REAPPRAISAL OF CASTELLI'S LETTER

§7.
CASTELLI *VERSUS* ARISTOTLE

The bull *Apostolici regiminis* compelled teachers of philosophy to defend the truth of faith, and "to apply themselves to the full extent of their energies to refuting and disposing of the philosophers' opposing arguments, since all refutations are available." Now, in 1607 Castelli was a teacher of mathematics at Cava. He would have never become, and probably never aspired to be, a professor of philosophy. However, in the first letter from Cava he argues *qua* natural philosopher against the arguments that Aristotle advanced in the beginning of the eighth book of *Physics* in support of the eternity of the world.

Aristotle's arguments are based on a particular idea of motion, broadly understood as a change, or passage, from potentiality to actuality. Aristotle argues that something can be set in motion only if it has the potentiality, i.e., the capacity, to reach a certain state of actuality. In other words, not all things can undergo all sorts of change. For instance, something burns (actuality) if it is capable of burning (potentiality). But there are things that cannot burn because they do not have the capacity for burning (e.g., water). If we limit our discourse to local motion, this means that something must have the capacity of undergoing local motion, that is, it must have the capacity of being moved in order to perform motion in actuality. Let us call *movable* something capable of motion, and *movability* its capacity. Aristotle argues that *movability* is not enough to perform motion, because motion is in actuality and therefore it must be triggered by something that is already in actuality. Something must cause the burning of an inanimate body capable of catching fire. In short, there must be a *mover* (in actuality) that moves the *movable*. Since the *mover* is by necessity a *movable*, it must be moved by another *mover*, and so forth *ad infinitum*; hence the world, being the realm of motion, is from eternity.[1]

[1] Cf. *Phys.*, VIII, 251a8 and ff. The difference between movable and mover is not terminologically evident in the original text. However, many commentators from antiquity till very recent times have highlighted it. For instance, Simplicius says that Aristotle assumed "that both the *movable* and the *mover* must pre-exist the motion…" (Simplicius (2012), p. 28, my emphasis). A similar distinction was used by David Ross in 1936: "The main argument used is to effect that (change being the realization of potentiality) if it is alleged that there was a first change, there must have existed, before it, something *capable of producing it* and *something capable of suffering it*…" (Ross (1936), p. 86, my emphasis). Here, it is important to notice that

But is it possible to argue, instead, that motion had a beginning? According to Aristotle, there may be two reasons to argue that motion had a beginning, although both of them are not viable. First of all, we can suppose that motion had a beginning, that is, it was generated. But generation is brought about by the motion and change of something that already exists. Hence the paradoxical conclusion is that something already existed and was already in motion before motion came to be. There is however another argument. We may suppose that things movable were *not* generated; instead, they have been existing from eternity. Then, we may also suppose that they have been at rest until a given time when they were suddenly set in motion. Against this argument, Aristotle argues that the definition of 'rest' is 'privation of motion'; this means that rest involves the existence of a previous state of motion. In conclusion, motion must be from eternity.[2]

Usually, the refutation of these arguments – which are regarded as parts of a single argument against the non-eternity of motion and world – rested on the main distinction between the production of something new, on the one hand, and the new production of the totality of existing things, on the other hand. That is, a difference between *generation* and *creatio de novo*. While generation requires motion, since it is a change of a preexisting subject, *creatio de novo* is instantaneous and *ex nihilo*, out of nothing. The principle 'nothing comes from nothing' (*ex nihilo nihil fit*) can be applied to generation, but it cannot apply to creation *de novo*. This conclusion appealed to the almighty power of God, who can create everything "neither through physical motion nor from a certain [pre-existing] subject" (*non per motum physicum et ex aliquo subiecto*).[3] Given that Aristotle did not contemplate the possibility of creation out of

Benedetto Castelli refers to this distinction in his letter to Galileo: "Supposto dunque da Aristotele che a principiar il moto è necessario che preceda l'esistenza del *movente* e *mobile*, segue dicendo: O questi sono fatti, o eterni…" (OG, X, *Castelli to Galileo*, 1 April 1607, p. 170, my emphasis).

[2] I believe the reader would also benefit a great deal from the clear summary provided by Michael Chase in his introduction to the English translation of Simplicius's commentary on the *Physics*: "Motion is the actuality (energeia or entelekheia) of what is movable insofar as it is movable. This, Aristotle claims, implies that before motion can take place, the things are either generated, or eternal. If generated, their existence must be preceded by the motion or change that generated them; if they are eternal, but were not *always* in motion, then they must have begun to move at a specific point in time, prior to which they were at rest. But if this is the case, since rest is the privation in motion, then while they were at rest there must have been some cause that kept them at rest. Aristotle's conclusion is that no matter whether the things capable of motion are generated or eternal, there is always a change or motion previous to any change or motion one chooses to consider. In this sense, the, motion is eternal" (Simplicius (2012), p. 6).

[3] "… [P]onitur ac sumitur [ab Aristotele], quasi certum et indubitatum, creationem esse omnino impossibilem, hoc est nullam rem ex nihilo fieri posse, omneque productionem cuiuslibet rei, vel esse motum, vel cum motu necessario coniunctam. Quod fundamentum, quam vitiosum et fragile, perspicuum est ex iis quae docuimus quinto libro huius operis, ubi de creatione disseruimus et multis argumentis probavimus, creationem non esse impossibilem. Quare supradicta tres rationes Aristotelis, quae tali fundamentum nituntur atque fulciuntur, infirmas esse necesse est. Nam et primam materiam, et primum mobile, et omnes coelos *de novo productos esse dicimus, non per motum physicum et ex aliquo subiecto*, ut

nothing, his arguments are biased: the eternity of the world cannot be demonstrated.[4]

Castelli probably knew this 'traditional' refutation. In his first letter from Cava there seem to be echoes of Jacopo Zabarella's commentary on the *Physics*, where Zabarella resorts to the traditional refutation of Aristotle's arguments.[5] These 'echoes' are rather feeble, and they cannot be taken as evidence that Castelli did directly or indirectly read Zabarella's commentary. For instance, Castelli resumes Aristotle's argument as though it was directed against an "adversary" (*avversario*), whereas Aristotle in the beginning of the eighth book of the *Physics* does not argue against a particular opponent.[6] Zabarella says in his commentary that Aristotle develops his argument against the objections that were raised by a supposed "adversary" (*adversarius*).[7] In Zabarella's exposition, the reference to Aristotle's "adversary" occurs often, and we cannot exclude that such a reference was customary.[8] Also, Castelli's Latin quotations

Aristoteles argumentatur, *sed per creationem ex nihilo*" (Pererius (1576), p. 466c-d, my emphasis).

[4] See, for instance, *Conimbricenses* (1602), pp. 436-437: "Haec [*viz.* rationes] aliaque esiusmodi, quae homines coelesti discipline, et fidei lumine destitutos in eum errorem induxerunt, ut putarint mundum non potuisse non esse ab aeterno, si humana ratio confutare nesciret, ad fidei regulam, ut ad tribunal veritatis provocare deberet. Sed potest humana ratio, et quidem facili negotio confutare, et diluere. Igitur ad primam rationem Aristotelis concessa maiori propositione dicendum: movens, quod non est Deus, verbu gratia intelligentiam, et mobilem, ut orbem coelestem, coepisse esse, non tamen per generationem et motum, sed per creationem, quae nec motum nec generationem praerequirit." The same refutation can be also found in the *reportationes* of Vitelleschi's lectures (cf. ms. APUG, F.C. 392, ff. 9r-v).

[5] "Ostendo igitur quod sine hoc principio [*viz.* ex nihilo nihil] demonstratio Aristotelis nil roboris habet, et haec est responsio, qua no pro Christiana fide uti *debemus* ad hoc Aristotelis argumentum, eamque ponit S. Thomas in prima parte summae queastione quadragesima sexta articulo primo. Quando enim quaerit Aristoteles si fuit primum initium motus motor et mobile suntne facta ad sunt aeterna? nos respondemus motorem quidem semper fuisse, et semper eodem modo se habuisse; sed mobile, nempe, universum mundum, esse factum a Deo. Cum autem Aristoteles argumentatur dicens: si factum, ergo per motum, nos negamus consequentiam, dicimus enim esse factum *a Deo in instanti, non per generationem, sed per creationem ex nihilo, quae quidem est sine motu*. Dum enim *confugimus* ad creationem ex nihilo, ratio Aristotelis nihil concludit, quamobrem si debet habere efficacitatem, necesse est praesupponere fundamentum hoc: ex nihilo nihil fit… sed eo negato, *ut nos negare debemus*, ratio Aristotelis corruit, et nihil habet efficacitatis… [A]pud nos est *articulus fidei, et principium indemonstrabile, Deum ex nihilo mundum creasse*" (Zabarella (1601), p. 108*r*, my emphasis). Zabarella's commentary on the *Physics* was published posthumously. Its anastatic reproduction is included in Zabarella (2009), edited by Marco Sgarbi.

[6] "Mi è poi occorso, a' giorni passati, sfogar un pensier mio circa la ragione d'Aristotele addotta per confirmar l'eternità del moto, la quale conclude esser stato il moto avanti il primo moto dell'*avversario*…" (OG, X, *Castelli to Galileo*, 1 April 1607, p. 170, my emphasis).

[7] "Primo loco breviter proferam ipsam Aristotelis rationem, deinde horum sex contextuum verba interpretabor, ubi eandem fusius explicabo, et explanabo; postmodum considerabo qualis haec ratio sit, quam habeat vim, et quam aeternitatem probet. Ratio talis est, supponit Aristoteles *adversarium* dicentem fuisse motum primum…" (Zabarella (1601), pp. 101*v*-102*r*, my emphasis).

[8] See, for instance, the following sentences, where I have emphasized the word '*adversarius*': "Sumendo primum non quidem primitate perfectionis, vel causalitatis, seu naturae, sic enim solus motus coeli dicitur primus, sed primitate originis, et temporis, ita ut nil aliud sit hoc in loco motus primus nisi initium universi motus, supponendo igitur *adversarium* dicentem fuisse aliquando motum primum ducit ipsum ad hanc contradictionem quod daretur motus prior primo. Ipsa autem deductio talis est, in primis supponit motum necessario pendere a mobili, et a motore, et sine his esse non posse, idqui dicit colligi ex definitione motus tradita in principio tertij libri Physicorum, immo, et clarum per se esse sine definitione motus quod motus

(“*si facta… ergo per motum*”) supposedly taken from Aristotle’s *Physics*, cannot be found in the two most used Latin translations made by William of Moerbeke and John Argyropoulos.[9] Yet, they can be found in Zabarella’s commentary.[10] Obviously, this is not enough to say that Zabarella’s commentary is the source of Castelli’s letter. However, it may be that Castelli’s reading of Aristotle’s *Physics* was to a certain degree influenced by commentaries and textbooks.[11]

At any rate, Castelli puts forth an ‘untraditional’ refutation of Aristotle’s argument for eternity. It is untraditional in that it does not leverage on the almighty power of God, who creates everything out of nothing.

Zabarella, for instance, says that Aristotle’s argument is grounded in the principle ‘nothing comes from nothing.’ But this principle *must* be denied, he says, because we know by faith that God created the world out of nothing. Thanks to revelation, then, we can say that Aristotle was wrong; *otherwise*, his argument for the eternity of the world is as secure as the principle on which it rests, namely nothing comes from nothing, which is undeniable in natural philosophy.[12]

Castelli does not follow this line of reasoning. Instead, he seeks to show that Aristotle’s argument, even if based on the *ex nihilo nihil* principle, is a paralogism – or, as he calls it, a “*consequenza stroppiata*.”[13] To this end, he also resorts to Galileo’s new definition of motion. Castelli does even say that it was *because* of Galileo’s definition of motion that he realized it was possible to refute Aristotle’s argument for the

supponit motorem et mobile. Fundamentum hoc iacit Aristoteles in contextu quarto, deinde in quinto quaerit, cum motum supponat mobile, et motorem, et per *adversarium* fuerit motus primus, an motor ille, et illud mobile sint facta, seu ambo, seu alterum ipsorum” (*ibid.*, p. 102*r*); “[N]on enim ex sola definitione motus supponit mobile esse prius tempore motu, sed ex ea simul cum positione *adversarij*. *Adversarius* autem afferebat motum omnino esse novum, et caepisse, quare apud eum nullus datur motus aeternus” (*ibid.*, p. 103*r*); “Iacto illo fundamento quod motus requirit motorem, et mobile, Aristoteles hic incipit argumentari, et supponens *adversarium* dicentem incaepisse omnino motum, quaerit ab eo an motor, et mobile sint facta, an sint aeterna, ut exutrolibet dato ostendat fuisse motum priorem primo motu, quae est implicatio contraditionis” (*ibid.*). For other examples, see *ibid.*, pp. 103*v*, 105*r*, 106*v*-107*r*.

[9] It must be noted, however, that Renaissance commentators of Aristotle used to modify at their discretion the Latin translations of Aristotle’s texts.

[10] “Dubitari hic posset adversus illam consequentiam Aristotelis, *si facta, ergo per motum* […]. Cum autem Aristoteles argumentatur dicens: *si facta, ergo per motum…*” (Zabarella (1601), pp. 103*v*, 108*r*, my emphasis).

[11] Schmitt (1988) remains a valuable source on the importance of commentaries and textbooks in the Renaissance.

[12] “Ostendo igitur quod *sine hoc principio* demonstratio Aristotelis nil roboris habet, et haec est responsio, qua nos pro Christiana fide uti *debemus* ad hoc Aristotelis argumentum…” (Zabarella (1601), p. 108*r*, my emphasis).

[13] “Che questa sia una *consequenza stroppiata*, io lo provo…” (OG, X, *Castelli to Galileo*, 1 April 1607, p. 170, my emphasis).

eternity of motion. This is why he sent a copy of his refutation to Galileo: to know whether Galileo considered his refutation to be partially or even totally off mark.[14]

First of all, Castelli lays out two "lemmas" that according to him are "true not only in themselves, but also in the very same doctrine of Aristotle" (*verissimi non solo per sé, ma nella dottrina istessa di Aristotele*)[15]:

1. if the totality of things – namely the world or universe – is made, it cannot be made by means of movement ("*se il tutto si facesse, sarebbe impossibile farsi con moto*");
2. if the totality of things is made, it is made out of nothing ("s*e il tutto si facesse, si farebbe di niente*").

The first lemma is confirmed by Galileo's definition of motion. Castelli argues that, since motion is a change with respect to something else, it would be impossible to find something with respect to which the totality of things began to move. For if there is nothing other than the totality of things, then there can be no motion at all. Hence, if the universe was made, it was *not* made by means of movement.[16] From this argument, it seems that for Castelli the total absence of *relata* takes away the necessary condition for the *existence* – not only the individuation – of motion and rest, which are therefore *ontologically* understood as relative states.

As regarding the second lemma, it must be recalled that in the Renaissance a long-debated controversy was unsettled as to whether Aristotle used the *ex nihilo nihil* principle in his argument for the eternity of the world. For instance, as we have seen Zabarella claims that Aristotle used this principle. When Zabarella says this, he does it to clarify his position with respect to that of Aquinas. Zabarella's argument is that Aristotle must have used the *ex nihilo nihil* principle, for otherwise his argument would have had no efficacy whatsoever (*nihil habet efficacitatis*).[17]

[14] "Mi è poi occorso, a' giorni passati, sfogare un pensier mio circa la ragione d'Aristotele addotta per confirmar l'eternità del moto [...]; e perché a questo m'indusse la definitione del moto dattami da V.S., cioè che il moto non sia altro che una mutatione di una cosa in relatione a un'altra, ho fatto disegno, come si sia, mandarne copia a V.S., acciò, se ci è bisogno di anullatione o di corretione, si degni compiacermene" (*ibid.*).

[15] "Che uesta sia una consequentia stroppiata, io lo provo, proposti prima e confirmati doi lemmi, verissimi non solo da sé, ma nella dottrina istessa d'Aristotile. Il primo è, che se il tutto si facesse, saria impossibi[le] a farsi con moto. [...] Il secondo è, che non sarebbe un assurdo quello che per tale si va predicando da' Peripatetici, che se il tutto si facesse, si farebbe di niente..." (*ibid.*).

[16] "La ragione è, perché ricercandosi, per la definitione del moto, qualche cosa a rispetto della quale si faccia la mutatione, et essendo da noi proposta la produttion del tutto, niente si ritrova: adonque non si fa con moto, che era il proposito nostro" (*ibid.*).

[17] "Ad hoc Simplicius, et alij respondent concedendo non usum esse Aristotelem hoc fundamento, quoniam (dicunt) maluit uti principijs proprijs, quam principio illo nimis communi, ideo uti voluit

Castelli, too, assumes that Aristotle used this principle. However, as I said, unlike Zabarella Castelli seeks to show that even the *ex nihilo nihil* principle cannot rescue Aristotle's argument. Castelli reasons more or less as follows: a thing is made out of something else; there cannot be anything else other than the totality of all existing things; hence, if the totality of all existing things, namely the universe, was made (thereby leaving aside the hypothesis that it was not made), it must have been made out of nothing. From this conclusion, which appeals to the *ex nihilo nihil* principle used by Aristotle, Castelli derives a further conclusion: "the axiom *ex nihilo nihil* must be understood and by necessity restricted (if it is a true axiom) as pertaining to the production of particular things, not to the production of the totality of things (if the totality [of all existing things] were made)" (*l'axioma Ex nihilo nihil va inteso e limitato a forza (se però have spetie di verità) alle prodottioni particolari, non a quella del tutto (se si facesse)*).[18] Castelli does neither claim that the principle *ex nihilo nihil* is true, nor he argues that the universe was actually made. He just argues that *if* one assumes the first to be true, then one must also conclude that *if* the universe was made, it was made out of nothing.

Here lies the core of Castelli's argument against Aristotle. On the one hand, Aristotle is willing to assume (*dona*) the hypothesis that the universe was made (*si facta*); on the other hand, he is not willing to concede (*non concede*) the logical consequences of this assumption, that is, if the universe was made, it was made without motion and out of nothing. Instead, Aristotle *arbitrarily* concludes that if the universe was made, it was made just like its parts are made, that is, through motion and out of something else; hence, the production of the universe must be traced back to eternity. But according to Castelli this conclusion is erroneous, because when Aristotle accepts the first premise (*si facta*), then he can no longer say (*si tronca la strada*) that the

definitione motus, ut principio proprio, et ex natura motus demonstrare motus aeternitatem. Sed horum sententia mihi non probatur. Errasse enim Ioannem, et hos omne puto, dum opinati sunt Aristotelem eo principio usum non esse. Cum potius ratio haec ita ex hoc principio pendeat ut eo sublato omnino corruat. Non enim quod Aristoteles hoc principium non exprimat dicendum est quod eo prinipio non utatur, siquidem principiorum communium is ferquentissimus est usus, *ut sine expressione ipsis innitantur demonstrationes, et sine his nullam habeant efficacitatem.* Ostendo igitur quod *sine hoc principio demonstratio Aristotelis nil roboris habet*, et haec est responsio, qua nos pro Christiana fide uti debemus ad hoc Aristotelis argumentum, eamque ponit S. Thomas in prima parte summae quaestione quadragesima sexta articulo primo… *Admonere autem hic volo me hac in re non omnino Divo Thomae assentire*, quod enim dicat rationem Aristotelis ita solvi, id quidem verissime dicitur, sed quod haec fuerit Aristotelis mens, nempe, quod de creatione cognoverit, quod fieri possit ex nihilo, et de sola generatione dixerit quod nihil potest ex nihilo fieri; hoc quidem ego nullo modo sentio, sed *credo Aristotelem negasse omnem productionem ex nihilo, neque cognovisse creationem, siquidem non sit Christianus, quando igitur utitur hoc principio ex nihilo nihil fit, puto ipsum semper intelligere id universaliter verum esse, ita ut nulla detur productio nisi ex praesupposita materia, hoc enim ita consituto valida est consequentia haec, factum, ergo per motum, sed eo negato, ut nos negare debemus, ratio Aristotelis corruit, et nihil habet efficacitatis*" (Zabarella (1601), p. 108*r*, my emphasis).

[18] Cf. OG, X, *Castelli to Galileo*, 1 April 1607, p. 170, ll. 35-40.

universe was made through motion (*per motum*) or out of something else.[19] Eventually, Aristotle seems to argue that if A, then not-A; yet Aristotle himself would agree that this is not possible (cf. *An. Pr.*, 57b14).

In my view, Castelli's letter contains an implicit criticism of Aristotle's (and the Aristotelians') abuse of the principle *eadem est ratio totius et partium*. Just as Galileo would do in his *Dialogue on The Two Chief World Systems* (1632), Castelli too tries in his first letter from Cava to unfold Aristotle's paralogisms. Also, he tries to do it within the purview of natural philosophy, without appealing to God's omnipotence. This attempt, as we have seen, does also leverage on the new definition of motion provided by Galileo. In light of this, we can see that Castelli's refutation of Aristotle's arguments for the eternity of motion does not stem from a pious attempt to defend the truth of faith, as disposed by the bull *Apostolici regiminis*. Castelli's refutation is motivated by the attempt to show that Aristotle was *philosophically* wrong.

§8.
Castelli's Agnosticism

Castelli's letter has another goal: to prevent Galileo's doctrine of motion from being used to demonstrate that the world was created *de novo*. We can realize that this is not an awkward objective for a Benedictine, as soon as we understand that it is motivated by almost the same reasons underlying Aquinas's agnosticism. I said 'almost' because I think that epistemological reasons play a major role in Castelli's agnosticism. Castelli does not justify his agnosticism by appealing to God's free will; rather, he argues that the principles of natural philosophy, such as *ex nihilo nihil*, have a limited range of application, such that they cannot help us understand whether the world had a beginning or not.

Also, Castelli is convinced that the study of natural phenomena does not provide any evidence that can put us in the condition to solve the issue on the eternity or beginning of the world. After having refuted Aristotle's argument for the eternity of the world, Castelli states his agnostic conviction as follows:

> Neither do I say that [the world] is made, nor that it is not made; [I only say] that its progress does not make me gain any knowledge [in this regard].

[19] "Hora, come può inferire quest'huomo da bene: Se sono fatti, adonque per moto? Non vede egli che, mentre mi dona, non concede, questo passo *si facta*, che imediate da sé stesso si tronca la strada, come nel primo lemma, di poter dire: *ergo per motum*?" (*ibid.*, ll. 40-45).

> *Io non dico né che sia fatto né che non sia fatto, ma che il progresso suo non mi fa guadagnar niente.*[20]

This is a clear agnostic statement with regard to the demonstrability of the beginning of the world. It is also clear that Castelli does not want to exceed the boundaries of natural philosophy. In his letter, there is no trace of any attempt to show the superiority of Galileo's doctrine of motion from a metaphysical and theological standpoint.[21] Castelli writes *as* a natural philosopher *against* a natural philosopher (Aristotle) and *to* another natural philosopher (Galileo). His agnosticism is the agnosticism of a natural philosopher.

However, this does not mean that Castelli does not worry about the perils for religion that may come from using Galileo's doctrine of motion to solve metaphysical-theological issues, such as God's existence and *creatio de novo*. Just like Aquinas warned against the demonstrability of *creatio de novo*,

> lest anyone, presuming to demonstrate what is of faith, should bring forward reasons that are not cogent, *so as to give occasion to unbelievers to laugh, thinking that on such grounds we believe things that are of faith*,[22]

so too Castelli reminds Galileo about the ridiculousness of those who used his science to demonstrate a truth of faith:

> from the doctrine of Your Lordship that a motive cause is necessary to start the motion, but the lack of obstacles is sufficient to continue it, *it makes me want to laugh* [*mi vien da ridere*] when they magnify such a doctrine as though it made the existence of God known to me. So, *if it is true that motion is eternal, then I could begin to be atheistic and say that we don't need God – what a wicked blasphemy!*[23]

[20] *Ibid.*, ll. 45-47.

[21] In this regard, my interpretation does clearly depart – and not a little – from that advanced by Massimo Bucciantini (cf. *supra*, §3).

[22] Cited *supra*, §4.

[23] Already cited *supra*, §3. For the sake of clarity, I cite again the passage in its original version: "Dalla dottrina di V.S., che a principiar il moto è ben necessario il movente, ma a continuarlo basta il non haver contrasto, mi vien da ridere quando esaltano questa dottrina come quella che mi faccia venir nella cognitione dell'esistentia di Dio; consciosiacosaché se fusse vero che il moto fosse eterno, io potrei doventar ateista e dire che di Dio non havemo bisogno, bestemia scelerata."

Castelli laughs, *as a theologian*, at the attempt of demonstrating God's existence by appealing to Galileo's doctrine of motion, also because he knows, *as a natural philosopher*, that this attempt is doomed from the start.

§9.
CASTELLI ON THE ETERNITY OF THE WORLD AND GOD'S EXISTENCE

To my mind, Benedetto Castelli's letter to Galileo is an example of painstaking rigor in the treatment of two different problems whose conciliation and solution were pursued by some unknown enthusiasts of Galileo's doctrine of motion. First, the controversy on the eternity of the world. Can it be demonstrated *naturali lumine* that the world had a beginning? Second, God's existence. Is it possible to prove that God exists?

If we are to place faith in the account provided by Castelli in his letter – unfortunately the only one that has come down to us –, the unknown 'enthusiasts' of Galileo's doctrine of motion sought to derive God's existence by arguing that the world must have had a beginning. Their reasoning was more or less the following: given that motion can go on eternally if not impeded ("*a continuarlo basta il non aver contrasto*"), and given that this happens only *after* motion is triggered ("*a principiar il moto è ben necessario il movente*"), then motion, as well as the world, must have had *a beginning*. From this, in turn, God's existence is proven, for nothing but God could trigger the first motion.

This argument does not hold water in many respects. Castelli was too learned and clever not to notice it. For instance, can it be truly argued that, from the fact that "a motive cause [*movente*] is necessary to start the motion," the motive cause must be God? What stops one from postulating different motive causes for different motions? Furthermore, a motive cause might have been set in motion by another one, and so forth endlessly. In this case, motion would not have a beginning.

The infinite regress of motive causes was traditionally avoided by pointing out that God is the only mover that is not moved by something else.[24] A definition that makes sense when read after the Aristotelian principle '*omne quod movetur ab alio movetur*.'[25] But holding that 'everything moved is moved by something else' is not the same as saying that everything requires an *initial* trigger to be set in (perpetual) motion. The Aristotelian principle can indeed be used to prove the existence of the

[24] Cf. *Phys.* VIII, 5, 256a13-21.

[25] Cf. *Phys.* VIII, 4, 255b31-256a3. On the reception of this principle in scholastic natural philosophy, see Maier (1982), pp. 42-43, 52-53.

primum movens regardless of the duration of the world. This is not the case for the principle derived from Galileo's doctrine of motion. In order to avoid an infinite regress of motive causes, the unknown enthusiasts of Galileo's doctrine would in fact be obliged to postulate the existence of a *temporally first* mover. And their argument would then be circular, for it would imply what was to be demonstrated, namely, God's existence.[26]

Also, provided that the point of departure is Galileo's doctrine of motion, we must assume that motion is no longer thought of within an *act-potency* framework.[27] This makes the proof of God's existence reported and criticized by Castelli differ much from Aquinas's *prima via* and from Aristotle's argument for the *primum movens* included in the *Physics* and *Metaphysics*.[28] Traditionally, the argument *ex parte motus* of God's existence does not imply that motion had a beginning. It simply assumes as a fact that the motion of something is caused by something else in state of actuality. This assumption remains valid regardless of the eternity or beginning of motion.

On the contrary, when motion is exclusively thought of within a 'Euclidean' *space-time* framework, disregarding any reference to act and potency, the first mover becomes literally the *first* in time. Hence, what is now in motion, the world, was *once* set in motion. From this standpoint, it is difficult to elude the objections raised above without slipping into a circular reasoning.

It is however noteworthy that the effort made by the unknown enthusiasts of Galileo's mechanics aimed at proving the existence, not only of God, but especially of the God that gave *beginning* to the world – or, at least, the world's motion. Although the attempt of demonstrating this view of God is not original, the originality of the argument put forth by the unknown enthusiasts lies in the fact that they appeal to

[26] For the same reason, I do not think it possible to successfully translate an Aristotelian-based demonstration of the *primum movens* into modern terms. Perhaps, Rudi te Velde's attempt to defend Aquinas's *prima via* is the most effective in this regard. Te Velde argues – in disagreement with Anneliese Maier's reading – that the principle '*omne quod movetur ab alio movetur*' has an ontological significance which can be generalized as follows: "the act of being-in-motion of corporeal natures is essentially reactive." In this form, the principle could also be applied to the theory of inertia. In fact, "[t]he central idea underlying the theory of inertia is that material bodies act in accordance with the necessities of the physical forces they undergo." Te Velde can therefore conclude that, even from the standpoint of classical mechanics, "the existence of motion cannot receive its ultimate explanation within the realm of nature" (te Velde (2006), p. 59). However, this conclusion is not as compelling as Aquinas's *prima via* (what prevent one from supposing that one day that "ultimate explanation within the realm of nature" will be discovered?). And, to my mind, this is due to the fact that te Velde achieves his conclusion at the expenses of a rigorous Aristotelian understanding of the principle *omne quod movetur ab alio movetur*.

[27] This also separates Galileo's notions of gravity from those of the Aristotelians (cf. *infra*, chapters VIII and IX). For now, see Dollo (2003), pp. 118-119.

[28] Cf. *S. th.* I, q.2, a.3; *Phys.* VIII, 4-5; *Met.* XII, 6-8. For a recent introduction to Aquinas's *prima via* and an interesting discussion on the notions of act and potency therein included, see te Velde (2006), pp. 48-63. Of course, the bibliography on Aquinas's proof *ex parte motus* is immense. Here I limit myself to indicate those (standard) works that I have read with profit: Gilson (2015), pp. 67-76; Owens (1966), pp. 132-137; Van Steenberghen (1980), pp. 113-122, 165-180 (249-258 are also beneficial); Wippel (2000), pp. 444-459.

Galileo's doctrine of motion. This made their demonstration a somewhat new attempt in history to demonstrate God's existence.

At any rate, Castelli does not bother pointing out the contradictions involved in their demonstration. His strategy is simple, although difficult to grasp. Simple, because it consists in showing that the two questions of the eternity of the world and God's existence cannot be treated as one and the same. It is impossible to answer the question on God's existence by solving the controversy on the duration of the world, or more specifically, of motion. In Castelli's view, one cannot afford to merge the two problems because there can be no demonstrative answer to the issue of the duration of motion. At least from the standpoint of natural philosophy, this question is unsolvable. It is true, Aristotle's argument for the eternity of motion is not cogent, and it can be also refuted thanks to Galileo's new doctrine of motion. But this same doctrine is not capable of determining whether motion had a beginning or not, let alone the world. How, then, can one even dare to rest God's existence on an assumption, the beginning of motion, which is not subject to demonstration?

But this is not all. The difficult part of Castelli's letter is that Castelli also resorts to a counterfactual reasoning: what if tomorrow we will be able to demonstrate that motion is eternal? This question is counterfactual for two reasons: (1) because a Christian thinker like Castelli holds by faith that the world was *de facto* created by God at the beginning of time; (2) because in the letter Castelli has established the impossibility of demonstrating whether motion had a beginning or not. However, Castelli imagines what would happen if motion were demonstrated to be eternal: would the eternity of motion and of the world be a compelling reason to become "atheistic"? Obviously not! According to Castelli – and this important – the eternity of motion does not provide any reason to become "atheistic," *unless one's faith in God's existence is grounded in a fallacious proof of the beginning of the world*. For this reason, Castelli laughs at the enthusiasts of Galileo's mechanics who used the latter to prove God's existence by showing that motion had a beginning. Indeed, they run the risk of endangering the truths of faith on the basis of sophisms, as already pointed out by Maimonides and Aquinas (cf. §4).

In my view, the misunderstanding of Castelli's counterfactual reasoning has led Pietro Redondi astray in his interpretation of Castelli's letter. According to Redondi, in 1607 Castelli was not "as ingenious a theologian as Descartes to postulate inertia on the immovability of God."[29] In other words, Castelli lacked ingenuity to ground the idea of eternal motion in God. The conclusion is that "Castelli had only his faith to rely on when he reminded Galileo at the end of his letter that, 'if it is true

[29] Redondi (1998), p. 182.

that motion is eternal, I could begin to be atheistic (*ateista*) and say that we don't need God. What a wicked blasphemy!'"[30] Thus, a religious belief prevented Castelli from regarding eternal motion as possible. Redondi is therefore convinced that Castelli states that, if motion is eternal, then one must do away with God. That is, for Castelli the eternity of motion necessarily leads to blasphemy.

But this is not Castelli's reasoning. On the contrary, this interpretation reverses Castelli's attempt to maintain a separation between, one the one hand, his arguments developed as a natural philosopher, and, on the other hand, his faith in God and the beginning of the world. What Castelli regards as pitiful is to think that God's existence can be grounded in arguments that appeal to the beginning of motion. If believers rest their faith on such a fallacious proof, they can become "atheistic" once this proof falls short of demonstration. The point, for Castelli, is that the belief in God must hold independently of any reasoning involving the duration of motion. Because of this, it would be ridiculous to ground God's existence in the uncompelling argument put forth by certain enthusiasts of Galileo's doctrine of motion. Unlike Descartes, Castelli's aim is to draw a neat separation between the purview of science, on the one hand, and that of metaphysics and theology, on the other, with respect to a precise problem, which is that of creation. By so doing, he also attempts to secure Galileo's science from a conflict with religion.

So, I believe that Redondi's interpretation conceals an essential feature of Castelli's letter: Castelli's warning to Galileo is an expression of great philosophical concern about the use of the new science of motion in matters of faith. It is also an example of rigor (performed by a clergyman!) at maintaining separated the two ambits of natural philosophy or science, on the one hand, and faith, metaphysics, and theology, on the other hand. Great emphasis must be laid on these points, lest risking to endorse a misguided reading of Castelli's letter.

It may be that one of the assumptions behind Redondi's interpretation is that Castelli's faith in God is one with the belief that the world, therefore motion, had a beginning.[31] But in my view this assumption cannot help us understand Castelli's letter. First of all, in his letter Castelli carefully avoids *as a natural philosopher* to take a definite position on the duration of the world, as he holds that the issue cannot be solved in natural philosophy. Secondly, it is true that Castelli is convinced *as a believer* that 'the world had a beginning,' but for him this is a factual statement that

[30] *Ibid.*

[31] Cf. *ibid.*, p. 192: "But to Castelli's mind, wouldn't a divine, first mechanical action of the universe imply the impious idea of an eternity of motion?"

nonetheless cannot be demonstrated.[32] For these reasons, the belief in a beginning cannot be used to infer God's existence. As a result, if God's existence is not grounded in the beginning of motion, *a fortiori* the eternity of motion cannot be used to disprove God's existence. So, even in a counterfactual situation, where it is demonstrated that motion is eternal, there would be no reason for a believer to become atheist. Besides, there would be no reason to stop thinking of God as the creator of the world. This last point can be clarified by drawing the difference – that I shall show to be also present to Renaissance natural philosophers, and to Galileo himself (§20-21) – between *creatio de novo* and *creatio ex nihilo*.

§10.
GALILEO'S RECEPTION OF CASTELLI'S LETTER

Castelli's first letter from Cava has received scarce attention in the secondary literature on Galileo. It is usually mentioned to show that in 1607 Galileo was already arguing for an inertia-like principle. Only a few scholars have attempted to shed light on the general meaning of Castelli's arguments in his first letter from Cava. Yet they did it almost *en passant* while they were dealing with other important historiographical issues. So, I believe that the flaws in their interpretations are attributable to a more than understandable negligence of the wider historical and philosophical context in which Castelli's letter must be placed. I am also convinced that the *Juvenilia* and other writings alike (such as the *reportationes* of Muzio Vitelleschi's lectures) are incredibly useful to get a first and rough understanding of that context. Furthermore, the *Juvenilia* are useful to understand to what extent Galileo was familiar with that context. This, in turn, may give us some clue about Galileo's reception of Castelli's letter.

Although there is no certainty that Galileo replied to Castelli, there are good reasons to believe that he did it (cf. §2). In any case, he must have read Castelli's letter, and now we are in a better position to guess what Galileo might have thought while

[32] This particular case has not been taken into account by Marcello Pera's assessment on the logic behind the conflicts between faith and science (cf. Pera (1998)). I agree that, as Pera argues, for Galileo the "independence principle" (*ibid.*, p. 367) – namely "science and religion belong to, and are competent on, two distinct and different domains: the factual domain of natural phenomena and the domain of faith of supernatural phenomena" – is what prevents a scientist from touching upon "supernatural phenomena." Yet Pera did not consider that the thesis "the world had a temporal beginning" can be regarded as something actually occurred in the past that nonetheless is indemonstrable in the "factual domain of natural phenomena." Thus, the problem as to whether the world had a beginning in time must therefore be left to the consideration of theologians. Also, Pera's claim that "[i]f God created the universe, then the universe has not always existed, for in such a case there would be no need to create it," (*ibid.*, p. 381) is based on an ahistorical understanding of creation that does not consider the difference between *creatio de novo* and *creatio ex nihilo*, a difference that has been at play at least since the time of Aquinas (cf. *infra*, chapter IV and V).

reading it. He most likely did not fail to recognize Castelli's agnostic view as regarding the demonstrability of *creatio de novo*, since he had once transcribed some pages that refer to the same opinion (cf. §6). Probably, he appreciated the arguments raised by Castelli against Aristotle's proof of eternity in that they highlight a more general and recurrent flaw in reasoning from the parts to the whole. Perhaps Galileo even enjoyed Castelli's cunning use of his definition of motion to show that, if one assumes the creation or production of the universe to be possible, one must also assume that such a production would not respond to the same logic governing the production of the universe's parts. It may be that Galileo was not surprised to hear that some persons were using his "doctrine of motion" to prove that the world had a beginning in time and that God exists (cf. §3). Also, it is likely that Galileo grasped the importance of Castelli's warning: the emergence of any kind of conflict between the new science and the truths of Christian religion must be avoided from the start. Galileo probably agreed with Castelli and realized that the new science was in danger of becoming as ridiculous as the supporters of it who clumsily sought to demonstrate God's existence.

We now have enough elements to resume the fictional narrative with which our inquiry into Castelli's letter began. We can imagine that when Galileo opens and reads the letter, he is truly relieved to see that Castelli is doing fine at Cava de' Tirreni. He has been waiting for news from Castelli since a while. Now he finally knows that his disciple lectures on Euclid and keeps devoting himself, though with some difficulty, to plane and solid geometry. The heavy expression Galileo had a moment ago, when he was working on his defense against Capra's charges, has now disappeared. He smiles and nods while his eyes run through his friend's letter. It is a pity that it is so short, he thinks. Then he looks outside through the window, the letter still in his hands. Springtime. The grapevines are growing nicely. Galileo whispers something to himself, as though this helps him fix it in his mind. He must remember to address his reply to Ermagora Basadelli.

IV.
INTERMEZZO ON *CREATIO EX NIHILO*

§11.
Creatio ex Nihilo and Early Modern Science

In the opening section of the volume *Creation and the God of Abraham*, Carlo Cogliati makes some important "introductory remarks."[1] One of his remarks unfolds with great clarity the misunderstanding affecting the fierce quarrel between creationists and evolutionists. This misunderstanding originated long time ago. Something went wrong, Cogliati says, from the "early modern period" onwards, when the metaphysical tenets of the *creatio ex nihilo* doctrine were abandoned to be replaced by those emerging within a philosophical current more attentive to the empirical realm:

> The doctrine was largely taken for granted until the early modern period, when it became simply ignored or misunderstood by both scientists and philosophers, as theologians shied away from metaphysics in order to align themselves with empirical science.[2]

Not only natural philosophers, but even theologians influenced by early modern science, started to disregard the metaphysical significance of *creatio ex nihilo*. They forgot that "creation accounts for the existence of things, not for the beginning of things."[3] In short, they assimilated improperly *creatio ex nihilo* with *creatio de novo*. This unpleasant misunderstanding has been dragged to the present day, causing a great deal of damage and pain in the dialogue between faith and science, and compromising their relationship.[4]

Cogliati's account is clear and simple, just as a general introduction to a complex theme is supposed to be. It suits extremely well the context and purposes for which it was written, and it is not my intention to criticize his contribution. Nor do I want to deny weight to the misunderstanding that he wisely puts at the heart of

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[1] Cf. Cogliati (2010), pp. 7-10.

[2] *Ibid.*, p. 8.

[3] *Ibid.*, pp. 9-10.

[4] However, Cogliati believes that "[s]uch a contrast can be overcome if we integrate the insights of *creatio ex nihilo* with our scientific understanding of life." (*ibid.*, p. 9).

quarrels that, as such, are inevitably flawed.[5] I just think it is important to prevent another misunderstanding that Cogliati's contribution might somehow elicit, namely, that early modern science is after all to be blamed for perverting the original doctrine of *creatio ex nihilo*.[6]

To this end, the broad objective of this and the following chapter is to show that: (*a*) the Christian doctrine of *creatio ex nihilo* started out as a statement also involving *creatio de novo*, and in order to defend a certain idea of God against other philosophical views (§12-15); (*b*) Augustine and Boethius provided the conceptual tools to rethink time from an ontological standpoint, thereby laying the groundwork for a rethinking of *creatio ex nihilo* detached from *creatio de novo* (§16-17); (*c*) the conceptual separation between *creatio ex nihilo* and *de novo* comes out as a strong and well-defined metaphysical stance only in the Middle Ages, especially thanks to Thomas Aquinas (§18-19); (*d*) Galileo was aware of the metaphysical subtleties involved in the notion of *creatio ex nihilo* as distinguished from *creatio de novo* (§21).

All this will serve to advance another thesis (§22): Galileo's avoidance to touch upon the problem of creation was brought about by a *conscious* choice. A choice that stemmed from a particular epistemological view, and that was to some degree invigorated by Castelli and other acquaintances of Galileo. The choice – most likely matured when nothing of Galileo's science was published – was to leave outside the reach of natural philosophy the creation problem insofar as it relates to theology and requires a certain metaphysical approach.

This removal should not be taken for granted at Galileo's time. As pointed out by Gary Hatfield, it is naïve and somewhat anachronistic to inquiry into the metaphysical foundations of modern science – to say it *à la* Edwin A. Burtt – without wondering as to what was actually regarded as 'metaphysical' in the modern age.[7] Now, was God's creation regarded as a metaphysical problem at Galileo's time? If yes, did God's creation fall within the problems that a natural philosopher was trained and therefore also supposed to touch upon?

I fear that there may not be a univocal answer to these questions. For this reason, it is imperative to broaden our knowledge of specific problems while at the same time contextualizing single cases.

If the specific problem has to do with creation understood as *creatio de novo*, we have already seen (§4-10) that there were different lines of thought which

[5] I fear, though, that there is more at stake. *Creatio ex nihilo* has little to do with the creation of man, and it can hardly relate to the debate on natural selection.

[6] It seems to me, however, that Cogliati does not mean to make such a point.

[7] Cf. Hatfield (1990), p. 94, where his view is explicitly pitted against that of Burtt (cf. Burtt (1932), pp. 11-22, 226): "The central difficulty with following Burtt's Collingwoodesque approach, lies not in the failure to discover unity, but in the fact that such an approach is blind to the types of intellectual activity actually recognized as constituting metaphysics in the sixteenth and seventeenth centuries."

developed within the Middle Ages and reached out to the Renaissance. Unlike Muzio Vitelleschi, Castelli warned Galileo that it is not in the power of the natural philosopher to determine whether the world had a beginning or not. By so doing, he drew a precise demarcation of the scope of Galileo's new doctrine of motion with respect to a theological problem.

On the other hand, if the specific problem has to do with *creatio ex nihilo*, and if our focus is to be kept on Galileo, we should at least attempt to get roughly acquainted with the development of this notion up to Galileo's time and milieu. This is what I shall try to do in this chapter.

But first, the inquiry into *creatio ex nihilo* can be already addressed from the angle of the controversy on the principle *ex nihilo nihil*, which was considered in the third chapter (§7). There, I attempted to highlight the peculiarity of Castelli's position by contrast with that of Zabarella. The latter held that the validity of the adage 'nothing comes from nothing' cannot be denied in natural philosophy. Therefore, revelation aside, Aristotle's demonstration of the eternity of the world in the eighth book of the *Physics* is valid. This is true because according to Zabarella – who on this point disagrees with Aquinas – Aristotle's demonstration rests on an undeniable principle in natural philosophy, that is, nothing comes from nothing. Borrowing Boethius of Dacia's terminology, we can perhaps say that for Zabarella the eternity of the world is true with respect to the principles of natural philosophy, but it is not true *simpliciter*.[8] Indeed, as Zabarella puts it, the creation of the world *ex nihilo* is an article of faith that must be accepted regardless of the principles of natural philosophy.[9]

Castelli's position, on the contrary, is that Aristotle's argument in the eighth of the *Physics* is a paralogism, since *ex nihilo nihil* cannot be logically applied to the production of the universe. Thus, Castelli argues for the limitation of a principle that was traditionally regarded as undeniable in natural philosophy ("*l'axioma* Ex nihilo nihil *va inteso e limitato a forza… alle prodottioni particolari, non a quella del tutto…*"). The result is that Aristotle's conclusion is false from the standpoint of natural philosophy. Castelli's conclusive remark is then very simple and traditional: a natural philosopher has no say about the creation of the universe ("*Io non dico né che sia fatto né che non sia fatto, ma che il progresso suo non mi fa guadagnar niente*").

[8] On Boethius's "epistemological pluralism" and his distinction between what is true *secundum quid* and *simpliciter*, see Bianchi's first introduction to Boethius of Dacia (2017), pp. 35-52.

[9] For the sake of clarity, I report here again a passage from Zabarella (1601), p. 108*r*: "… credo [contra Thoman] Aristotelem negasse omnem productionem ex nihilo, neque cognovisse creationem, siquidem non sit Christianus. Quando igitur utitur hoc principio ex nihilo nihil fit, puto ipsum semper intelligere id universaliter verum esse, ita ut nulla detur productio nisi ex praesupposita materia. Hoc enim ita constituto, valida est consequentia haec: factum [*viz.* mundum], ergo per motum. Sed eo negato, ut nos negare debemus, ratio Aristotelis corruit, et nihil habet efficacitatis." As far as I know, no one has ever tought that the *ex nihilo nihil* principle is demonstrable. On this, see Pasnau (2011), pp. 20-27. (My only (ironic) remark to Pasnau's splendid study is that bread is not made out of eggs.)

However, it is still not clear how the notion of *creatio ex nihilo* was understood by Galileo and his contemporaries. Had it already lost its 'metaphysical import'? Was it already confounded with *creatio de novo*, as complained by Cogliati? How did natural philosophers think of it?

In what follows, I will take a long digression into the history of the doctrine of *creatio ex nihilo*. Although it will make us depart from Galileo, this digression is needed to clarify the bond that, at Galileo's time, tied the notion of *creatio ex nihilo* with that of God as *primum ens* (§20). This strong bond was brought about by a metaphysical understanding of *creatio ex nihilo* – an understanding that originated only with the Middle Ages, and that plays a prominent role in Galileo's *Juvenilia* (§21). As I said, this will serve me, later on, to argue that Galileo was to a certain degree aware of the metaphysics involved in the creation problem. This, also, will provide some evidence that Galileo decided *consciously* to drop the idea of God as *primum ens* in his original writings, and to leave the creation problem – as well as all the metaphysical subtleties therein involved – outside his aims as a natural philosopher. An important distinction will be therefore drawn between *creation* and *cosmogony*, the latter being regarded by Galileo as a scientific problem rather than a metaphysical or theological one (this will be the subject of Part II).

Since the doctrine of *creatio ex nihilo* has a long and complex history, I decided here to focus chiefly – but certainly not exhaustively – on two issues: (1) when was this doctrine developed, and why? (2) How did it change over time, especially with respect to *creatio de novo*?

§12.
Creation, Time, and Beginning, in the Neoplatonic Tradition

Already in antiquity, the idea of creation commenced to be interpreted in different ways. In the backdrop of the exegetic controversies on Plato's *Timaeus*, certain interpretations were advanced where creation was not linked to the idea of the temporal beginning of the world.

Taurus (fl. 2nd century AD) provides the best-known example in this regard. He spelled out four meanings that make 'created,' or better 'generated' (γενητός), consistent with eternity. 'Generated' can be said of things which are (1) "in the same genus as things which are generated," or (2) "notionally composite, even if they have not been put together." But 'generated' can be also said of the world (3) "because it is always coming to be, changing, like Proteus, in all sorts of shapes"; or (4) "because its being is from another source, namely from God, through whom it is ordered."[10]

These definitions are cited by Philoponus (AD *c.* 490 - *c.* 570) in his treatise against Proclus's (AD *c.* 412-485) arguments for the eternity of the world. In the same treatise we are also told that, at Taurus's time, 'generated' was commonly used in reference to things that had a temporal beginning:

> […] Plato is not using 'generated' in the sense we describe as 'generated' things that have come into existence from any temporal beginning. As a matter of fact, it is falling back on this sense whenever the word 'generated' is used that has led the majority of people astray.[11]

Taurus's definitions are older than Taurus. Richard Sorabji has noticed that the third definition provided by Taurus is also mentioned by Philo Judaeus of Alexandria (*c.* 20 BC - *c.* 50 AD), and the fourth definition can be traced back as far as to Crantor (died *c.* 290 BC).[12] Long before Sorabji, Pererius pointed out that the third definition was held ("*praecipue sequuti sunt*") by Taurus's contemporary philosophers Apuleious (AD *c.* 124-170) and Alcinous (fl. *c.* 2nd century AD). Pererius, too, noticed that the fourth definition was embraced ("*amplexus est*") by Crantor.[13] I do not find it easy to understand whence Pererius got the reference to Alcinous and Apuleius.[14] For, although it is true that he, as many other authors in the Renaissance, was not accustomed to declare his sources, it is equally true that the origin of some of his other references can be spotted more easily. His reference to Crantor, for instance, is most likely taken

[10] Ap. Philoponus, *Aet.*, VI, 145.10-30. I have used the English translation by Michael Share in Philoponus (2005), pp. 28-30. Henceforth I will only refer to the English edition, as it is already paired with the correspondent passages of the original Greek text.

[11] Philoponus (2005), p. 28.

[12] Cf. Sorabji (1983), p. 275.

[13] Cf. Pererius (1576), p. 493a: "Ex illis autem quatuor [Tauri] significationibus, Crantor, prostremam amplexus est. Porphirius secundae significationi assentiur; Proclus, Iamblicus et Simplicius, duabus postremis adhaeserunt; Apuleius et Alcinous, tertiam significationem praecipue sequuti sunt."

[14] The reference must be to Alcinous's *De doctrina Platonis* and to Apuleius's *De dogmate Platonis.* As noticed by N. Joseph Torchia, in these works there is an echo of some of Taurus's definitions of creation (cf. Torchia (1999), pp. 24-25, ntt. 111-115). Torchia identifies the author of the *De doctrina Platonis* with the medio-Platonic Albinus, following Freudenthal's opinion in this regard. However, today there are more than good reasons to believe that the author was Alcinous (cf. Whittaker's introduction to Alcinous (2002), pp. VII-XII). It must be noted that in 1576, when Pererius's *De communibus* was first published, Ficino had already translated into Latin the *De doctrina Platonis* (cf. Ficino (1561)). Before him, Pietro Balbi provided a Latin translation that was strongly criticized by Francesco d'Asola, who therefore decided to publish for the first time in 1521 the original Greek text. D'Asola's *princeps editio* was appended to Apuleius's *Metamorphoses* (cf. Alcinous (2002), pp. XLVIII-LIX).

from Proclus's *In Timaeum*, which is often quoted by Pererius.[15] Commenting on *Tim.* 27d5-28c2, Proclus draws, indeed, a distinction between, on the one hand, the interpretation of "Plutarch, Atticus, and many others of the Platonists," and, on the other hand, the one advance by "the interpreters of Plato that follow Crantor."[16]

The first group thought that the problem discussed by Plato in the *Timaeus* was "whether the world is unbegotten or *generated according to time*."[17] Their answer was that in the *Timaeus* it is written that the world was generated according to time. Its generation involved time in that time is brought about by motion, and motion has always existed, even before the world was put in order by god. Before the world had been arranged, indeed, there was a chaotic motion which brought about a disorderly kind of time.[18]

The second group, headed by Crantor, claimed that "the world is said [by Plato] to be generated, *as being produced by another cause, and not being self-begotten, nor self-subsistent*."[19] This interpretation can be illustrated by an analogy provided by Taurus. Granted that the world is eternal and the speed of light instantaneous, "the light that the Moon gets from the Sun is generated, even though there has never been a time when it has not been illuminated by it."[20] Here comes again to the surface what was initially underlined by Taurus: contrary to what most people think (now including Plutarch and Atticus), the world can be said to be generated *regardless of time*.

In effect, it appears that what is at stake here is to understand whether creation *must* involve time. Both views allow something with a temporal beginning to be defined as 'generated' or, to say it otherwise, 'created.' But only Crantor's view does not in principle exclude that the world and time had an absolute and unprecedented beginning. Time seems to have no role in Crantor's definition of creation. Strictly speaking, then, who shares Crantor's definition of 'created' does not necessarily hold the idea that creation is *beginningless*. The fact that after Taurus almost all Neoplatonists endorsed this idea,[21] does not detract from what I have just said; rather, it may be that they had other reasons in support of a *beginningless creation*.

Although Crantor speaks of a generic "cause" on which created things depend, Taurus specifies that that cause is god. He also provides the 'Sun-Moon' example,

[15] For example, cf. Pererius (1576), p. 494c.
[16] Cf. Thomas Tylor's translation in Proclus (1820), p. 232-233.
[17] *Ibid.*, p. 232, my emphasis.
[18] *Ibid.* See also Sorabji (1983), p. 270.
[19] Proclus (1820), p. 233, my emphasis.
[20] Philoponus (2005), p. 29.
[21] Philoponus is an exception (see Sorabji (1983), pp. 268-269).

which is meant to work by analogy with the creative power of god.[22] Just as the eternal Sun illuminates the Moon's surface, so does god produce and sustain creatures. Just as the light propagates by nature from the Sun, so does creation *necessarily* emanate from god. Accordingly, creatures depend upon god in that they come from god through a *natural process* of emanation. From this, it can be gathered that the world exists from eternity – it is coeternal with god, and yet it is created. Only god is non-created, as his existence relies on nothing else than himself. In this sense, also matter is created, as its existence depends upon god.[23]

§13.
THE 'DOCTRINAL CORE' OF *CREATIO EX NIHILO* IN EARLY CHRISTIANITY

Richard Sorabji has rightly emphasized that in the account just described matter is "created *not out of anything*."[24] And this, he said, "is the most orthodox Neoplatonism and follows from Plotinus own theory. Matter is itself created, and no independent stuff is needed for its creation."[25] Accordingly, "there is no need to involve Christianity to explain God's dispensing with matter, and, indeed, it would be unwise to do so."[26] For this reason, Sorabji is convinced that creation *out of nothing* had never been ascribed to the Neoplatonists because of two reasons. First, because creation was never defined as 'out of nothing' by the Neoplatonists, who preferred, instead, to say that things are generated *from God*. Second, because the Neoplatonists' idea of creation out of nothing involves no beginning of time, whereas the Christian doctrine was developed by assuming that the world had an unprecedented beginning.[27]

Although I concur with Sorabji's consideration, the issue in its entirety requires a more nuanced approach than that cursorily suggested by the eminent historian. I agree with Sorabji that the idea of creation *ex nihilo* cannot be detected only by

[22] This is only one of the analogies that were used to illustrate changeless and eternal causation. In the *City of God*, Augustine provides the famous image of the footprint in the sand (cf. *De civ. Dei*, X, 31). But he was certainly not the first one to use this analogy: cf. Sorabji (1983), p. 311, nt. 23.

[23] Cf. *ibid.*, p. 193: "certain Greeks, notably Platonists, allowed, as we shall see, that matter was created, because they took creation as not implying a *beginning*: its *beginningless* existence was due to God."

[24] *Ibid.*: "[Certain Greeks, notably Platonists,] allowed matter to be created *not out of anything*, in this sense, that the Creator needs no independently existent stuff in order to create matter. But once again this creation not out of anything does *not* imply a beginning."

[25] *Ibid.*, p. 314.

[26] *Ibid.*

[27] "This Neoplatonist conception of creation without matter might be described as a kind of creation *out of nothing*, albeit one with no beginning. But Porphyry prefers to put it by saying that God generates things 'from himself' (*aph' heautou*), rather than out of nothing, and Plotinus also talks of coming from the One." (*ibid.*)

focusing on certain expressions (e.g., 'out of nothing' or 'from God'). But this also means that it is unwise to level different ideas of creation *ex nihilo* by overlooking the different uses of identical or similar expressions. Indeed, expressions that uses prepositions have little meaning by themselves, out of context, especially in languages where the same preposition can be used to convey different meanings when accompanied by different verbs. So, one should first of all define the meaning of creation *ex nihilo*.

Yet here comes the main nuisance. It is indeed highly problematic to put forth the solution just suggested. The formula *ex nihilo*, translated indifferently as 'from' or 'out of nothing,' does not allow us to always refer to a well-defined notion of creation. None of the first thinkers who called on this formula ever felt the need to provide a precise philosophical definition of it.[28]

With some approximation, it is however possible to single out what I would call, for convenience, the 'doctrinal core' of *creatio ex nihilo* for early Christians. We can fairly claim that, when they appealed to this formula, they were not simply attempting to describe – using Sorabji's words – "God's dispensing with matter." Neither were they just saying that matter literally leaps out of nothing, literally comes from nothing. Their main claim was that matter does not come from God by necessity; rather, it comes from nothing because of a willing act of God. In this sense, where great emphasis is laid on the gratuitous act of creation, in no way can the Neoplatonic view be assimilated with the Christian doctrine of *creatio ex nihilo*.[29]

Also, it may be that certain prepositions or expressions, such as 'from God' or 'from nothing,' are used differently by different authors. For example, it is likely that Gregory of Nyssa (AD *c.* 335 - *c.* 395) did not breach the doctrinal core of *creatio ex nihilo* when he resorted to the expression ἐκ τοῦ θεοῦ, from God, which was usually used in a Neoplatonic fashion.[30] Apart from Sorabji's perspicacious suggestion – still,

[28] Ernan McMullin has justly emphasized that the doctrine of *creatio ex nihilo* "only gradually took shape over more than a thousand years" (McMullin (2010), p. 11). John C. Cavadini has argued that, for Augustine at least, the refusal to describe *creatio ex nihilo* in clear philosophical terms stemmed from a profound conviction. Augustine used *creatio ex nihilo* "to evoke 'creation' as a mistery that must remain, essentially, a mystery, one that (in other words) refuses to resolve itself into a clear and distinct philosophical idea, although it certainly has philosophical implications" (Cavadini (2018), p. 151).

[29] Cf. Fergusson (2014), pp. 18-19, where this view is ascribed to Teophilous of Antioch and Irenaeus. See also Vannier (2011), p. 3. More on Irenaeus in Chaieb (2011). Gherard May has also laid great emphasis on the fact that the early Christian doctrine of *creatio ex nihilo* emerged to defend God's absolute power and freedom (cf. May (1994)). In the light of this, Sorabji's considerations reported above fall short of accuracy. Although Sorabji distinguishes between the Neoplatonic view on creation and that of early Christian thinkers, his distinction is pivoted on: (*a*) the different use of expressions such as 'from God' or 'out of nothing'; (*b*) the further distinction between beginningless and unprecedented creation. However, this is just a nitpicking of mine that does not detract anything from Sorabji's argument in its original context.

[30] At at the time of Gregory of Nyssa, this expression was indeed used only with reference to the Word and the Holy Spirit (cf. the bibliography cited in Sorabji (1983), p. 314, nt. 42). But in the *On the Making of Man*, Gregory applies it to the genesis of the sensible world.

partially influenced by the discussion initiated in 1970 by Harry A. Wolfson –, there may be another possible reading of Gregory's claim that "Scripture requires us to believe that the sensible world comes *from God*."[31] If the preposition 'from' is taken in a less literal sense, there would be no need to solve the apparent contradiction involved in saying that the world comes from God as well as from nothing, as Gregory states elsewhere. Gregory perhaps believes the genesis of all sensible things *to be* (εἶναι) from God in that they would not exist if it were not for God.[32] In this sense, this statement does not clash with Gregory's other claim that the power of the divine will is sufficient "to the things that are, for [their] *coming into existence* [πρὸς τὴν… ὑπόστασιν] from nothing" ("ἀρκεῖν ἡγούμεθα τοῖς οὖσι πρὸς τὴν ἐκ τοῦ μὴ ὄντος ὑπόστασιν, τὴν τοῦ θείου θελήματος δύναμιν").[33] Thus, it may be that Gregory does not seek to reformulate – as suggested by Wolfson – the Neoplatonic doctrine of emanation out of god in agreement with the Christian view that the world had an unprecedented beginning.[34] Quite the contrary, Gregory may be saying that things created by God are *hypostases* of nothing, and this does clearly clash against the Neoplatonic doctrine of creation out of or from god. According to Gregory, creation from nothing is possible thanks to God's will, whose power has no limit.[35] There is no need to recall here that, in agreement with his brother Basil, Gregory believes that *only* the Trinity can be regarded as three *hypostases* of the same *ousia,* namely, the Godhead.[36] It is likely, then, that Gregory does not withdraw this view when he appeals to both the expressions ἐκ τοῦ θεοῦ and ἐκ τοῦ μὴ ὄντος when he refers to the sensible world. Perhaps he uses the preposition ἐκ with a different meaning: on the one hand, he uses it to express the origin of the existence of the sensible world (from God); on the other hand, he uses it to point out the material origin of the sensible world (from nothing). In sum, although God is not nothing, there is no contradiction in saying that creation is from God and comes from nothing. Likewise, 'this gift is *from* Santa,' 'this gift comes *from* Lapland,' and

[31] Sorabji (1983), p. 294, paraphrasis of Gregory of Nyssa, *de Hom. Op.*, XXIII, 3 (my emphasis). For Wolfson's and Sorabji's interpretation, see Wolfson (1970) and Sorabji (1983), pp. 290-294.

[32] Gregory of Nyssa, *de Hom. Op.*, XXIII, 3: "ἡ ἁγία πρεσβεύει Γραφή¸ πάντων τῶν ὄντων ἐκ τοῦ θεοῦ εἶναι διαβεβαιουμένη τὴν γένεσιν."

[33] Gregory of Nyssa, *de Hom. Op.*, XXIII, 5.

[34] In my view, Wolfson's reading is flawed because it rests on an arguable interpretation of the objections reported by Gregory against his statement. Wolfson claims that those objections are Neoplatonic in inspiration. As a result, Gregory's statement means that "according to Scripture, God created the world out of Himself by an emanation like that conceived by Plotinus, except that in Gregory's use of it the emanation had a beginning in time and it was an act of the divine will." (Wolfson (1970), pp. 55-56). However, it is not at all clear that Gregory's reply is addressed to Plotinus or Neoplatonists alike. In fact, his reply is explicitly addressed to the Manichaeans (cf. Gregory of Nyssa, *de Hom. Op.*, XXIII, 4).

[35] It is remarkable that neither Wolfson nor Sorabji have noticed Gregory's important reference to the *hypostasis*. Wolfson translates it simply as "the genesis of all things is from nothing" (Wolfson (1970), p. 55).

[36] See, for example, Ayres (2004) and McGuckin (2011), pp. 62-65.

'this gift is *from* recycled waste,' are not contradictory statements.

Another example of the confusion that may arise when one only focuses on the use of prepositions, can be taken from Augustine. In his writings, the Latin preposition '*ex*' is used to convey provenance as well as efficient causality. As a result, Augustine sometimes describes the creation of the world by using both *ex nihilo* and *ex deo*. However, the context clarifies that the first clause concerns the material provenance of the world, whereas the second has to do with God's causal agency in the making of the world.[37] Augustine also resorts to the preposition '*de*,' which in Latin is rarely used to express causal agency. Thus, the creation of the world is defined by Augustine as *de nihilo* (material provenance) by contrast with *ex* or *a deo* (efficient causality).[38]

Contrary to the standard Neoplatonic account of creation, early Christians agreed that the world was created by God *ex nihilo* in that it was not the product of a necessary emanation from God. The world comes from nothing because God willed it to be so. This is what I called, for the sake of convenience, the 'doctrinal core' of creation *ex nihilo*. So understood, this doctrine is certainly an original product of early Christianity. It must be noted that it was developed in opposition to certain philosophical (including religious-based philosophical) understandings of God. In this regard, it must indeed be noted that reference to the Bible alone cannot explain the emergence of this doctrine.

§14.
CREATIO EX NIHILO AND THE BIBLE

As amply shown by scholars, the Old Testament does not provide sufficient ground to assert that God created the world out of nothing. Quite the contrary, the first three verses of the *Genesis* seems to suggest that the world was produced by God out of preexistent matter.[39]

[37] For example, cf. *De vera rel.*, XVIII, 35: "*Unde* fecit? *Ex nihilo*. Id igitur est, *unde* fecit deus omnia…" (my emphasis); *De Gen. ad lit.*, V, 5.12: "Potius ergo tempus a creatura quam creatura *coepit* a tempore, utrumque autem *ex deo*…" (my emphasis).

[38] *De Gen. contra Man.*, I, 2.4: "… omnia quae fecit deus bona sunt valde… nec ea genuit de seipso, ut hoc essent quod ipse est, sed ea fecit *de nihilo*, ut non essent aequalia nec ei *a quo* facta sunt nec filio eius per quem facta sunt" (my emphasis). *De Gen. imp.*, 1.2: "… creatura omnis… *non de deo* nata, sed *ex deo* sit facta *de nihilo*" (emphasis mine). In another manuscript is written "sed *a deo* sit facta *de nihilo*" (cf. Augustine (2018), p. 230, emphasis mine). That being said, I think that Torchia's observations on this matter are incomplete. Torchia claims that "for all practical purposes, the preposition '*ex*' and '*de*' are synonymous in meaning and usage; both indicate a 'movement away from' a given state or condition. But like '*ex*,' '*de*' also designates that *out of which* something is taken or derived. Accordingly, any ambiguity present in the formula *creatio ex nihilo* is present *in creatio de nihilo* as well" (Torchia (1999), pp. 113-114).

[39] Richard C. Dales has argued that in the initial account of the *Genesis* "one thing which seems quite

From the Hebrew, the overture of the *Genesis* can be translated as follows: "In the beginning when God begun to create the heavens and the earth, [and when] the earth was a formless void and darkness covered the face of the deep, while a wind from God swept over the face of the waters, then God said, 'Let there be light'; and there was light."[40] Now, the peculiarity of this account is not that God creates the world out of nothing; rather, it is that preexistent matter does not bound God's creative action. As Jon Levenson has put it: "In the *Genesis* there is no active opposition to God's creative labor. He works on inert matter. In fact, rather than *creatio ex nihilo*, 'creation without opposition' is the more accurate nutshell statement of the theology underlying our passage."[41] And Gary A. Anderson has pointed out that this account can be perceived as a novelty only by readers accustomed with the idea of a matter that constrains the divine power. But this was not the case in the ancient Near East.[42]

Gerhard May has shown that neither does 2 *Maccabees* 7:28 – apparently the strongest textual proof for *creatio ex nihilo* – bear evidence of creation out of nothing. There it is written: "I beg you, my child, to look at the heaven and the earth and see everything that is in them, and recognize that God did not make them out of existing things [ὅτι οὐκ ἐξ ὄντων ἐποίησεν αὐτὰ ὁ θεός]."[43] In fact, this sentence does not necessarily mean that something is literally made out of nothing. A similar construction, May argues, was used by Xenophon to describe the parental conception of children, which cannot be taken as an example of creation *ex nihilo*.[44] According to May, then, 2 *Maccabees* 7:28 lays great stress on God's omnipotence with respect to the world, and it has no say in the role of matter in the formation of the world. "In this way – May concludes – the omnipotence of God is expressed, which guarantees the future awakening of the dead; but a critical move away from the doctrine of world-formation out of eternal matter is quite outside the scope of this text."[45]

I agree with May – among others – that *creatio ex nihilo*, even in its 'core' version, cannot stem *solely* from the Old Testament (including, of course, Deuterocanonical books). This opinion is also shared by Anderson, although he has nonetheless

clear is that God created the world where before there had been nothing. 'In the beginning' denoted a starting point" (Dales (1990), p. 3). Luca Bianchi has been more precise in this respect. In his works about the controversy on the eternity of the world, he has emphasized that, even in antiquity, the reading suggested by Dales was only one of other possible interpretations of the *Genesis* (cf. Bianchi (1984), p. 1, and Bianchi (1987), p. 5).

[40] I have integrated the text of the NRSV with one of the adjustments suggested by Gary A. Anderson (cf. Anderson (2018), p. 16).

[41] Levenson (1994), p. 122. Also quoted in Anderson (2018), p. 18.

[42] *Ibid.*, p. 19.

[43] Cf. May (1994), p. 7, nt. 29.

[44] *Ibid.*, pp. 7-8.

[45] *Ibid.*, p. 7.

attempted to show that the Hebrew text of the *Genesis* "may still be of some value for creation *ex nihilo*."[46] Along the lines of Anderson, I would dare add that a parallel reading of the Septuagint version of *Genesis* 1:1 – which more strongly suggests that the heavens and the earth were the first things created by God – and 2 *Maccabees* 7:28 might have had induced some Greek readers to conceive of God's creation as out of nothing.[47]

At any rate, there is consensus among scholars that the origins of the doctrine of creation *ex nihilo* are eminently Christian (even if tendencies towards it can also be identified in Hellenistic Judaism).[48] From what I could gather, this might have happened because of two main reasons: first, because Christians read the *Genesis* account of creation in the light of the New Testament; second, because they were committed against Gnosticism and Manicheism.[49]

§15.
Creatio ex Nihilo and God's Eternity

One of the problems early Christians were confronted with had to do with maintaining a conception of God as a fully transcendent being that nonetheless incarnated in the body of Christ.[50] If there has to be a separation from the immaterial and material levels, how could God possibly be part of the immanent world? How could something material and extended in space, like the world, come from a non-extended and immaterial being, such as God?[51] When to this we add that, for Christians, God transcends every aspect of the world, including time, no wonder the largely philosophical extent taken by the Christian enterprise. In fact, if the properties or qualities of matter were already in God before the world was created, in which sense matter is said to be not *coeternal* with God?[52]

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[46] Anderson (2018), p. 17.

[47] Anderson himself underlines that the "Septuagint renders *Genesis* 1:1 as an independent sentence and thus portrays the making of the heavens and the earth as the first act of creation and the subsequent description of the chaotic nature of the earth, heaven, and waters as a description of how they appeared after this first creative act" (*ibid.*)

[48] This is Gherard May's thesis (cf. May (1994), pp. 21-26), shared by the majority of scholars. As far as I know, only Richard Sorabji and Janet M. Soskice have argued against May's 'conservative' thesis (cf. Sorabji (1983), p. 195, nt. 16, Soskice (2010), p. 31 and ff.).

[49] Cf. May (1994), pp. 26 and ff.; Vannier (2011); McMullin (2010), pp. 16-20; Fergusson (2014), pp. 15-21.

[50] Cf. Cogliati (2010), p. 1, and Fergusson (2014), pp. 18-19.

[51] These objections are taken from Gregory of Nyssa, *de Hom. Op.*, XXIII, 3.

[52] *Ibid.*

To solve these questions, early Christian thinkers resorted to an important distinction, which partially reflected in a different use of the clauses *from nothing* and *from God*. Only the Word and the Holy Spirit come from God's substance, as they both are consubstantial and coeternal with God. The world, on the contrary, was made by God out of nothing. The result is that, from an ontological standpoint, the differences between God and the created world hold good notwithstanding the Word "was made flesh." Here is visible another important feature of the doctrine of *creatio ex nihilo*: as already noticed in the case of Gregory of Nyssa, this doctrine develops along with a particular understanding of the Trinity.[53] Thanks to this understanding, the ontological incommensurability between God and the created world is maintained, and at the same time it is repeated on the temporal level by leveraging on the difference in duration between God and creatures.

It seems, indeed, that at least in its first formulations the doctrine of creation out of nothing was one with the belief that the world had an absolute beginning. However, in my view it would be trivial to think that this resulted only from a specific reading of *Genesis* 1:1. Probably, *creatio de novo* was also grounded in another belief, namely, that the world will certainly end, for "it is He alone who has immortality [ὁ μόνος ἔχων ἀθανασίαν]" (1 *Timothy* 6:16). From this, one could reach out for further conclusions and argue that what is not eternal *a parte post*, cannot be eternal *a parte ante*.[54]

At any rate, what I want to emphasize is that early Christians were committed to a genuinely innovative philosophical task: to defend the idea of "God who acts in history but yet remains the transcendent Creator of all that is",[55] including time. From the beginning, *creatio ex nihilo* was used in defense of this peculiar idea of God, with whom nothing of the created world can be associated, neither ontologically nor temporally. Christian thinkers initially separated these two claims. The coeternity issue was in fact perceived as a problem of coextensive duration. As a result, *creatio ex nihilo* was also associated with the idea of creation *post nihil* or *de novo*. God and the world were therefore thought of by early Christians as ontologically and temporally different. Separating the ontological from the temporal aspect would have required a rethinking of time from an ontological standpoint.

[53] This feature is justly stressed by Fergusson (cf. Fergusson (2014), p. 21: "What is significant for the doctrine of creation in this clarification of Trinitarian theology is that the ontological difference between God and the world is further accentuated").

[54] Cf. Gregory of Nyssa, *de Hom. Op.*, XXIII, 1. Here Gregory says that those who do not accept the world to have an end, cannot allow the world to have a beginning either. But who believes in God does not doubt that the world is going to end. He must therefore put faith in Scripture and believe that the world had beginning and will end.

[55] Cogliati (2010), p. 1.

§16.
AUGUSTINE AND THE RELATIVIZING OF ETERNITY

The first to start with this rethinking process was Augustine.[56] He reformulated the coeternity issue as a question on the meaning of 'eternity.' A term that, when referred to the world or to the world's time, for Augustine has a different connotation than when it is ascribed to God. According to Augustine, the world's time is said to be 'eternal,' not because it extends infinitely in duration, but because it has *always* existed *along with* the world. Likewise, the world, although limited in duration, is nonetheless said to be 'eternal' because it has always existed along with its time.

It is a matter of perspectives. The world's time is eternal in that it started to be and will finish to be along with the world: it is *coextensive with the world*. For the same reason, the world is eternal in that it is 'at all times,' that is, it is *coextensive with time*. Yet, from God's standpoint, neither the world's time nor the world itself can be said to be eternal. Indeed, God is *before* (*ante*) the world's time, for he is the Creator of the world and therefore of time.[57] In the *De Genesi Contra Manicheos* (henceforth *DGCM*), Augustine explains this as follows:

> [W]e do not say that this world is coeval [*coaevus*] with God, for this world does not have the same eternity as the eternity that God has. God certainly made the world, and thus times began to be along with this same creature [*viz.* the world] that God made, and in this sense times [, since they were made along with the world,] are called eternal. Nonetheless, times are not eternal in the same way that God is eternal, because God, who is the maker [*fabricator*] of times, is before [*ante*] times.[58]

[56] At least, this is Vannier's opinion: "Augustin est également le premier [parmi les Pères] à réfléchir sur le temps…" (Vannier (2011), p. 4).

[57] According to Augustine, time exists only as a consequence of the creation of the world and the latter's motion. Cf. *De gen. ad lit.*, V, 5.12: "Factae itaque creaturae motibus coeperunt currere tempora: unde ante creaturam frustra tempora requiruntur, quasi possint inveniri ante tempora tempora. Motus enim si nullus esset vel spiritalis vel corporalis creaturae, quo praesens praeteritis futura succederent, nullum esset tempus omnino. Moveri autem creatura non utique posset, si non esset. Potius ergo tempus a creatura quam creatura coepit a tempore, utrumque autem ex deo…"

[58] *De gen. contra Man.*, I, 2.4: "… non enim coaevum deo mundum istum dicimus, quia non eius aeternitas est hic mundus, cuius aeternitas est deus; mundum quippe deus fecit, et sic cum ipsa creatura quam fecit deus tempora esse coeperunt, et ideo dicuntur aeterna tempora. Non tamen sic sunt aeterna tempora, quomodo aeternus est deus, quia deus est ante tempora qui fabricator est temporum." I have slightly modified the English translation by Roland J. Teske in Augustine (1991), pp. 50-51.

This passage might be understood as though time was *already* there *when* times had been made along with the world. The preposition *ante* is therefore taken in a temporal sense, and the passage is read assuming that differences with respect to eternity must be differences in duration of time. In this sense, Roland J. Teske was justified when he translated '*coaevus*' through the periphrasis "same duration as."[59] However, this interpretation clashes against the broader context in which this passage appears.

At the outset of the *DGCM*, Augustine replies to two questions raised by his adversaries. The first question is twofold: (1) if the world was created at a given beginning of time (*in principio aliquo temporis*), what was God doing before he created the world?[60] (2) And why did he suddenly (*subito*) decide to make something he had never made before?

Augustine's answer is also twofold: (1) the beginning (*principium*) in which the world is said to be made is not the beginning of time, but it should be regarded as a reference to the Word, in which and through which the world was made (cf. *John* 1:1-3; 8:25); (2) however, even if one believes that the world was made at a given beginning of time, this only means that before (*ante*) that beginning there was no time, for times were created along with the world.[61] Taking the beginning of time as a benchmark, Augustine can claim that without that benchmark there would be no 'before' or 'after,' and certainly no 'suddenly' (*subito*). Also, using the same benchmark, he can speak of God as being before (*ante*) the beginning of time. In this sense, Augustine concludes, one should also read and understand *Titus* 1:2 ("…*promisit non mendax deus ante tempora aeterna*").

But what if the Manicheans drop the temporal adverb '*subito*'? What if they simply ask as to why God created the world? Augustine replies that this would amount to an inquiry into the will of God.[62] But before providing such an answer, he insists that even if the question makes no reference to a time *in* which the world was created, the world would be eternal in a different sense than that attributed to God.

Here comes the passage quoted above. In this passage, Augustine maintains that the world begins to be along with time, but he changes the benchmark, which is no longer the beginning of time along with the world, but the very fact that the world was created *ex nihilo*. This new benchmark, or criterion, can be better understood by

[59] *Ibid.*, p. 51. To be fair, we must notice that Teske seems to explain his use of 'duration' by referring to Boethius's definition of eternity (cf. *ibid.*, nt. 13). But, at least in principle, it seems to me methodologically unsound to translate Augustine in Boethius's terms.

[60] On the 'why not sooner?' argument, also called 'idleness argument,' cf. Sorabji (1983), pp. 232-238.

[61] Cf. *De gen. contra Man.*, I, 2.3.

[62] *Ibid.*, I, 2.4: "Si autem non dicunt: quid placuit deo subito facere caelum et terram?, sed tollunt inde 'subito' et hoc tantum dicunt: quid placuit deo facere caelum et terram?… respondendum est eis, ut prius vim discant voluntatis humanae qui voluntatem dei nosse desiderant. Causas enim voluntatis dei scire quaerunt, cum voluntas dei omnium quae sunt ipsa sit causa."

analogy, as is clear from the passage that comes immediately after the one already quoted:

> So too, all the things that God has made are very good, but they are not good in the same way that God is good, because He made them, while they are made. Nor did He generate them out of himself [*de se ipso*] so that they are what he is; rather He made them out of nothing [*de nihilo*] so that they are equal neither to Him by whom they have been made nor to His Son through whom they have been made.[63]

Just as everything that has been created *ex nihilo* by God is good, albeit not as good as God, so too are the world's times eternal, but they do not have the same kind of eternity that fits God and His Son. For God *created* the eternity of the world's times, whereas their eternity *was created* by God. Also, God created the world's eternity *ex nihilo*, whereas His eternity and that of His Son are neither created nor *ex nihilo*.

In this light, God *takes priority over* anything He creates *ex nihilo*. The preposition '*ante*' assumes in this context an ontological as well axiological value, such that the sentence quoted above could also be interpreted as: "times are not eternal in the same way that God is eternal, because God, who is the maker of times, *has priority over* [*ante*] times." Although metaphorical, this is not an awkward use of the preposition '*ante*,' which Augustine perhaps maintains in order to be consistent with *Titus* 1:2, previously quoted.

At any rate, Augustine clarifies elsewhere how God can be said to be 'before' times. Provided that a creature has always existed, in the sense already specified, God would nonetheless precede it. In fact,

> if God was always the Lord, He has always had some creature to obey His commands, some creature, not begotten of Him [*non de ipso*], but created by Him out of nothing [*ab ipso de nihilo*] and not coeternal with Him. For, the Creator was before this creature [*ante illam*], although at no time was He without it, preceding it not in a lapse of running time but in the stillness of perpetuity [*non eam spatio transcurrente, sed manente perpetuitate praecedens*].[64]

[63] *Ibid.*: "… sicunt omnia quae fecit deus bona valde sunt, sed non sic bona sunt, quomodo bonus est deus, quia ille fecit, haec autem facta sunt; nec ea genuit de seipso, ut hoc essent quod ipse est, sed ea fecit de nihilo, ut non essent aequalia nec ei a quo facta sunt nec filio eius per quem facta sunt." English translation from Augustine (1991), p. 51.

[64] Cf. *De civ. Dei*, XII, 16: "Quapropter si Deus semper dominus fuit, semper habuit creaturam suo dominatui servientem; verumtamen non de ipso genitam, sed ab ipso de nihilo factam nec ei coaeternam;

This comes as a conclusion of a passage where Augustine muses about the eternal nature of the angels. If the angels were not created in the beginning along with the world, Augustine says that they would certainly be "before all times" (*ante omnia tempora*), which is the same expression used with reference to God in the *DGCM*. And yet, their existence, Augustine continues, would still be marked off by some sort of change and motion whereby their time is measured. This time would differ from the world's "all times" measured by celestial movements. It is in this sense that the angels are said to be "before all times." Still, they would not be coeternal with God, because they, too, as the world itself (and the world's times), would have been created by God *ex nihilo*. God's eternity has indeed an ontological priority that escapes the logic of change involved in the creatures' time, and that is grounded upon the status of God as a creator. The angels and the world, on the other hand, come out of nothing along with their own kind of time. They are eternal in that each of them has always existed along with the kind of time that stems from their own nature, or, better, from their own being.

From this, one may argue that time fits creatures, and that the kind of eternity that suits God is timeless. In effect, since time is caused by any sort of change, and given that God does not undergo any sort of change, then God is timeless. Augustine does indeed attempt to relativize the notion of eternity by singling out different kinds of eternity. Compared to the eternity of creatures, God's eternity is timeless.

However, this 'time/timeless' distinction can be tricky. It should not prevent us from noticing that what is crucial in Augustine's attempt to relativize eternity is the notion of *creatio ex nihilo*. Taking creation out of nothing as the discriminatory criterion par excellence, Augustine is able to set out an ontological hierarchy of 'eternities,' on top of which resides God's uncreated and *therefore* timeless eternity.

This relativized idea of eternity has been masterly explained by Gérard Remy in a passage that is worth quoting in its entirety:

> Pour prévenir toute confusion dans leur emploi, les notions capitales de temps, d'éternité, sont à penser en fonction de leur sujet. L'impossibilité d'un temps avant le temps, à moins qu'ils ne soient autres, le suppose inséparable d'une réalité donnée, dont il partage le statut propre. Même si les anges ont toujours existé, ayant inauguré le temps, cette propriété doit être homogène avec leur nature créée. En effet, le critère de différenciation décisif n'est plus d'abord le temps opposé à l'éternité mais la mesure du temps, c'est-à-dire l'état de

erat quippe ante illam, quamvis nullo tempore sine illa; non eam spatio trascurrente, sed manente perpetuitate praecedens." English translation (slightly modified) by G. G. Walsh and G. Monahan in Augustine (1952).

> mutabilité inhérent à la nature créée des anges. Créés "*de nihilo*," mais établis dans une condition d'immortalité, ils sont arrachés à leur mobilité naturelle en vertu de leur contemplation béatifiante de Dieu. Voilà pourquoi tout en partageant l'éternité divine, ils ne sont pas coéternels à Dieu.[65]

I fear, though, that Remy's splendid analysis does not lay enough stress on an important point. That is, the key concept used by Augustine in dealing with eternity is *creatio ex nihilo*. To every creature created *ex nihilo* Augustine ascribes eternity, not only to angels. To every such a creature, Augustine denies the same eternity as that of God. The very same difference between the mutability of creatures and God's immutability stems from the fact that creatures are created *ex nihilo*:

> Thus, there can be no unchangeable good except our one, true, and blessed God. All things which He has made are good because made by Him, but they are subject to change *because they were made, not out of him, but out of nothing*.[66]

> It is true, indeed, that the human will resides in a nature that was created good because its creator is good, but that nature is mutable even though its maker is immutable, *for the simple reason that it was made out of nothing*.[67]

It is not by chance that, as we have seen, years earlier, in the *DGCM*, Augustine had already rejected the world's coeternity with God by analogy with the difference between the goodness of God and that of creatures.

In the light of that, I struggle to understand why Remy, in partial disagreement with Jean Guitton, says that Augustine saw no contradiction between eternity and the creation of angels, but he saw it between eternity and the creation of the universe.[68] This conclusion makes sense only if 'eternal' is understood as meaning 'beginningless.' But for Augustine the two issues, that concerning the eternity of the world, and the other one about the beginning of the world, must be kept separate.

On the one hand, if the issue is about the possibility of something created *ex nihilo* to be eternal, one should say that Augustine advanced a groundbreaking solution based on a relativized notion of eternity. Armed with this, he saw no clash between *creatio ex nihilo* and eternity. This solution, though, forced him to clarify in

[65] Remy (2011), p. 118.

[66] *De civ. Dei*, XII, 1: "Dicimus itaque immutabile bonum non esse nisi unum verum beatum Deum; ea vero, quae fecit, bona quidem esse, quod ab illo, verumtamen mutabilia, quod non de illo, sed de nihilo facta sunt." English translation from Augustine (1952), p. 246 (my emphasis).

[67] *Ibid.*, XV, 21: "Quoniam voluntas in natura, quae facta est bona a Deo bono, sed mutabilis ab immutabili, quia ex nihilo…" English translation from Augustine (1952), p. 468 (my emphasis).

[68] Remy (2011), pp. 130-131.

which sense no creature is coeternal with God. Augustine faced this difficulty by appealing to the very same idea of *creatio ex nihilo*. This doctrine had always implied an ontological gap separating God from creatures. Once the notion of eternity had been relativized in accord with different natures, it was easy for Augustine to use *creatio ex nihilo* as a criterion to avoid coeternity between God, the creator, and the world, His creation. By so doing, Augustine inaugurated the ontological treatment of a temporal category such as eternity, and this was needed to eliminate incompatibility between *creatio ex nihilo* and eternity.

On the other hand, if the issue is the possibility of *creatio ex nihilo* to be beginningless, it is true that Augustine is extremely skeptical – to say the least – about this possibility. But his doubts are understandable. In fact, as he puts it and from his viewpoint, the position of those who believed that creation lacks a temporal beginning is rather incomprehensible:

> They who admit that the world was made by God, yet do not wish it to have a beginning of time but only a beginning of its creation [*suae creationis initium*], so that it was always made in some sense that is scarcely intelligible, do indeed say something…[69]

It seems to me that this sentence is more ambiguous than it is usually understood. For, those who allowed the world to be created without a temporal beginning, would have probably been silent about the "beginning" of creation. Of course, the contrast between "beginning" (*initium*) and "always" (*semper*) could have made Augustine suspicious. Nonetheless, he only confesses his incapability to understand *how* they make a sense out of their view. For one thing is sure: by then, Augustine had already found a way to reconcile the beginning of time and creation (*initium*) with a certain idea of eternity (*semper*). But in order to reconcile these ideas, in his view time must begin along with creation, or else it would be impossible to say that a creature has always existed, i.e., at all times. From Augustine's standpoint, then, it is difficult to grasp in which sense someone can hold that there is a beginning of creation but not of time.

However, this does not mean that, for Augustine, *creatio ex nihilo* is one and the same doctrine as *creatio de novo*. When Augustine resorts to the doctrine of *creatio ex nihilo*, he does not do it in order to show that the world was created *de novo*. Although he believes that creation *ex nihilo* cannot understandably match with the idea of a beginningless creation, nonetheless he attempts to reconcile the notion of eternity

[69] *De civ. Dei*, XI, 4: "Qui autem a Deo quidem factum fatentur, non tamen eum temporis volunt habere, sed suae creationis initium, ut modo quodam vix intellegibili semper sit factus, dicunt quidem aliquid…" I readapted the English translation included in Aquinas-Siger of Brabant-Bonaventure (1965), pp. 22-23.

with that of creation out of nothing. It is an ontological difference in 'being eternal' that Augustine wants to emphasize when he appeals to the doctrine of *creatio ex nihilo*. This difference, again, is not singled out within a universal timeframe, according to which one could indeed say that the world and God are not coeternal due to a different length in time. Augustine, instead, reframes time within a relativized coordinate system, where the chief manner to avoid the risk of relativizing God's eternity too, is to leverage on the ontological gap separating created times from the creator of all times.

§17.
Eternity and Perpetuity in Boethius

With Severinus Boethius the ontological rethinking of time was developed further. Unlike Augustine, Boethius established a more systematic distinction between two temporal categories: eternity and perpetuity. While eternity denotes a "complete possession all at once of limitless life" (*interminabilis vitae tota simul et perfecta possessio*), perpetuity refers to a diachronic way of encompassing "the whole space of infinite life."[70] Eternity is synchronous with all that happened, that is happening, and that will ever happen. Perpetuity, instead, is marked by a gradual succession of times.[71]

The difference can be more easily grasped when great stress is laid on the Latin terms *possessio* and *simul*. Who lives in eternity possesses simultaneously the past, present, and future of a beginningless and endless life (*interminabilis vita*). As such, eternity possesses the whole of time outside the diachronic dimension of time. Who lives in perpetuity, on the other hand, also possesses the past, present, and future of a beginningless and endless life (*infinita vita*), but does not possess all of them together and at once. In this sense, this last kind of *possessio* is not "complete" (*perfecta*). For who lives in perpetuity does no longer possess the past, and not yet the future.

This distinction allows Boethius to argue that the world, even if regarded as eternal in an Aristotelian sense (i.e., lacking a temporal beginning and end), can in no way be as eternal as God. Only God, indeed, possesses the whole of infinite time simultaneously. For the same reason, Boethius claims that those who charge Plato with holding that the world is coeternal with God have misinterpreted Plato's words:

> Therefore, when certain people heard that the world seemed to Plato neither to have had a beginning of time nor was going to have an end, they wrongly

[70] Cf, Boethius (2005), pp. 155-5-156.51 [= *De cons. phil.*, V, 6]. English translation from Dales (1990), pp. 14-15.

[71] See also Boethius's *De Trinitate*, IV, in Boethius (2005), pp. 175.231-176.248, 155.5-156.51.

> supposed that the created world is in this manner coeternal with its founder. For it is one thing to lead an interminable life, which Plato attributed to the world, and another thing to embrace the whole of interminable life as if equally present, which is clearly the property of the divine mind. Nor ought God to seem older than created things by a quantity of time, but rather by the property of his simple nature. […] Therefore, if we wish to put the correct names on things, let us, following Plato, say that God is indeed eternal, but the world is perpetual.[72]

Richard C. Dales has emphasized the affinity between Boethius's view on eternity and that of Augustine. Boethius provided Augustine's view with greater terminological clarity. Just as Boethius differentiated the *nunc temporis* of the world from the *nunc aeternitatis* of God, so too had Augustine already differentiated the world's temporal eternity from God's timeless eternity.[73] This view might however conceal the differences between the two authors just mentioned. Also, it downplays the difficulties in interpreting Boethius's idea of God's eternity. Although many modern commentators have argued that divine eternity is timeless for Boethius, John Marenbon has argued that Boethius's view can be interpreted otherwise, without involving the notion of timelessness, or the even obscurer one of timeless duration. According to Marenbon – and I agree with him – in the passage above Boethius "is describing, not the topology of a special sort of duration, eternity, but God's way of living […]. Boethius is not talking here about time but about the changing existence of temporal things."[74]

But let us suppose that Boethius and Augustine do indeed agree on God's timeless eternity and the temporal kind of eternity of the world. I believe that even in this case there would be a far more fundamental distinction which is consistently called on by Augustine and which is not mentioned by Boethius – a distinction steadily grounded in the doctrine of *creatio ex nihilo*. The fact that Boethius does not resort to the idea of creation out of nothing when he wants to differentiate eternity from perpetuity, is not of little importance. If, for instance, Plato's account of creation were interpreted after a Neoplatonic fashion, as a sort of direct and necessary emanation from God, Boethius's distinction would still prevent the world to be as eternal as God. Yet the same would not hold for Augustine's distinction, whose appeal to *creatio ex*

[72] *Ibid.*

[73] Cf. Dales (1990), pp. 16-17. It should be noticed that in these pages Dales is convinced that "both Augustine and Boethius held that a beginningless world would not be coeternal with God." In my view this opinion cannot be so easily ascribed to Augustine.

[74] On the different interpretations of the timelessness involved in Boethius's idea of divine eternity, see Stump-Kretzmann (1981), Sorabji (1983), pp. 119-120, Leftow (1991), pp. 112-146, Stump-Kretzmann (1992). As for the reading held by Marenbon, see Marenbon (1988), pp. 48-53. The quotations are from Marenbon-Luscombe (2003), p. 53.

nihilo cannot be used to distinguish God's eternity from that of a world which emanates directly and necessarily from God's substance.

Boethius's missing reference to *creatio ex nihilo* leaves us without an explicit passage in which *creatio ex nihilo* is put on a par with beginningless creation. Although the problem of coeternity is intelligently but – to my mind – differently avoided by Augustine and Boethius, none of them plainly states that *creatio ex nihilo* can be also reasonably regarded as a beginningless creation.

V.
CREATIO EX NIHILO AND THE *PRIMUM ENS*

§18.
AQUINAS AND *CREATIO EX NIHILO*

It is only thanks to Thomas Aquinas, almost eight centuries after Boethius, that emerges with great philosophical clarity the possibility of differentiating *creatio ex nihilo* from *creatio de novo*. For Aquinas, *creatio ex nihilo* designates a relation of total dependence of the existence of creatures upon the Creator.

In the meantime, though, the opposite tendency to associate *creatio ex nihilo* with *creatio de novo* had taken hold, along with different interpretations and developments of Boethius's distinction between eternity and perpetuity (to which another form of duration was added, namely the *aevum*, to measure the time of immutable entities such as angels and celestial bodies).[1] Also, from the last quarter of the twelfth century onwards, Augustine and Boethius had ceased to be the chief or the only points of reference. New philosophical views, which Dales has for the sake of convenience called "exotic," had invigorated the discussions on the eternity of the world.[2]

One of the great merits of Dales's work is to have shown that the Latin appropriation of Aristotle's (and pseudo-Aristotle's) *libri naturales*, Avicenna's and Algazel's *Metaphysics*, Averroes's commentaries, and Maimonides's *Dux dubitantium*, exerted important influence on the late thirteen-century controversy on the eternity of the world, but nonetheless it did not occasion the debate.[3] Before that, Peter Lombard's second book of the *Sentences* (c. 1150) had already given further stimulus for reflections on the matter. It also prompted to find out efficacious arguments to provide a better defense of *creatio de novo*.[4] Thus, from the first half of the thirteenth century, some of the "stock" or "repertory arguments"[5] were developed which would be often taken as

[1] Cf. Dales (1990), pp. 24, 26, 59-60.

[2] Cf. *ibid.*, pp. 39-49.

[3] Cf. *ibid.*, p. 49: "[T]he thirteenth century debate on the eternity of the world was already well under way before Aristotle's natural philosophy, Averroes's commentaries, or Maimonides's interpretations exerted any appreciable influence, and although the works of these exotic authors influenced the later content and direction of the debates, they did not occasion it."

[4] Cf. *ibid.*, p. 50. Dales consider it to be also a consequence of the Fourth Lateran Council in 1215, which "had declared the temporal beginning of the world to be an article of faith, thus limiting the scope of disputations on the eternity of the world. There was only one permissible solution to the question. Also, Peter Lombard had been explicit on that matter…"

[5] These are Dales's definitions.

a reference in later discussions on the eternity of the world. One of these arguments was used by William of Durham, and it is "the contention that since a creature is 'from nothing,' it must have its being after non-being, and thus it could not be beginningless (*ab aeterno*); that is, *ex nihilo* means *post nihil*."[6]

A caveat is necessary here. Strictly speaking, it would be inappropriate to regard this contention as an "equivocation"[7] of the doctrine of *creatio ex nihilo*. Certainly, what impeded many thinkers – from William of Durham onwards – to reconcile creation out of nothing with eternity was to an extent the result of an equivocation, or better, a reinterpretation of the terms at play, such as eternity. The latter was ascribed to God in agreement with Boethius's definition, while at the same time it was more and more often understood in an Aristotelian sense, as an infinite duration. This idea was put in contrast with the finite duration the world. As amply shown by Luca Bianchi, this way of interpreting the temporal differences between God and the world led with time to a strong theological as well as philosophical stance, which consisted in ensuring to God the primacy over infinity, including the infinite duration of time.[8] In this light, the contention that *creatio ex nihilo* is but *creatio de novo* was no equivocation, for it stemmed from a critical standpoint on the finitude of creatures as opposed to the creator's infinity. At Aquinas's time, the possibility for creatures to be coterminous in duration with God would have been seen as a problem by the so-called 'conservative' theologians.

There is also another sense in which it would be problematic to speak of equivocation. Neither Augustine nor Boethius had yet formalized the meaning of *creatio ex nihilo*. As shown in the previous chapter, early Christian thinkers had often associated *creatio ex nihilo* with the idea that the world had an unprecedent beginning. Although the original sense of Boethius's eternity helped rethink the meaning of creation, from this to a consistent reconceptualization of *creatio ex nihilo* as explicitly different from *creatio de novo*, the step is short but not obvious. It requires a crucial rethinking of the relations between God's being and that of creatures. That is, it requires a well-articulated metaphysics.

In this regard, it is worth noticing that, from its very debut within universities, the controversy on the eternity of the world had prompted a philosophical clarification of the doctrine of *creatio ex nihilo*. It may appear to be rather obvious, perhaps even instinctive, to hold that what is brought out of non-being, must have started to be after not being. And yet this argument was never used in such clear metaphysical terms by early Christian thinkers.

[6] Dales (1990), p. 53.
[7] This is how Dales refers to it (cf. for instance *ibid.*, nt. 12, and pp. 85, 133).
[8] Cf. Bianchi (1984), pp. 170-171.

John of Damascene perhaps implied something akin when he wrote that "what is brought to existence from non-existence is not of such a nature as to be coeternal with Him who is without beginning and exists forever."[9] But this sentence is not formulated – not explicitly at least – by assuming as a metaphysical principle that whatever comes out of non-being, comes after non-being. It may be that Damascene is appealing to two different views: (*a*) the sensible world is going to end, thus it likewise had a beginning; and (*b*) God did not create the world out of Himself, but out of nothing. Hence, since the world is out of nothing *and* had a beginning, it cannot be as eternal as God.

The absence of an explicit metaphysical claim in John of Damascene was exploited by Thomas Aquinas to argue against those who supported the principle *out of nothing* = *after nothing*. According to Aquinas, Damascene's sentence can be "clarified by what Boethius says in the last book of the *Consolation*."[10] And this means that, in order for the world not to be coeternal with God – that is, in order to meet John of Damascene's conclusion – there is no need to think of *creatio ex nihilo* as equivalent to *creatio de novo*.

As we have seen in the previous chapter, the doctrine of *creatio ex nihilo* was developed by early Christian thinkers in an attempt to fight other religious-philosophical views of God and creation, including the Neoplatonic one. It also served to denote that the world is the result of a free act of God. This position stands in sharp conflict with another one, according to which the world is by necessity the product of natural emanation out of God. Now, as far as I know, Aquinas is the first Christian thinker that exploits *creatio ex nihilo* as a fitting expression to denote also (but not only) the Neoplatonic account of creation. Before him, there had been at least one case, related to Gregory of Nyssa (cf. §13), in which the double use of the formula ἐκ τοῦ θεοῦ and ἐκ τοῦ μὴ ὄντος with reference to the sensible world, creates some confusion when they are put out of context. But Aquinas seems to be the first Christian thinker who associates, in clear terms, creation out of nothing with the Neoplatonic

[9] John of Damascene, *De fide orthodoxa*, I, 8. Also quoted in Aquinas's *De aet*. I have used the English translation provided by Cyrill Vollert in Aquinas-Siger of Brabant-Bonaventure (1965), p. 23.

[10] Aquinas, Siger of Brabant, Bonaventure (1965), p. 23. Aquinas uses Boethius's distinction in duration also to read Hugh of St. Victor. In the same passage, Aquinas resorts also to Augustine: "Dicit enim Damascenus I Lib. 8 cap.: non aptum natum est quod ex non ente ad esse deducitur coaeternum esse ei quod sine principio est et semper est. Item Hugo de sancto Victore in principio Lib. sui de sacramentis dicit: ineffabilis omnipotentiae virtus non potuit aliud praeter se habere coaeternum, quo faciendo iuvaretur. Sed harum auctoritatum et similium intellectus patet per hoc quod dicit Boetius in ultimo de consolatione… Unde patet quod etiam non sequitur quod quidam obiiciunt, scilicet quod creatura aequaretur Deo in duratione; et quod per hunc modum dicatur, quod nullo modo potest esse aliquid coaeternum Deo, quia scilicet nihil potest esse immutabile nisi solus Deus, patet per hoc quod dicit Augustinus, in libro XII de Civ. Dei, cap. 15: tempus, quoniam mutabilitate transcurrit, aeternitati immutabili non potest esse coaeternum."

account of creation as an emanation from God. This is most likely due to the importance that Neoplatonic sources exerted on Aquinas's rethinking of creation out of nothing.[11]

For instance, Avicenna – one of Aquinas's influential sources on creation – labels his heavily Neoplatonic view of creation as 'out of nothing.'[12] In his view, this means that the existence of the world depends upon God; without God, the world is nothing. Avicenna's metaphysic compels him to hold that creation out of nothing cannot be *after* nothing.[13] Thus, for Avicenna *creatio ex nihilo* and *de novo* contradict each each other. Rahim Acar has linked this conclusion to a metaphysical principle that pertains to a particular kind of efficient causality, in which the effect produced by the cause is the existence of something different than the cause. Acar calls it the "principle of co-existence," which "requires that when the cause exists, the effect must exist, but it does not require that both cause and effect are on a par with regard to existence."[14] So, thanks to this principle Avicenna can maintain that an ontological gap separates God's existence from that of the world. Also, the same principle leads Avicenna to affirm that the world is eternal. In fact, given that the efficient cause and the effect, namely, God and the world, must be simultaneous, and since God's existence is eternal, then the world must be eternal.[15]

By appealing to the difference between a voluntary efficient cause and a natural one, Aquinas can neglect Avicenna's principle of co-existence. Being a voluntary agent, God can create the world *after* nothing, *de novo*. But this, according to Aquinas, and contrary to what Avicenna thought, can be reconciled with the idea that God's creation is out of nothing. Aquinas seeks to reframe the notion of *creatio ex nihilo* so that the latter can be used to describe different views of creation. For instance, in his reconceptualization, '*ex nihilo*' becomes a common denominator for doctrines that differ with respect to the temporal and causal aspect. *Creatio ex nihilo* is ultimately reduced by Aquinas to a simple stand: to be created out of nothing means to be dependent upon God's existence, regardless of duration and independently of the kind of efficient causality ascribed to God. Dependence upon God is the mark of creation. With Aquinas, *creatio ex nihilo* becomes a heavily metaphysical doctrine, for it

[11] Cf. te Velde (1995), pp. 102-108; Burrell (2003); Burrell (2010), pp. 47-50. Obviously, on Aquinas's metaphysics and its sources in general, Wippel's works are a must read (I have consulted Wippel (2000), and many of the papers included in Wippel (1984) and Wippel (2007)).

[12] Cf. Acar (2010), p. 79.

[13] Cf. *ibid.*, pp. 77-83.

[14] *Ibid.*, p. 82.

[15] In the *Metaphysics*, Avicenna says that "if anything is essentially always the cause for the being of some other thing, it [i.e., this other being] is always the cause for it as long as [i.e., the cause] is an existent. If it exists always, then its effect exists always." Cited in Acar (2010), p. 82.

concerns the relation between God and creatures in the light of their existence only. In David B. Burrell's clear terms, this doctrine shows that "the very existence (*esse*) of a creature is an *esse-ad*, an existing which is itself a relation to its source,"[16] namely, God.

Devoid of any sort of temporal sense, the notion of *creatio ex nihilo* is now clearly distinguished from *creatio de novo*. Thanks also to Augustine and Boethius, Aquinas believes it possible to overcome the coeternity issue. This allows him to prevent the notion of *creatio ex nihilo* from being perceived as unorthodox, even though it does not necessarily refer to the idea that the world was created *after* nothing.

This crucial metaphysical turn affected the reception of the controversy on the eternity of the world during and after Aquinas's life. If one had been able to show that the substance of existing things depends upon God's existence – whatever their relation may be from a temporal standpoint, and independently of creation being from necessity or not – this would have amounted to a demonstration of *creatio ex nihilo*. However, such a demonstration would have not allowed to conclude that the world had an unprecedented beginning in time. The two questions, (1) whether it is possible to demonstrate that the world is out of nothing, and (2) whether it is possible demonstrate that the world began to be at a given time, were now definitely separated. It is worth to keep this in mind, in order to better assess, later on, the influence of Aquinas's metaphysical view of *creatio ex nihilo* on Renaissance thinkers.

§19.
AQUINAS AND THE *PRIMUM ENS*

According to Aquinas, it can be demonstrated that the world was created out of nothing.[17] There is a notion that appears to have a pivotal role in Aquinas's

[16] Burrell (2010), p. 51. This also reminds me of Taurus's definitions of creation, taken from Crantor, according to which something is created "because its being is from another source, namely from God, through whom it is ordered" (cf. *supra*, §12).

[17] This may seem to be in contrast with Aquinas's 'agnostic' view described in chapter II (§4). Yet we must always bear in mind that with Aquinas the notion of creatio *ex nihilo* has become a 'neutral' metaphysical claim; neutral, in the sense that it says nothing about the kind of causal and temporal modality of creation. Its only claim is about the dependence of the existence of creatures upon God. Taken in this broader sense, a demonstration of *creatio ex nihilo* is not a demonstration of the Christian doctrine of *creatio ex nihilo*. For it does not prove that creation is a free act of God. It is true, as Rudi te Velde has pointed out, that "[c]reation as faith takes it implies a beginning of duration" (te Velde (1995), p. 117, note 3). But this is not the only kind of creation that Aquinas considers to be indemonstrable (see also *ibid.*, note 2). In fact, creation as faith takes it is also out of nothing in the sense that it is not by necessity. In this respect, *creatio ex nihilo* is therefore not demonstrable for Aquinas. I am just applying here an interpretation that I found in Jacopo Mazzoni's *De comparatione*, where Mazzoni agrees with Thomas and says: "Voluntas enim

demonstration of *creatio ex nihilo* – the notion of God as *primum ens*.

From a strictly Aristotelian standpoint, God can be regarded as a *primum movens*, that is, an eternal and unmoved mover that, as such, is also the first (final) cause of motion. In the backdrop of an eternal world, '*primum*' should not be understood in a temporal sense, but only to accentuate the priority of the uncaused cause over its effects.[18] Likewise, one may be tempted to understand '*primum ens*' in the sense that God is the first cause of being. But Aristotle never gives such a definition, and he never uses the notion of *primum ens*. Where does it come from?

According to Jan A. Aertsen, this idea of God as a source of being is genuine of Thomas Aquinas. In fact, it cannot be found in Aristotle, nor in Plato. Besides, Aquinas developed this view in partial disagreement with the Neoplatonic doctrine of the One-Good as a principle superior to the being itself. In Aquinas, this perspective is in fact reversed, and the *esse* has the primacy over anything else.[19] However, Giovanni Ventimiglia has pointed out that sometimes Aquinas ascribes to the Neoplatonists a view that reconciles the doctrine of the One-Good with the idea of God as *primum ens*.[20] In his comment on Dionysius's *On the Divine Names*, Aquinas writes that the

> Platonists placed a *primum ens*, that is, the very same essence of the goodness, the unity, and the being [*esse*], which we call God; and all the other things are said to be good, one, or *entia*, by means of derivation [*per derivationem*] from that *primum ens*.[21]

And in another passage of the same commentary, Aquinas claims that

> there had been some Platonists who brought the processions of perfect things back to different principles: one is the principle of life, which they called first life; another one is the principle of knowing, which they called first intellect; and another one [is the principle] of existing, which they called good and *primum ens*.[22]

Dei non potest aliqua rationi perquiri, nisi in illis circa quae necessarium est Deum absolute velle, inter quae poni non debent res ex nihilo productae" (Mazzoni (1597), p. 210h [= Mazzoni (2010), p. 322]).

18 Aristotle says that the first mover is first in that it is not moved by anything else (cf. *Phys.*, VIII, 5, 256a 13-15).

19 Cf. Aertsen (1992).

20 Cf. Ventimiglia (1997), pp. 127-128.

21 "[P]latonici ponebant unum primum quod est ipsa essentia bonitatis et unitatis *et esse*, quod dicimus Deum et quod omnia alia dicuntur bona vel una *vel entia* per derivationem ab illo primo" (*In Dion. De div. nom.*, Proemium, my emphasis. Cited also in Ventimiglia (1997), p. 127).

22 "[F]uerunt enim quidam Platonici qui processiones perfectionum ad diversa principia reducebant,

Ventimiglia has also singled out other texts where Aquinas ascribes to Plato and Aristotle the view of God as a source of being:[23]

> But later philosophers, like Plato, Aristotle, and their followers, came to the consideration of the same universal being [*esse*]; for this reason, they were the only one who placed some universal cause of things, whence the being of all other things come [*in esse prodirent*].[24]
>
> Later philosophers, though, like Plato and Aristotle, came to acknowledge the principle of the whole being [*principium totium esse*].[25]

To these texts, I would add other two interesting passages from Aquinas's commentary on the *Physics* and on the *Book of Causes*:

> Although Aristotle claimed that the world is eternal, nonetheless he did not think that God is not the cause of the world's existence but only the cause of its motion, as some have said.[26]
>
> According to the Platonists, the *pimum ens* (namely, the idea of *ens*) is something above the first life (i.e., above the idea of life), and the first life is something above the first ideal intellect [*supra primum intellectum idealem*]. However, according to Dyonisius, the *primum ens*, the first life, and the first intellect are one and the same, that is, God. Hence, Aristotle, too, in the twelveth book of the *Metaphysics* argues that the first principle is the intellect, and that its knowing is life; accordingly, all things have being [*esse*], life, and knowing.[27]

ponentes unum principium esse vitae, quod appellabant primam vitam, et aliud principium esse intelligendi, quod appellabant primum intellectum et *aliud existendi quod appellabant primum ens* et bonum" (*In Dion. De div. nom.*, V, my emphasis. Cited in Ventimiglia (1997), pp. 128-129).

[23] Cf. Ventimiglia (1997), p. 127.

[24] "Posteriores vero, philosophi, ut Plato, Aristoteles et eorum sequaces, pervenerunt ad considerationem ipsius esse universalis; et ideo ipsi soli posuerunt aliquam universalem causam rerum, a qua omnia alia in esse prodirent" (*Q. de pot.*, q. 3, a. 5).

[25] "Postremi vero, ut Plato et Aristoteles, pervenerunt ad cognoscendum principium totium esse" (*In VIII Phys.*, 2).

[26] "[Q]uamvis Aristoteles poneret mundum aeternum, non tamen credidit quod Deus non sit causa essendi ipsi mundo, sed causa motus eius tantum, ut quidam dixerunt" (*In VIII Phys.*, 3). Cited in Van Steenberghen (1980), p. 255.

[27] "[S]ecundum Platonicos primum ens, quod est idea entis, est aliquid supra primam vitam, id est supra ideam vitae, et prima vita est aliquid supra primum intellectum idealem; sed secundum Dionysium primum ens et prima vita et primus intellectus sunt unum et idem quod est Deus; unde et Aristoteles in xii

In this last passage Aquinas is showing that the idea of God as *primum ens* can be derived from a certain reading of Aristotle's *Metaphysics*, Book Λ (which is described by Aquinas as book XII instead of book XI, after William of Moerbeke's introduction to his translation into Latin of Book K).[28]

At any rate, Ventimiglia concludes that Aquinas's notion of *primum ens* is somehow indebted to Neoplatonic texts and authors, like the *Book of Causes* and (pseudo-)Dionysius the Areopagite.[29] This also explains the use of '*ens*.' For us, this term might suggest a sense of reification, as though God was an *entity* that gives existence to all other entities. But this is not the case. In his comment on (pseudo-)Dionysius's *On the Divine Names*, Aquinas explains how the term '*ens*' should be understood:

> Dionysius shows that when *ens* is said of God, *ens* indicates the process of existing things from God [*processum existentium a Deo*]. He also shows that this name *ens*, or *who is*, is most conveniently said of God.[30]

Thus, '*ens*' can be fittingly translated into English as 'being,' as it points at the fact that something *is* and *exists* ("*ens, vel qui est*"). When this term is applied to God, it conveys the idea of God as the source from which all existing things derive ("*processum existentium a Deo*"). In this sense, God can be said to be the *primum ens*, the first being.

This notion is central in Aquinas's demonstration of *creatio ex nihilo*. In his commentary on Lombard's *Sentences*, Aquinas develops an argument for God's existence "*per viam causalitatis*." He appeals to the fact that creatures are not perfect: they always lack something, even with respect to something that is within their capacity. In sum, Aquinas shows that, since creatures are from nothing, their being must be caused by something else which is "*primum*," namely, God.

Since this argument involves some interpretative difficulties which have

metaphysicae primo principio attribuit quod sit intellectus et quod suum intelligere sit vita, et secundum hoc ab eo omnia habent esse et vivere et intelligere" (*In De causis*, in prop. 18). Due to the pandemic, I could not visualize the translation provided by Richard C. Tylor. It must be noted that the eighteenth proposition of the *Book of Causes* runs as follow: "Res omnes habent essentiam per *ens primum*, et res vivae omnes sunt motae per essentiam suam propter vitam primam, et res intelligibiles omnes habent scientiam propter intelligentiam primam" (my emphasis).

[28] This is an important hint that allows us to place the composition of Aquinas's comment after 1270 (cf. Saffrey's introduction to Aquinas (2002), p. XXXIV). Also in his comment on the *Physics*, Aquinas resorts to the twelfth book of the *Metaphysics* to claim that Aristotle regarded God as "causa essendi" (cf. *supra*, note 31, and Van Steenberghen (1980), pp. 254-255).

[29] Cf. Ventimiglia (1997), p. 129. See also te Velde (1995), pp. 254-279.

[30] "[Dionysius] ostendit quod ens dictum de Deo, signat processum existentium a Deo; et ostendit quod hoc nomen ens, vel qui est convenientissime de Deo dicitur" (*In Dion. De div. nom.*, V).

troubled modern commentators, I shall also report the original Latin version:

> The first argument is taken from the way of causality, and it goes as follows: Whatever has being out of nothing must be by something [else] from which its being has come. But all creatures have their being out of nothing. This is evident from their imperfection and potentiality. Hence, [creatures] must be by something unique and first, i.e., God.

> Prima ergo ratio sumitur per viam causalitatis, et formatur sic. Omne quod habet esse ex nihilo, oportet quod sit ab aliquo [ed. Busa: alio] a quo esse suum fluxerit. Sed omnes creaturae habent esse ex nihilo: quod minifestatur ex earum imperfectione et potentialitate. Ergo oportet quod sint ab aliquo uno primo, et hoc est Deus.[31]

Fernard Van Steenberghen argued that in this sentence the expression *ex nihilo* is very likely to have a temporal sense. In fact, since the existence of every creature comes from God, and God is not nothing, their being out of nothing can only mean that they were created *after* nothing. At most, adds Van Steenberghen, *ex nihilo* may be taken in a negative sense, that is, it is used to say that creatures do not come from a preexisting subject. However, Van Steenberghen concluded that the temporal sense should be preferred over the negative one.[32]

Van Steenberghen's conclusion can be contended at least in two respects. First, in his sentence, Aquinas may not be ambiguous, since he uses the expression *ex nihilo* next to *ab aliquo*. The latter is probably used to convey causality, and the expression *ex nihilo* excludes that God is the material cause of creatures. Also, Aquinas's use of Neoplatonic terminology (in this case, the verb '*fluo*') is devoid of reference to creation understood as a material emanation from God's substance. Neoplatonic expressions, such as *flowing from* or *participation of* God, are especially used by Aquinas to emphasize a generic link of efficient causality between God, the universal cause of all that is, and creatures.[33] For these reasons, I fear that giving a temporal sense to the expression *ex nihilo* would amount to placing Aquinas's understanding of *creatio ex nihilo* into too

[31] *In Sent*, I, d. 3, q. 1. I have partially based my translation on Wippel's paraphrase in Wippel (2000), pp. 400-401.

[32] "L'expression *ex nihilo* ne peut évidemment pas désigner l'origine ou la source de ces êtres, puisqu'on affirme au contraire qu'ils procèdent de Dieu comme de leur source (*a quo esse suum fluxerit*); d'ailleurs il est clair que rien en peur 'sortir' du néant. *Ex nihilo* ne peut avoir ici qu'un sens temporel (*post nihilum*, après n'avoir rien été), ou négatif (*non ex subiecto praeexistente*). Les sens temporel paraît ici le plus probable" (Van Steenberghen (1980), p. 14).

[33] Cf. te Velde (1995), p. 157: "The process of creation is at once and immediately completed. But this is not to say that there is no process at all. The dynamic sense of creation which remains is that of the 'influence' the cause exercises upon its effect, what Thomas calls the 'influx of being' from God into creatures, a way of becoming as a result of simple emanation."

a narrow metaphysical grid. The sentence above does not call for such a solution.

The second reason to depart from Van Steenberghen's conclusion, is that Aquinas himself shows that *creatio ex nihilo* need not be read in a temporal sense when it is understood as *creatio ab aliquo*. Further on, in the same commentary on the *Sentences*, Aquinas indeed demonstrates *creatio ex nihilo* by proving that: (*a*) there must be only one first principle or cause for all that is; (*b*) this cause need not be material in order to be the source of matter; (*c*) this cause is perfect, as it is always in actuality, and its being (or existence) does not differ from its essence (*natura*).[34] From these premises, Aquinas can conclude that, since existing things (*res*) are not perfect, they must imperfectly participate of the '*primum et perfectum ens*':

> I reply that creation is not only held by faith, but it is also demonstrated by reason [*ratio demonstrat*]. For it is clear that whatever is of a certain imperfect kind, originates with something whose kind is first and perfect; just like it is evident that the heat of hot things originates with fire. Since whatever thing, and whatever is in a thing, somehow participates in being, and is tangled with imperfection, then it is necessary that every thing – including whatever is in it – originates with a *first and perfect being* [*a primo et perfecto ente*]. This is what we call 'creation,' that is, the production of a thing's being in all its substance. Thus, it is necessary that all things proceed from a first principle through creation.[35]

Aquinas clarifies that this demonstration holds true only when *ex nihilo* is understood in a negative sense, that is, when creation is not out of something already existing ("*dicatur esse ex nihilo, quia non ex aliquo praeexistenti*").[36] In this sense, the idea that all things have non-being *before* being is used to underline that the existence of all things depends upon God. And if the same idea is taken in a temporal sense, then there can be no demonstration of creation.[37]

Thus, when Aquinas infers that all creatures are out of nothing, as shown by

[34] Cf. *In Sent.*, II, d. 1, q. 1, aa. 1-2.

[35] "Respondeo quod creationem esse, non tantum fides tenet, sed etiam ratio demonstrat. Constat enim quod est in aliquo genere imperfectum, oritur ab eo in quo primo et perfecte reperitur natura generis: sicut patet de calore in rebus calidis ab igne. Cum autem quaelibet res, et quidquid est in re, aliquo modo esse participet, et admixtum sit imperfectioni, oportet quod omnis res, secundum totum id quod in ea est, *a primo et perfecto ente* oriatur. Hoc autem creare dicimus, scilicet producere rem in esse secundum totam suam substantiam. Unde necessarium est a primo principio omnia per creationem procedere" (*In Sent.*, II, d. 1, q. 1, a. 2, *resp.*, my emphasis).

[36] *Ibid.*

[37] "Si autem accipiamus tertium oportere ad rationem creationis, ut scilicet etiam duratione res creata prius non esse quam esse habeat, ut dicatur esse ex nihilo, quia est tempore post nihil, sic creatio demonstrari non potest, nec a philosophis conceditur; sed per fidem supponitur" (*ibid.*).

("*quod manifestatur*") their being imperfect, he is already implying that this inference is *only* valid when *ex nihilo* is taken in a negative sense. It seems, then, that Van Steenberghen's temporal interpretation deprives Aquinas's conclusion of a logical validity.[38]

In conclusion, it must be emphasized that the pivotal notion of *primum ens* does not necessarily denote a being that is first in time. This notion only implies that there is a being which does not participate of any other being except its own. All other beings are created out of nothing in that they depend upon, emanate from, the *primum ens*.

§20.
Creatio ex Nihilo and the *Primum Ens* in the Late Renaissance. A Few Examples From Natural Philosophy

The history so far recounted bears no claim to exhaustiveness. Its only objective was to help shed some light on the late-Renaissance understanding of creation. And now there are enough elements to take a giant leap into the late Renaissance, in order to assess whether the distinction between *creatio ex nihilo* and *de novo*, so lucidly put forth by Aquinas, was still acknowledged at Galileo's time among natural philosophers. Obviously, Aquinas's teachings did not get lost; on the contrary, they were revived in the Renaissance thanks to the work of theologians such as Thomas Cajetan (Gaetano De Vio).[39] However, my aim here is to understand whether a Renaissance natural

[38] John F. Wippel has accepted Van Steenberghen's reading, but for another reason. According to Wippel, when *ex nihilo* is taken in its negative meaning, "then the claim would be that anything which has its being from no preexisting subject depends on something else for its being. So understood, it would seem to say more than Thomas intends. God does not have his being from any preexisting subject, but this does not imply that he is caused. Against this objection one might counter that the verb 'has' (*habet*) implies that the subject in question merely participates in being. While this is certainly true for Aquinas in his more formal discussions of participation, he has hardly justified or developed this point within the present context. It seems, therefore, that the expression as it is employed here should rather be understood in the temporal sense" (Wippel (2000), p. 401). I believe, though, that against Wippel's objection there may be another argument that does not need to involve a well-developed view of participation. Let us assume that for something to be *ex nihilo* means that it has its being from no preexisting subject. Even if so understood, Aquinas does explicitly restrict this meaning of *ex nihilo* to creatures, as he says that their being *ex nihilo* "is evident from their imperfection and potentiality." This meaning of 'being *ex nihilo*' cannot apply to God. Also, this restriction to creatures does not necessarily imply that '*out of* nothing' is the same as '*after* nothing.' On the other hand, if Aquinas did really ground his argument for God's existence in the temporal sense of *ex nihilo*, then his argument would rest on an indemonstrable assumption, as Aquinas says in the second book of the same commentary on the *Sentences*. What would be the point of grounding an argument for God's existence upon so weak a ground?

[39] Cf. Crantz (1978). It must be recalled that "over 200 printings of the works of Thomas Aquinas appeared before 1501" (Grendler (1988), p. 38); and that Aquinas played a considerable role in the *Studio Patavino* toward the end of the fifteenth century (cf. Mahoney (1974)). On the relevance of Thomism in the

philosopher was supposed to deal with the creation problem, and how. Did this problem fall within the purview of a natural philosopher? Which conceptual tools were involved by natural philosophers who dealt with the creation problem?

To start with, one should always bear in mind that in the late Renaissance a natural philosopher was primarily supposed to be able to comment upon Aristotle's *libri naturales*. This exegetical enterprise was a very eclectic exercise, as it involved a wide range of *quaestiones* which often required what we may anachronistically call an 'interdisciplinary' approach.

Consider the following example. In the first book of the *Physics*, Aristotle addresses the "*aporia*" raised by the ancient philosophers, who thought it equally impossible for generation to be either from being and from non-being. By introducing his view about the number and nature of the principles, the Stagirite shows that the ancient philosophers were mistaken. According to him, it is in fact possible to speak of generation from being and from non-being, provided that the latter is not taken in an absolute sense.[40] When reading these passages from the *Physics*, a Renaissance natural philosopher was faced with a bunch of problems that did not cross Aristotle's mind; and yet they had to be solved. It was the duty of a natural philosopher *qua* natural philosopher to highlight these problems and suggest a solution.

Concerning the just recalled passages from the *Physics*, Agostino Nifo[41] confesses that they raise an "extremely difficult issue: whether something can be made in time *ex nihilo*" (*Sed circa hae exoritur difficillima quaestio: Utrum in tempore possit aliquid ex nihilo fieri*). He wants to show that, contrary to Aristotle, something can be made *ex nihilo*. But, first of all, he clarifies the title of the question ("*Circa hanc quaestionem primo declarabo titulum quaestionis*").[42] He provides two *animadversiones*. The first one clarifies the sense of the expression '*ex nihilo*':

> All things were made from an *ens* [*ex ente*], as all things require God as the first and most universal author of things. So, a certain thing is said to be made

Italian Renaissance see Kristeller (1964), and the up-dated English translation in Kristeller (1974). See also Mahoney (2000), Chapter XI, which was originally published in 1976. For a general overview on the reception of medieval philosophy in later thoughts, see Fitzpatrick-Haldane (2003).

[40] Cf. *Phys*., I, 8, 191a-191b34.

[41] On Agostino Nifo, see Mahoney (2000), and De Bellis (2012).

[42] "Sed circa hae exoritur difficillima quaestio: Utrum in tempore possit aliquid ex nihilo fieri. Et arguitur quod sic. Ex aliquo nihil fit; igitur non ex nihilo nihil fit. Tenet consequentia per legem contradictoriarum, non ex nihilo nihil fit; igitur falsum est ex nihilo nihil fieri; igitur propositum, videlicet ex nihilo aliquid fit. In contrarium est Aristoteles omne quod fit vult quod fiat ex ente in potentia. Circa hanc quaestionem primo declarabo titulum quaestionis…" (Nifo (1569), p. 106, col. 2).

> out of nothing since it requiries nothing of necessary to be made, such as a matter or substratum of which that very same thing is made.[43]

The second one concerns the distinction between *ex nihilo* and *de novo*:

> "To be created out of nothing" can be understood in two ways. First, it can denote creation in time [*in tempore*], because the thing that is created is preceded by nothing in time [i.e., it is preceded by no time] […]. Second, it can be understood as unrelated to time, but as a creation from eternity. In this case, the nothingess does not preceed creation according to time, but according to nature, or according to our way of thinking. For this reason, some say that for Aristotle the world was created from eternity; and they go so far as to say that the world is preceded by non-being according to our way of thinking only [*secundum rationem tantum*]. But the *quaestio* we are dealing with now is about the creation that is made in time *de novo*, not about the eternal one. For, the eternal creation will be discussed when we will comment on the eighth [book] of this [work, that is, Aristotle's *Physics*].[44]

As a natural philosopher, Nifo is required to solve the question as to whether it is possible for something to be *ex nihilo* and *de novo*. His answer contradicts Aristotle, who claimed that nothing can come from absolute non-being. Nifo claims, instead, that it is possible to show that something has a temporal beginning *ex nihilo*. But in order to do so, Nifo first has to clarify that Aristotle, although he was right in saying that there must be a being in which things originate, he was wrong in pointing out that this being is the first matter or substratum. In fact, says Nifo, things are from nothing in that their existence postulates the existence of "God as the first efficient and universal author of all things." In this sense, and in this sense only, it is possible to say that what is *ex nihilo* is also *ex ente*. Probably, Aquinas would have used the expression '*ab aliquo*' and described the '*aliquis*' as the *primum ens* from which everything is derived *ex parte essendi*. Nifo prefers to insist on the fact that, in order for something to be *ex nihilo*, there must be an author, an efficient cause, but there need

[43] "Sic enim omnia ex ente fierent, quoniam omnia supponunt Deum uti efficientem primum et universalissimum rerum auctorem. Dicitur igitur aliquid fieri ex nihilo, quando necessario effectivi nihil praesupponitur, ut materia vel subiectum ex quo res ipsa facta educitur" (*ibid.*).

[44] "Creari potest intelligi dupliciter ex nihilo. Uno modo in tempore, quia videlicet rem ipsam creatam nihil praecessit tempore […]. Alio modo non in tempore, sed ab aeterno, ipso nihilo praecedente non tempore, sed natura sive ratione nostra concipiendi, quo nonnulli mundum creatum esse ab aeterno aiunt ad mentem Aristotelis, quatenus ipsum mundum praecessit non esse secundum rationem tantum. Quaestio nostra quaerit de creatione quae fit in tempore de novo, et non eaterna. Quia de aeterna disputabitur in 8 huius [*viz.* Aristotle's *Physics*]" (*ibid.*, p. 107, col. 1).

not be any matter or substratum (*materia vel subjectum*). This conclusion implies an interesting departure from Aristotle's natural philosophy with respect to the 'coming-into-being' issue. A departure which rests chiefly on notions (God as *ens*, *creatio ex nihilo*, *creatio de novo*) whose metaphysical status is somewhat taken for granted by Nifo.

It should not come as a surprise, then, that a similar nonchalance in the use of such notions can be also found in popular works on natural philosophy written by the Jesuits. Let us consider Pererius's *De communibus*. As already illustrated in the second chapter (§5), this work was a standard textbook in the Renaissance. It was used as a thorough introduction to the study of natural philosophy. In this book, Pererius is very precise in distinguishing what concerns theologians and what (natural) philosophers, instead. The fifth book of the *De communibus* is about the first matter (*De materia prima et privatione*). The fifth chapter of this book covers the topic of creation (*De creatione*). Here, at the outset, Pererius notices that it is necessary to say something about creation before proceeding further in the investigation on the prime matter. In fact, if it is true (as Aristotle says) that matter is needed to allow any kind of production, then nothing can be made *ex nihilo*. Yet Christian theology teaches that, not only is creation *ex nihilo* possible, but it is also used by God in the production of things. And Christian theology cannot be mistaken. Therefore, in order to elucidate this theological claim in natural philosophy (*in Philosophia*), Pererius takes on three tasks: (1) to define the notion of creation; (2) to understand whether for Aristotle creation is possible; (3) to understand whether creation can be demonstrated by natural reason.[45] In effect, task 2 and 3 cannot be undertaken by those philosophers that do not bear in mind the correct notion of creation.

Pererius therefore proceeds by singling out five notions of creation,[46] the last of which is the one that theologians "philosophize" about (*haec Theologi de procreatione*

[45] "Hic locus nos admonet, ut prius quam progrediamut ad enodandas alias quaestiones quae de Materia prima propositae sunt, nonnihil dicamus de creatione. Etenim quae praecedenti capite posita sunt, ea videntur funditus tollere creationem. Si enim materia necessaria est ad cuiuslibet rei productionem, ergo non potest quicquam ex nihilo effici; cui necessario consequens est, nullam esse creationem. At Theologia Christiana, cui nullus error nullumque mendacium subesse potest, pro vero et certo docet, non modo possibilem esse creationem, sed ea plerunque usum esse Deum in rebus procreandis. Quare ut hunc etiam locum in Philosophiam illustremus, videamus primum quod sit creatio; tum an ea concedi et admitti queat secundum Aristotelis doctrinam; ad extremum an creationem esse possibilem, lumine naturae cognosci possit et manifestis atque necessariis rationibus demonstrari" (Pererius (1576), p. 171b-c).

[46] Cf. *ibid.*, p. 171c-d. The first four notions are the following: "[1] Una, nullam esse generationem; eorum videlicet qui faciebant omnia esse unum ens immobile. Quam sententiam Aristoteles attribuit Parmenidi et Melisso. [2] Altera, nihil de novo generari, sed generationem nihil aliud esse quam segregationem quandam et manifestationem eorum, quae prius erant permixta et abscondita. Quae sententia fuit Anaxagorae. [3] Tertia (quam perhibent fuisse Avicennae) formas naturales ex nihilo creari a quadam intelligentia, quae praesidens huic mundo inferiori, producit omnes formas intelligibiles, sensibiles et phisicas. Itaque agentia particularia tantum disponere materiam ad recipiendas huiusmodi formas. [4]

rerum et necessitate materiae gravissime verissimeque philosophantur). It says that creation must be divided in (1) creation of immaterial things and (2) creation of material things. The creation of material things must be further divided into (2.1) a first creation made by God in the beginning along with the production of the world; and (2.2) a second creation, that follows from the first one, as if it was propagated by the first one (*quasi per propagationem*). Furthermore, the first creation of material things (2.1) is made by God *ex nihilo*, in that it does not come from a preexisting matter or substratum. The creation that follows from the first one (2.2) is out of matter, and it is brought about by natural agents according to the ordinary law of nature (*ex materia, ab agentibus naturalibus secundum legem ordinariam*). Pererius clarifies that God has always the power to make instantaneously what takes time to be made through secondary causes. Thus, the creation *ex materia* can in any moment be made by God *ex nihilo*. Although this is a theological commonplace (the so-called "principle of immediacy"),[47] it is noteworthy that, with this clarification, Pererius is making the novices of natural philosophy acquainted with the distinction between *potentia Dei absoluta* and *ordinata*.[48]

As the chapter continues, Pererius teaches his readers in which sense to take the expression *ex nihilo*:

> Then, the expression '*ex nihilo*' does not indicate a substratum: in fact, how can nothing be the substratum of something? Nor it indicates a temporal order, such that it is necessary that what is created was nothing before it was created. [The expression '*ex nihilo*'] does only indicate the total absence of

Quarta, Aristotelis qui sensit omnes formas naturales et mortales produci ex materia, ab agentibus particularibus, et idem esse agens disponens materiam, et inducens formam. Vide Averroem septimo Metaphysicorum, commento 31."

[47] On this principle and its important consequences on the philosophy and theology of the fourteenth century, cf. Bianchi (1990), pp. 79-82.

[48] "Quinta [opinio de generatione rerum], nostrorum Theologorum, qui distinguunt res quae producuntur, in res [1] materiales et [2] immateriales; et rerum materialium productionem, in [2.1] primam quae initio simul cum molitione mundi a Deo facta est, et [2.2.] eam quae post consecuta est, quasi per propagationem. Et item potentiam Dei in absolutam et infinitam, atque in ordinariam et quae ad caussas secundas naturales temperata et accomodata est. His positis, convenienter iis quae in sacris literis scripta sunt, affirmant res immateriales creari a Deo, siquidem non possunt ex materia effici; tum aiunt primam rerum materialium productionem fuisse ex nihilo: cum enim simul cum ipsis rebus producta fuerit materia, non praecesserat aliquid ex quo ceu subiecto, tales res fieri possent. At caeteras productiones earum rerum, quae sunt veluti propagationes illius primae productionis, docent fieri ex materia, ab agentibus naturalibus secundum legem ordinariam. Secundum potentiam autem Dei absolutam, etiam nunc posse creari ex nihilo, propterea quod Deus sit agens liberum infinitae virtutis, et potens immediate, ac per se facere, quicquid fecit per caussas secundas. Haec Theologi de procreatione rerum et necessitate materiae gravissime verissimeque philosophantur" (Pererius (1576), pp. 171d-172a).

> substratum [*negatio subiecti*]. In this sense, 'creation out of nothing' means that creation was not made out of any sort of substratum or matter.[49]

Armed with the same distinction already found in Nifo, Pererius can finally goes on to address the other two problems enlisted above: is it possible to ascribe creation to Aristotle? Can creation be demonstrated? It is the duty of the natural philosopher to advance an answer to these questions.

As for the first question, Pererius claims that, on the one hand, it can be argued that Aristotle allowed *creatio ex nihilo*. On the other hand, though, Pererius shows that *creatio de novo* is rejected by Aristotle, because it stands in contrast with the fondative principles of Aristotle's natural philosophy.[50] In the last book of the *De communibus*, Pererius insists on this point, pushing hard on his conclusion against that of Aquinas (or at least a certain reading of it) and all those thinkers who thought that Aristotle never meant to demonstrate the eternity of the world. These thinkers used to leverage on a famous passage from the *Topics*, where Aristotle considers the controversy on the eternity of the world as a dialectical problem. According to certain interpreters, Aristotle knew that this kind of problems cannot be answered conclusively, and he adhered to this view in all his writings.[51] But Pererius refutes this conclusion: such interpretation would amount to a rejection of Aristotle's natural philosophy in its entirety, and it is therefore inadmissible.[52]

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[49] "Postea illa vox *Ex nihilo* non significat subiectum: qui potest enim quod est nihil, esse subiectum ullius rei? Neque significat ordinem temporis, ut necessarium sit quod creatur, prius fuisse nihil. Sed tantum indicat negationem subiecti, ut sensus sit, creationem fieri ex nihilo, hoc est non ex aliquo subiectum vel materia" (*ibid.*, p. 173b).

[50] *Ibid.*, p. 174d-175d.

[51] On the use of *Topics* 104b to interpret Aristotle's view on the deuration of the world, cf. Bianchi (1987), p. 13. See also *supra*, §4.

[52] Cf. Pererius (1576), p. 461a-c: "Verum, quia putant nonnulli Aristotelem, vel non sensisse mundum esse aeternum; vel ipsum certe non existimasse aeternitatem motus et mundi firmis, ac necessariis rationibus a se fuisse conclusam, atque demonstratam: sed eum contradicere tantum voluisse opinionibus antiquorum, qui aiebant Mundum ex materia per motum physicum esse procreatum. Hos falli, et doctrinae Aristotelis perspicue adversari, obiter ostendamus. Equidem non ignoro, multis videri posse D. Thomam, non multum ab illorum sententia abhorrere. Is enim 1. Par. [Summae theologiae] quaest. 46. art. 1 ita scribit… Sed, sive hoc D. Thomas illis verbis significare, sive aliud quidpiam innuere voluerit, mihi sane nunquam verisimile fieri potuit, quod illi aiunt. Quis enim, tantum non omnino rudis, et ignarus scriptorum, et doctrinae Aristotelis legens octavum librum Physicorum, primum librum de Caelo, extremam partem secundi libri de Generatione, et corruptione, posteriorem item partem duodecimi libri Metaphysicae, non aperte videat, si quod est dogma apud Aristotelem et Peripateticos, certum, et exploratum, firmum, ratum, et constitutum, hoc de aeternitate mundi, esse quam quod maxime? An non hoc uno maxime fundamento, nititur doctrina, quam is de caelo, de Intelligentiis, et Deo tradidit? Quis veterum Peripateticorum? quis etiam aliorum (his unius paucis exceptis) mundum aeternum esse secundum Aristotelem unquam dubitavit? Tolle aeternitatem motus, neque Intelligentias esse, neque aeternitas esse, nec immateriales, nec indivisibiles, nec omnis expertes potentiae, nec intelligentes, nec optimam dispositionem, ac statum habere, probavit Aristoteles: cum haec omnia ex motus aeternitate concluserit. Tolle aeternitatem motus, necesse est admittere

As for the problem concerning the possibility of demonstrating creation, Pererius holds, like Aquinas, that *creatio ex nihilo* can be demonstrated. He points out eight arguments whereby *creatio ex nihilo* can be demonstrated. Arguments 3 to 5 are the most relevant here, because they call on the idea of God as a *primum ens*:

> 3. The way of acting follows the way of being. The action of a thing is of the same kind as the being of that thing. But the being of God does not depend on anything, and it requires and needs nothing. Accordingly, neither does His action [require or need anything].
> 4. Everyone has imprinted in their soul this infinite notion of God as *primum ens*, which is perfect, depending on nothing, self-sufficient, lacking-nothing. Accordingly, His action is also self-sufficient and does not need [to be exerted upon] a substratum.
> 5. God is the cause of everything. Otherwise, if God did not exist, a thing would be without a cause, that is, it would have its being [*esse*] by itself, which is not possible, since this would mean that not everything depends on God. But there are many things that could not have their being by God out of nothing and through motion, such as the first matter, the skies and the intellects. Hence, [they had their being] through creation. If you say that this means that things have their being by God from eternity, I reply that this is not against creation, whose meaning is that it is from no substratum, not that it is made *de novo*, or that what is created was not existing before, according to duration. Neither creation from eternity and its conservation require less power than creating *de novo*.[53]

The notion of *primum ens* is pivotal to prove creation *ex nihilo*. Just like Nifo, Pererius too takes this notion for granted. He says that everyone is naturally endowed with this "infinite notion," which is imprinted in the soul.

There are enough elements to think that the '*primum ens* argument' was a standard repertory argument in the late-Renaissance expositions of Aristotle's natural

creationem; quam ne cognitam quidem fuisse Aristoteli, nedum ei probatam, quinto libro huius operis ostendimus."

[53] "3. Modus agendi, sequitur modum essendi, et quale est esse quiusque rei, talis est actio. Sed Deus in esse a nullo pendet, nihil praerequirit, aut praesupponit, ergo nec in agendo. 4. Hanc omnes habent notionem Dei naturaliter animis infinitam et impressam, Deum esse ens primum, perfectum, a nullo pendens, per se sufficiens, nullius indigens, ergo per se sufficit ad agendum, nec eget subiecto. 5. Deus est caussa omnium rerum. Alioquin praeter Deum esset aliquid sine caussa, habens esse a se, quod fieri non potest, non enim omnis penderent a Deo. Sed multa sunt, ut materia prima, caeli, intelligentiae, quae non potuerunt habere esse a Deo ex materia per motum, ergo per creationem. Si dicas huiusmodi res habere esse a Deo ab aeterno, respondeo id non obstare creationi, in cuius ratione ponitur ut sit ex non subiecto, non ut fiat de novo, vel ut quod creatur prius duratione fuerit non ens. Nec minoris sane virtutis est ab aeterno aliquid creare et conservare posse, quam de novo" (*ibid.*, p. 176c-d).

philosophy. Confirmation in this regard is provided by another Jesuit commentary on the *Physics*. The Jesuits of Coimbra resort to a similar order of exposition. They first clarify the distinction between *creatio ex nihilo* and *de novo*, then they apply it to the understanding of Aristotle's position in this matter, and finally use it to formulate two different questions: one, as to whether it is possible to demonstrate *creatio ex nihilo* by the natural light of reason; the other one, on the possibility of demonstrating *creatio de novo* by the natural light of reason.[54]

As already shown (§5-7), there was no unanimity, even amongst the Jesuits, on how to answer the second question. And this might explain why the bull *Apostolici regiminis* does not compel natural philosophy professors to provide a demonstration of *creatio de novo*, but it requires them to persuade their disciples that the world had an unprecedented beginning, while dissuading of the contrary.

On the other hand, the question on the possibility of demonstrating *creatio ex nihilo* was unanimously answered as affirmative. And, as I said, one of the arguments upon which this conclusion rested, was formulated in a standard fashion by appealing to the notion of God as *primum ens*. The Jesuits of Coimbra put it as follows:

[54] Cf. *Conimbricenses* (1602), pp. 417-434. The title of questions II and III is the following: "Quaestio II. Utrum creatio naturae lumine cognosci potuerit, et an eam Aristoteles cognoverit"; "Questio III. Fueritne mundus ex aeternitate procreatus, an non." The second question is then divided into two further questions: "Alterum, quo anni tempore videatur mundus a Deo fuisse conditus. Alterum, an nova mundi creatio physicis rationibus demonstrari possit." And article 3 of question II replies that "Novam mundi creationem non posse Physicis rationibus demonstrari; licet ad eam suadendam probabilia argumenta suppetam." This conclusion is obviously constrary to that provided by Muzio Vitelleschi (cf. *supra*, §4). Concerning the difference between *creatio ex nihilo* and *de novo*, the Jesuits of Coimbra usually refer to the first one as "creatio absolute sumpta." In the beginning of Question II they clarify: "Non quaerimus de creatione rerum initio temporis exhibita, sed de creatione absolute sumpta; num videlicet haec innato rationis lumine absque divino afflatu cognosci quiverit." Addressing Question I ("Quid creatio sit, et quo pacto a conservatione distinguatur"), they had already established that "creationem esse alicuius e nihilo productionem." They distinguished two senses of *creatio ex nihilo*: "Sciendum vero est creationis nomen dupliciter accipi: nonnunquam proprie, interdum fuse." The first one (*proprie*), is defined as the creation out of nothing of entities that can sustain themselves (like the angels and the celestial bodies). The second one (*fuse*), includes the creation out of nothing of those things that are codependent upon something else and cannot sustain themselves: "Si igitur iuxta priorem acceptionem creatio spectetur, hic erit propositae definitionis sensus: creatio est actio, qua quippiam per se subsistens producitur ex nihilo; id est, ita ut nihil eius praecesserit. Sic vero nec materia nec formae Physicae, excepta rationali, creari dicuntur, quia non sunt res per se, ac propria vi substinens. Nec item homo, qui ab alio gignitur, propterea quod licet is per se cohaereat, et materia ac forma, ex quibus coalescit, non nisi per creationem existant; tamen cum totum ipsum emergit, aliqua eius pars antecesserat, nempe materia initio mundi a Deo producta. Si autem creatio posteriori modo sumatur, amovenda erit ab eius definitionis particula 'per se substinens' sicque censebuntur creari quaecunque nullo praeiacente subiecto fiunt, sive per se cohaereant, sive non." This is not dissimilar from Pererius's distinciton between the creation of immaterial things on the one hand, and the creation of material things on the other.

> Since nothing except God has a being that is perfect in every respect [*omnibus numeris*], but rather it has an imperfect and participated being, then no creature can be by itself [*esse a se*], and so by necessity its being derives from a superior cause, namely, from the first and most perfect *ens* [*a primo et perfectissimo ente*]. [This *primum ens*] houses the being [*esse*] in an essential and absolute way, as its prime origin. From this, it must be gathered that the origin of everthing is from God. Furthermore, certain things, like the prime matter, the intellects, and the rational soul, can be produced only through creation, as they cannot be made by second causes, nor are they made out of an already-existing substratum. Hence, [they are produced through creation]. For this reason, it is possible to grasp creation by natural light of reason, as this arguments [*rationes*] – which we have tried to provide without the aid of the divine faith – can be looked for and found by natural reason, as it will be clear to those who consider this matter.[55]

Francesco Buonamici – one of Galileo's professors in Pisa[56] – was also acquainted with this stock argument. But his position is quite unique in this regard, and therefore it deserves special attention.

So far, I sought to show that natural philosophers of the late Renaissance were supposed to work with theological notions which had taken a great deal of time and philosophical effort before acquiring a well-defined metaphysical import. Natural philosophers were now in the position to apply with relative facility these notions to the solution of certain problems, such as the elucidation of Aristotle's position on creation, or the controversy on creation *ex nihilo* and *de novo*. These problems and notions fell within the scopes of a natural philosopher.

Buonamici, on the contrary, fights against the custom of transposing theological notions into the field of natural philosophy. The conceptual tools developed in theology are of no use in physics. As shown by Mario O. Helbing, Buonamici defends a sharp demarcation of ambits which is based on a particular understanding of the *methodus* of natural philosophy.[57] The first axiom (*principium*, *effatum*) of natural philosophy says that one must abide by the judgment of sense experience (*standum esse*

[55] "Cum nihil praeter Deum habeat esse omnibus numeris perfectum, sed imperfectioni admistum et participatum, nulla creatura potest esse a se, ac proinde necessario suum esse mutuabitur a superiori caussa, id est, a primo et perfectissimo ente, in quo ipsum esse, ut in primaeva origine absolute, et essentialiter inest. Oportet igitur res omnes a Deo ortum ducere. Praeterea earum rerum nonnullae, ut intelligentiae, ut materia prima, ut anima rationalis, non nisi per creationem produci possunt, cum nequeant a causis secundis effici, nec fiant e praeiacente subiecto. Ergo, etc. Quare potest naturali lumine creatio deprehendi. Siquidem hae rationes, quibus eam dari astruximus citra divinam fidem, ipso ductu naturali luminis investigari, atque inveniri queunt, ut consideranti planum erit" (*ibid.*, p. 425).

[56] On Buonamici, cf. Helbing (1989), Camerota-Helbing (2000a), and Camerota (2007).

[57] Cf. Helbing (1989), pp. 77-103.

iudicio sensus).[58] But when the principle *ex nihilo nihil* is refuted through arguments that leverage on the notion of *primum ens*, that first axiom gets trespassed and perverted along with all the other principles that make up the *methodus* of natural philosophy. Buonamici does not doubt that, through their pious study, many righteous men (*sanctissimi viri*) are able to reach the conclusion they aimed for. And he does not deny the importance of their inquiry into creation *ex nihilo*. Nor does he intend to depart from what religion has decreed (*quod religio iussit*). He only doubts that it is possible to demonstrate creation in natural philosophy (*tantum dubito physice ne confici queat*).[59]

The arguments Buonamici argues against are 'bricolaged' almost verbatim from Pererius, quoted above.[60] But the latter is not mentioned by Buonamici. In other occasions, instead, Buonamici rails explicitly against Pererius.[61] To my mind, Buonamici has no reason to refer only to Pererius in this matter. He is likely aware that the arguments reported by Pererius were standard at the time. His purpose is to contest a widespread practice. To this end, he spells out the flaws of the *primum ens* arguments.

One flaw (*vitio*) is particularly interesting. Buonamici describes it as the fallacy of *secundum quid* ("*peccatum a secundum quid ad simpliciter*"). This fallacy becomes evident especially when *creatio ex nihilo* is inferred from assuming that God, *being* perfect, contingent on nothing, self-sufficient, and lacking nothing, can also *act* likewise. In effect, to what extent is a natural philosopher allowed to say that God acts perfectly, self-sufficiently, and so forth? In keeping with sense experiences and logical inferences, a natural philosopher can only infer that God is a perfect agent (*agens*) with respect to a contemplative kind of action. Experience shows us that there can be different kinds of action, such as motive and contemplative actions. But we can also experience that the only action that need not be performed onto an external subject, is

[58] Cf. Buonamici (1591), p. 6e, and Helbing (1989), pp. 79-80.

[59] "Neque vero hic ego dubitabo, quin studio pietatis adducti sanctissimi viri conferant in hunc locum suos conatus; neque studium reprehendo. Mihique ab ijs non recedere certum est in eo quod religio iussit. Sed quantum ego rem ita se habere novi, tantum dubito physice ne confici queat." (Buonamici (1591), p. 20g-h)

[60] Cf. the following passage (from *ibid.*, p. 20h) with Pererius (1576), p. 176c-d (quoted *supra*, nt. 53): "Haec vero inter alia afferuntur: I. [= 3 in Pererius] Modus agendi sequitur modum quo res est: et quale est esse cuique rei, talis est actio. Sed Deus in eo quod est, a nullo pendet, nihil praerequirit, aut praesupponit; ergo nec in agendo. II. [= 4 in Pererius] Haec est etiam notio Dei naturaliter animis insita et impressa: Deum esse ens primum, perfectum, a nullo pendens, per se sufficiens, nullius indigum; ergo per se sufficit ad agendum; itaque non eget subiectum. III. [= 5 in Pererius] Affertur et illud: Deum esse caussam omnium rerum; ceteroqui praeter Deum aliquid esset sine caussa, habens esse a se. Id vero fieri nequit, neque omnia penderent a Deo. Sed multa sunt, ut materia prima, caeli, mentes beatae, quae non potuerunt habere esse a Deo ex materia per motum; per creationem igitur. Quod si accipias huiusmodi res habere esse a Deo ex aeterno tempore. Atqui id creationi non obstat: eius enim ratio posita est in eo quod fit ex non subiecto non autem quod de novo existat. Immo si potuit hoc ex aeterno tempore efficere, poterit etiam nunc et forte multo magis; et quo aeternum non aeterno difficilius est."

[61] See, for example, Helbing (1989), pp. 90-93.

the contemplative one. The latter is therefore the only perfect, contingent-on-nothing, and self-sufficient action that a natural philosopher is allowed to ascribe to God. This is the kind of perfect action proper (*actio propria*) to God as distinguished from actions that can be commonly performed by other natural beings (*actiones communes*) and that, for the physician, cannot be performed *ex nihilo*:

> We clearly concede that God is the *primum ens*, having everything perfectly [*omnium absolutissimum*], and lacking nothing. We also concede that He does not need a substratum in order to act. But we add that He does not need a substratum when he accomplishes His proper action, which is contemplation. For, if it was a common action, the natural philosopher [*physicus*] would still ask for a confirmation for this assumption – and we deny that this assumption can be confirmed by our senses [*a sensu*].[62]

It is not difficult to see a certain irony hidden in Buonamici's criticism. Pererius, who wrote a book entitled *On the Common Principles and Properties of All Natural Things* (*De communibus omnium rerum naturalium principiis et affectionibus*), is not able to distinguish between an action 'proper' to God and other actions that are 'common.' Also, he does not realize that not all kinds of action can be efficient causes. The perfect and self-sufficient action of God within the reach of natural philosophy is the contemplative one, which according to Buonamici must be regarded as a final cause.[63] In natural philosophy, then, the metaphysics involved in the notion of *primum ens* must be disregarded. The creation problem simply does not concern the natural philosopher (*physicus*):

> These things are not said by us in such a way that is meant to dismiss creation; rather, they are said so that you can see that creation has not been acknowledged by Aristotle and natural philosophers. Also, we say these things so that you recognize that the principles [*initia*] of our salvation are beyond the reasons that can be reached by the natural phylosopher through sensitive experience.[64]

[62] "Damus enim plane Deum esse ens primum, omnium absolutissimum, nullius indigum, et non egere subiecto ad agendum. Sed addimus ad praestandum propriam actionem quam dicimus esse contemplationem. Quod si fuerit actio communis, adhuc exquiret physicus confirmationem talis assumpti, quam a sensu peti posse negamus" (Buonamici (1591), p. 21b).

[63] On Buonamici's idea of God as the final cause of the universe, see Helbing (1989), pp. 331-342.

[64] "Haec non eo dicta sunt a nobis ut creationem everteremus, sed ut ab Aristotele et physicis haud approbatam fuisse perspiceres et agnosceres altius sese extulisse nostrae salutis initia quam ut a physico rationibus quae sensu niterentur, attingi possent" (Buonamici (1591), p. 22e). Cf. also Helbing (1989), p. 82.

§21.
CREATIO *EX NIHILO* AND THE *PRIMUM ENS* IN GALILEO'S *JUVENILIA*

Some scholars have suggested that Buonamici's antitheological approach was also employed in his lectures on natural philosophy.[65] The suggestion is plausible, but, unfortunately, it cannot be confirmed, since the *reportationes* of Buonamici's lectures are not extant. The passages quoted above are from his *De motu libri decem*, an enormous work that took several years before Buonamici was able to finish it in 1587 and publish it in 1591. Also, it must be noted that – as Buonamici himself says and Helbing accurately reports – the development of Buonamici's *methodus* of natural philosophy was not immediate.[66] It likely took Buonamici some time and a lot of effort (*summo studio*) to finalize the *De motu*, whose main purpose is indeed to illustrate and then make use of the correct *methodus* of natural philosophy. Given that his reflections upon the distinction between the purviews of theology and natural philosophy rest on such a *methodus*, it seems appropriate to assume that those reflections also came with time. Perhaps, then, Buonamici's lectures prior to 1587 were not original, but standard, so to speak. His accurate knowledge of Pererius's *De communibus* is perhaps the result of an extensive use of Pererius's textbook in his lectures. The *primum ens* argument might have been included into Buonamici's lectures without criticism, as part of a common way of teaching natural philosophy. A common way that took hold well before Buonamici and Pererius. As we have seen, Agostino Nifo himself, who taught natural philosophy at Pisa (from 1519 to 1522),[67] resorted to this argument. Because of these and other reasons, as of today there is no sufficient ground to dismiss Antonio Favaro's suggestion that Galileo's *Juvenilia* were compiled from Buonamici's lectures prior to 1587.[68]

In the *Juvenilia*, there is an extensive treatment of the creation problem, whose solution is pivoted on the notion of God as *primum ens*. First, Galileo shows that "it is necessary to posit some uncreated and eternal *primum ens* on whom all others depend, and to whom all others are orderly arranged as to an ultimate end" (*aliquod primum ens increatum et sempiternum, a quo cetera omnia dependeant, et ad quod tanquam ultimum finem ordinentur*). Second, he shows that, not only is this *primum ens* an uncreated and eternal final cause, but it must also be the efficient cause (*causa effectiva*)

[65] See, for example, Camerota (2004), pp. 42-43.
[66] Cf. Helbing (1989), pp. 77, 83.
[67] By then, he had already published in 1508 his commentary on the *Physics*, which was completed in 1507 in Sessa.
[68] Cf. OG, I, p. 12. On this, see my arguments in Malara (2019).

of all that exists (*totius esse simpliciter*). Third, Galileo resorts to a metaphysical argument and says that "the essence of this uncreated *primum ens* is its being, and therefore is infinite, and has infinite capacity and power" (*hoc ens primum et increatum habere esse per essentiam, ac proinde esse infinitum, et habere virtutem ac potentiam infinitam*). So, no wonder that this *primum ens* can produce an effect from the most remote potency, that is, *ex nihilo* (*non erit mirum si ex remotissima potentia, hoc est ex nihilo, poterit producere effectum*). Fourth, the *primum ens*, namely God, can act "freely and without necessity *ad extra*" (*libere et contingenter operari ad extra*). This allows for two further conclusions. The first one is that the *primum ens* is capable of creating the world *de novo*. The second one is that the *primum ens* did actually (*de facto*) create the world *de novo*. The last conclusion is not demonstrable in philosophy, but it is true according to faith (cf. §6). Besides, the world must have been created by God in time (*in tempore*), so that the human mind can be reminded of the divine attributes of God while contemplating the world.[69]

This exposition stands clearly at odds with Buonamici's idea of God and the demarcation of ambits held in the *De motu*. But is this enough to conclude that the sources of Galileo's *Juvenilia* must have been theological in orientation? As I tried to show, natural philosophers at Galileo's time were trained to deal and work with notions derived from theology and characterized in a precise metaphysical fashion. Pererius's *De communibus* was a manual designed to be adopted by any university professor of natural philosophy, including those who were not affiliated to the Roman College. It is likely, then, that Buonamici or other Pisan professors relied to some degree on Pererius's *De communibus* in their lectures. Therefore – provided that the historian should at least try to avoid giving credit to conclusions that are methodologically flawed – the fact that the *Juvenilia* bear textual similarities with Roman College textbooks cannot be regarded as strong enough evidence for a *direct* link between the

[69] Cf. OG, I, *Juvenilia*, pp. 24-27. It must be noted that Wallace's translation of these passages is often inaccurate. Just to make an example, the formula "habere esse per essentiam" is translated by Wallace as follows: "this first and uncreated being *has existence through its essence*" (Wallace (1977), p. 40, emphasis mine). As Wallace put it, the sentence means that the *primum ens* has its existence, or being, *thanks to*, or *by means of*, its essence. This, however, is exactly the opposite of what Galileo says. Resorting to the traditional distinction between (*a*) *esse per essentiam*/*esse per participationem* and (*b*) *esse*/*essentia*, Galileo says that the *primum ens* does not depend upon another being, in that its essence is its being. This thesis that can be easily traced back to Aquinas's *De ente et essentia* (cf. Porro's introduction to Aquinas (2017), pp. 27-33, and the general overview provided by Wippel in Wippel (1993), pp. 99-107). I am therefore surprised that Wallace incurred in such a slip. It is quite obvious that in Galileo's sentence the preposition '*per*' cannot be taken as a clause expressing a means (e.g., *through essence*). It should be rather understood as a clause expressing a way of being (e.g., *essentially*, or *in essence*). Because of this, I have translated that sentence less literally, but – I believe – more accurately ("the essence of this uncreated *primum ens* is its being").

Juvenilia and the Roman College.[70] Such a link can very well be *derivative*. It can very well be explained by showing that many of the arguments of the *Juvenilia* are repertory arguments, that also happened to be exposed in the Renaissance with the aid of textual bricolages. Because of this, they cannot be easily traced back to a precise direct source.[71]

As a consequence, the practice encouraged by some scholars – such as Adriano Carugo, Alistair C. Crombie, and William A. Wallace – to determine the dating of the *Juvenilia* according to the publication date of their alleged sources, should also be reconsidered.[72] The only conclusive result in this regard is that the *Juvenilia* were certainly composed after the 1581 edition of Clavius's *Sphere*. Another book that Buonamici – as well as many other natural philosophers – knew very well.[73]

We must therefore admit that we are fully in the dark about the direct sources of the *Juvenilia*. This admission of ignorance is not for granted nowadays – given that many modern scholars have the habit to directly and uncritically link the *Juvenilia* to Roman College sources – and it requires a good deal of painstaking historical work. Although my analyses are but a beginning in this regard, my hope is that for now they can sufficiently show that the relationship between Galileo and Jesuit sources is more complicated and fascinating than it is usually presented.

[70] After all, something similar was already said by Eugenio Garin, although his remark concerned Favaro's opinion: "In verità se il confronto degli appunti di Galileo con i testi del Buonamici fosse stato condotto più a fondo, e se si fossero presi in mani più testi analoghi, le dipendenze sostenute dal Favaro, e poi da quanti lo hanno ripetuto, si sarebbero dimostrate molto generiche. Questo non significa, ben inteso, negare la possibilità che si tratti veramente di corsi del Buonamici…" (Garin (1965), pp. 144-145, nt. 25).

[71] Cf. Malara (2019).

[72] Cf. Carugo-Crombie (1983), and Wallace (1984).

[73] Cf. Helbing (1989), pp. 195-203, 306-310.

Part Two

COSMOGONY

VI.
INTRODUCTION TO COSMOGONY AS A SCIENTIFIC PROBLEM

§22.
GALILEO, GOD'S CREATION, AND THE GOD OF CREATION

Galileo and God's Creation is the title of a paper written by Winifred L. Wisan and published in 1986. The thesis advanced therein is as much suggestive as controversial. Suggestive in that, according to Wisan, Galileo's troubles with the Church and Urban VIII were caused by Galileo's "own obsession" with the creation theme.[1] As Wisan puts it, "the real trouble was that Galileo – discoverer of a vastly enlarged cosmos and other wonders of the heavens – was quite sure that it was he himself who best understood God's creation. From his first to his last writings on motion Galileo's interest in the process of creation remained undiminished."[2]

From what has been said in the previous chapters, it is however clear that Wisan refers to a problem that has more to do with the theme of cosmogony ("process of creation") than it has to do with creation. In fact, apart from the *Juvenilia*, any reference to the creation problem is absent in Galileo's writings, although the difference between creation *ex nihilo* and *de novo* was certainly known to him. Also, no room is given by Galileo to the notion of God as *primum ens*, which was often used in natural philosophy discussions on creation.[3]

To my mind, Galileo's position in this regard should be regarded as an original and conscious departure from the metaphysical subtleties involved in the creation problem and in the notion of *primum ens*. Buonamici, who expunged the creation problem from natural philosophy, nonetheless allowed the natural philosopher to speak of God as the *primum ens* within certain limits. That is, the natural philosopher was only allowed to conceive of the *primum ens* as the most perfect and absolute

[1] Cf. Wisan (1986). Here we read that "Since neither Galileo's friends nor those of the Curia had any desire to make the story public, the true cause of the papal fury – and Galileo's condemnation – is still frequently misunderstood. Once it is made clear, however, the pope's behavior before Galileo's trial, as reported by the Florentine ambassador to Rome, becomes more intelligible and Galileo's *own obsession* more striking" (*ibid*., p. 483; emphasis mine).

[2] *Ibid*., p. 486.

[3] Although a thorough study on Galileo's idea of God is still missing today, it can be however already pointed out with certainty that the expression '*primum ens*' appears only in the *Juvenilia*.

contemplative agent, best understood as the final cause of the universe. Galileo is more radical: he seems genuinely disinterested in God as the first *being*.

It is widely known that, in his original writings, Galileo forsakes the inquiry into the essence of things. In the *Letters on Sunspots* (1613), this view is made explicit from the incipit of the third letter.[4] Here, Galileo holds that it is impossible to know the essence of nearby objects, because it would require an endless type of inquiry. From this, he concludes that it is equally, or even more impossible to know the essence or substance of celestial objects like the Sun. Nonetheless, the "properties" (*affezioni*) of natural objects, "such as their location, motion, shape, size, opacity, mutability, appearance and disappearance," (*come il luogo, il moto, la figura, la grandezza, l'opacità, la mutalibilità, la produzione, e il dissolvimento*) can be profitably studied. They can indeed provide the means to "better philosophize" (*meglio filosofare*) about other and more controversial "conditions" (*condizioni*) of natural substances. Also, according to Galileo, this is what gives us the hope (*speranza*) that in the afterlife (*sollevandoci all'ultimo scopo delle nostre fatiche*) it will be possible for us to comprehend all other truths *in* God (*in lui*), the "divine Craftsman" (*divino Artefice*), "source of light and truth" (*fonte di luce, e di verità*).[5] It seems likely to me that this peculiar epistemological standpoint allows Galileo to shrug off the notion of God as *primum ens*, which is described in the *Juvenilia* as the being that "*habet esse per essentiam*." It must be noted, however, that in the passage I have just paraphrased Galileo is replying to the following observation by Marc Welser:

> I will be so bold as to say that Your Lordship's [viz. Galileo's] discourses proceed with great verisimilitude and probability. *That they arrive precisely at the*

[4] For an accurate English translation of and introduction to the *Letters on Sunspots*, cf. Galilei-Scheiner (2010). On the history behind the publication of the *Letters on Sunspots,* see also Stabile (1994), pp. 38-46.

[5] "Perché, o noi vogliamo specolando tentar di penetrar l'essenza vera ed intrinseca delle sustanze naturali; o noi vogliamo contentarci di venir in notizia d'alcune loro affezioni. Il tentar l'essenza, l'ho per impresa non meno impossibile e per fatica non men vana nelle prossime sustanze elementari che nelle remotissime celesti: e a me pare esser egualmente ignaro della sustanza della Terra che della Luna, delle nubi elementari che delle macchie del Sole […]. E nell'istesso modo non più intendo della vera essenza della terra o del fuoco, che della Luna o del Sole: e questa è quella cognizione che ci vien riservata da intendersi nello stato di beatitudine, e non prima. Ma se vorremo fermarci nell'apprensione di alcune affezioni, non mi par che sia da desperar di poter conseguirle anco ne i corpi lontanissimi da noi, non meno che ne i prossimi, anzi tal una per aventura più esattamente in quelli che in questi. […] Voglio per tanto inferire, che se bene indarno si tenterebbe l'investigazione della sustanza delle macchie solati, non resta però che alcune loro affezioni, come il luogo, il moto, la figura, la grandezza, l'opacità, la mutabilità, la produzione ed il dissolvimento, non possino da noi esser apprese, ed esserci poi mezi a poter meglio filosofiare intorno ad altre più controverse condizioni delle sustanze naturali; le quali poi finalmente sollevandoci all'ultimo scopo delle nostre fatiche, cioè all'amore del divino Artefice, ci conservino la speranza di poter apprender in Lui, fonte di luce e verità, ogn'altro vero" (OG, V, pp. 187-188). English translation in Galilei-Scheiner (2010), pp. 254-255.

> *truth human frailty cannot affirm, until Blessed God permits us to survey from above what now we contemplate from below, in this vale of misery.*[6]

Galileo is therefore trying to prevent his correspondent Welser from adhering to a sort of epistemological skepticism that would question the objectivity of all of Galileo's scientific findings.

William A. Wallace tried to show that Galileo's ideal of science "received its preliminary formulation within a scholastic context provided by the Collegio Romano."[7] Wallace aligned Galileo's view in the *Letters on Sunspots* with that ascribed to Aquinas in the *Juvenilia*, according to which – Wallace wrote – "the substantial forms of the elements are hidden from us."[8] Unfortunately, Wallace referred here to a passage of the *Juvenilia* that bears several lacunae, which he himself had filled in between square brackets as follows: "the forms of the elements are substantial forms hidden from us [but knowable through their] qualities."[9] As we shall see (§30), this is a common (Averroist) viewpoint in the Renaissance, also adopted by Girolamo Borro, another professor of Galileo at Pisa. One of the issues at stake was that there are no *names* for the substantial forms of the elements, although they are often and mistakenly named after their primary qualities. For thinkers like Borro, it is however possible to attain a certain knowledge of the hidden substance or essence of the elements from what is best known to us (*notius a nobis*), i.e., qualities and capacities (*facultates, potestates, virtutes, vis*).

In the light of this, it is manifest that Galileo's epistemological position differs quite heavily from that reported in the *Juvenilia*. For Galileo, the properties of things have no bearing on the knowledge of substances, the latter being simply unachievable by natural reason. However, Wallace insisted that the Jesuit Giuseppe Biancani was also convinced, like Galileo, that "a true knowledge of material substance can never be attained."[10] Wallace's reference is to a passage from Biancani's *De mathematicarum natura dissertatio* (1615), where the Jesuit claims that, even if someone thinks that the subject of mathematics are accidents, it is however *better* to know many truths about an accident *than* to consider thousands of opinions on the material substance without

[6] *Ibid.*, p. 252, my emphasis, and OG, V, p. 184.

[7] Wallace (1984), p. 338.

[8] *Ibid.*, p. 290, nt. 12.

[9] Wallace (1970), p. 188 (cf. OG, I, *Juvenilia*, p. 130: "Quarta opinio est dicentium, formas elementorum esse formas substantiales …… qualitates nobis occultas").

[10] Wallace (1984), p. 290, nt. 12. This note is used by Wallace to provide evidence for the following claim: "Blancanus likewise makes much of the valuable information that can be provided by a study of quantitative *accidenti*, and scholastic philosophers were quite agreed that knowledge of the true natures of materials substances is indeed beyond human grasp."

ever reaching a conclusion about it.[11] Biancani's statement comes as a rhetorical reply against a certain slander (*calumnia*) concerning the status of mathematics on the part of its subject. The reply is therefore particularly (*praesertim*) limited to the consideration of the material substance (the subject of mathematics), and it is silent about the possibility of knowing the essence or (formal) substance of all things in natural philosophy.[12] This observation might appear to be a fruitless and nitpicking exercise of mine. Yet I am convinced that these details are essential to assess Galileo's epistemological standpoint.

If the reasons underlying Galileo's neglect of the notion of *primum ens* are epistemological in principle, the same could be claimed about the creation problem. Castelli's April letter in 1607 is to my mind a further testimony in this regard. At any rate, once it has been ascertained that Galileo is not interested in God's creation (*ex nihilo* and *de novo*), neither is he interested in the God of creation (the *primum ens*) and the metaphysics therein involved, a question arises spontaneously: *why* is Galileo so 'obsessed' with the cosmogony problem?

§23.
COSMOGONY AND GOD'S OMNIPOTENCE

Unfortunately, Wisan did not attempt to understand the reasons of Galileo's "obsession" with cosmogony. By so doing, though, she somehow revived an old controversial and apologetical claim that reduces the Galileo affair to a matter of obstinacy, stubbornness, and hubris on Galileo's side.[13] The latter, according to Wisan, was advised not to touch upon exegetical matters, and yet he kept behaving as the only one capable of understanding the creation account of the *Genesis*. This insistence led him inevitably to the tragedy we all know. Moreover, he clearly refused to endorse the position of Urban VIII, who told him that God's omnipotence allows for different

[11] "Decimaquarta [calumnia], subiecti ignobilitatem Mathematicis exprobant, quod videlicet sit accidens. Sed respondetur primo, quod quamvis sit accidens, est tamen immateriale, et abstractum, qua ratione inter subiecto Physicae, et Mathematicae collocantur. Secundo, melius esse de aliquo accidente veritates innumeras cognoscere, easque admirabiles, quam circa substantiam materialem praesertim, mille opinionum turbis ac dissensionibus perpetuo huc illuc agitari, neque unquam ad ullius substantiae cognitionem pervenire" (Biancani (1615), p. 26).

[12] On the status of mathematics in the late Renaissance, cf. De Pace (1993), and Van Dyck (2006a), pp. 41-65.

[13] For example, in the nineteenth century Henri de l'Épinois claimed that "Il [viz. Galilée] avait tort dans plusieurs de ses propositions, et sa conduite manqua souvent de prudence," and he reportes in note the opinion of Alberi, who in turn calls on Tiraboschi to claim that "il fervore e l'impetuosità sua [*viz.* di Galileo] contribuissero ad irritare gli avversari del sistema Copernicano» (cf. de l'Épinois (1867), p. 80). Against this reading, cf. Galilei (2009), pp. XXI-XXV.

conclusions on the real constitution of the universe than those inferred from scientific demonstrations.[14]

It is true – as recalled by Wisan – that in the *Dialogue*, after the exposition of the heliocentric cosmogony, where each planet acquires its own orbital speed *naturally* and through free fall, Galileo have his spokesman Salviati explain that

> I do not say, nor do I dare to say, that for God or nature it would be impossible to immediately confer that velocity, but I do indeed say that *de facto* nature does not do this. For, this would be an operation outside the natural course and therefore miraculous.[15]

However, in this regard it must be recalled what was already observed by Luca Bianchi twenty years ago. Galileo here resorts to an argument based on the traditional 'principle of immediacy.'[16] This argument is probably used by Galileo in a prudential and precautionary fashion in order to show that God's action is not bound by natural laws.[17] It must be also recalled, though, that the idea that God in the beginning arranged the universe through secondary causes was customary at Galileo's time among natural philosophers. As we have seen in Pererius's *De communibus* (§20), it was normal for a natural philosopher to clarify that God can however do without secondary causes.

As for the role of miracles in God's cosmogony, I would like, first of all, to draw attention to Benedictus Pererius's first volume of the *On the Genesis* (1589). This is the most influential work on the *Genesis* in the Late Renaissance, also known by Galileo by the time he wrote the *Dialogue*.[18] Pererius's interpretation of the *Genesis* is grounded in four principles or rules (*regulae*),[19] the first two of which say that: 1) Moses's account is historical and accommodated to the rough understanding of his Jewish readers;[20] 2) exegetes must not appeal to miracles and God's omnipotence unless they have good reason:

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[14] Cf. Wisan (1986), pp. 484-486.

[15] English version ap. Wisan (1986), p. 481. Cf. also Drake's translation in Galilei (1967), p. 21, and the original passage in OG, VII, *Dialogue*, p. 45. On this passage, see also Stabile (1994), pp. 60 and ff.

[16] Cf. Bianchi (2000), pp. 245-246.

[17] Cf. *ibid.*, p. 245.

[18] On the high influence of Pererius's commentary on the *Genesis*, see Williams (1937). Other interesting insights on the same commentary are in Blum (2014), esp. pp. 217-219.

[19] For a general overview on Pererius's rules, cf. Fabris (1986), pp. 30-31.

[20] "Prima regula. Doctrina Mosis, quae de oratione mundi iraditur, est plane historica. Narrat enim Moses mundum factum esse a Deo ex aliquo certo temporis initio; nec totum simul punto temporis esse conditum, sed per partes spatio sex dierum esse fabricatum. Confirmat hanc regulam Beatus Augustinus initio libri octavi de Genesi ad literam, ita scribens… [cf. *De gen. ad lit.*, VIII, 1.2 (slightly modified by

> In dealing with and explaining this doctrine of Moses, no appeal must be made without reason to miracles and to the absolute power of God. Some do it, instead, in an ignorant and inappropriate manner. Given that they are not able to provide a good and likely reason for their opinions, they take refuge in miracles and in God's omnipotence, like in a shelter.[21]

Pererius ground this principle on a passage from the second book of Augustine's *De Genesi ad litteram*:

> Since this [second] rule is sufficiently patent in itself, being worthy of the approval of anyone who is mentally sane, I shall confirm it with but a testimony from Augustine. In fact, at the outset of the second book of *De Genesi ad litteram*, when Augustine talks about the firmament, he teaches that it is necessary to disprove and bury, as it were, all those who deny that water can be above the sky without that involving miracles or God's omnipotence. Augustine says: "Nor should anybody try to refute them by appealing to the omnipotence of God, for whom all things are possible [cf. *Mark* 10:27], and saying that the waters above the sky are of the same nature as those placed above earth. Our business now, after all, is to inquire how God's scriptures say He established the natures of things, and not what He might wish to work in them or out of them as a miracle of His power."[22]

This is a 'meta-citation'; or better, it is a beautiful example of intertextuality. In fact, had Pererius kept the original passage in its entirety, we would have noticed that

Pererius)]. Ex his perspicue intelligitur, si narratio Mosis est historica, consequens esse, ut is proprius et germanus, atque, ut vocant, literalis, sensus sit verborum Mosis, quem reddunt verba eius secundum propriam, et vulgo usitatam eorum significationem accepta" (I quote from a later edition: Pererius (1607), pp. 22-23).

[21] "In hac Mosis doctrina tractanda et explicanda, non est sine causa recurrendum ad miracula, et ad potentiam Dei absolutam, sicut inscienter et inepte faciunt nonnulli, qui cum opinionis suae rationem idoneam et probabilem reddere non possint, quasi ad asylum, confugiunt ad miracula et omnipotentiam Dei" (Pererius (1607), p. 24).

[22] "Hanc regulam [secundam] ut satis per se manifestam, et cuius sanae mentis probabilem, non aliter confirmabo, quam unico Augustini testimonio: is enim initio libri secundi de Genesi ad literam, de aquis quae super firmamentum sunt disputans, docet eos, qui super coelo aquas esse posse negant, non esse miraculis et omnipotentia Dei confutandos, et tanquam obruendos. Sic enim ait: *Nec quisquam istos ita debet refellere, ut dicat secundum omnipotentiam Dei, cui cuncta sunt possibilia, oportere nos credere tales esse aquas super coelos quales sunt super terram. Nunc enim quemadmodum Deus instituerit naturas rerum, secundum scripturas eius nos quaerere convenit; non autem quid ipse in eis vel ex eis ad miraculum omnipotentiae suae velit operari*" (*ibid.*, pp. 24-25). I modified the English translation provided in Augustine (2002), p. 190, in accordance with the modifications made by Pererius himself.

Augustine has a precise locus of Scripture in mind. He says indeed that God is the Maker "*qui omnia in mensura et numero et pondere disposuit*."[23] Thus, Pererius's second rule can be ultimately grounded in an Augustinian reading of *Wisdom* 11:20 (Vulgate = 11:21), a locus dear to many seventeenth-century natural philosophers, including Galileo.[24]

Another principle (Pererius's fourth rule) – from which Galileo drawn heavily in his *Letter to the Grand Duchess Christina* –[25] is complementary to the second one:

> We must also take heed, in handling the doctrine of Moses, that we altogether avoid saying positively and confidently anything which contradicts manifest experiences and the reasoning of philosophy or the other sciences. For since every truth is in agreement with all other truth, the truth of Holy Writ cannot be contrary to the true reasons and experiences of human knowledge.[26]

These principles are repeatedly called on by Pererius with pronounced insistence. Especially the second one is used as a criterion to reject a good deal of previous interpretations, including some of those advanced by the Church Fathers.[27] In effect, although the principle was not original of Pererius – who indeed ascribes it to Augustine – his understanding of nature, natural order and laws, often differs much from that of previous exegetes. Yet they all seem to agree that the point of departure for a correct interpretation of the *Genesis* must involve a certain idea of nature, which is derived from the best available scientific knowledge of the time. As shown by Frank E. Robinson, this was a common view "consciously or unconsciously" endorsed by the first

[23] Cf. Augustine, *De gen. ad lit.*, II, 1.2. In this passage, Augustine is *not* saying that God never acts against nature in that He makes up nature, therefore His acts are all natural, although they might appear to be unnatural to us (cf. *Contra Faustum*, XXVI, 3: "Deus autem creator et conditor omnium naturarum, nihil contra naturam facit: id enim erit cuique rei naturali, quod ille fecerit, a quo est omnis modus, numerus, ordo naturae"). On the contrary, in the passage quoted by Pererius, Augustine says that God establishes a certain *ratio* in nature, which He does not trespass during the six-day arrangement of the world, although He could.

[24] Cf. OG, IV, *'Memoranda' for the Discourse on Floating Bodies*, p. 152.

[25] Cf. OG, V, *Letter to Christina*, p. 320. On Galileo's use of this rule, cf. Fabris (1986), p. 31-32, McMullin (1998), pp. 307-308, Galilei (2009), pp. 47-48, Damanti (2010), pp. 166, 168, 203-204, 427-428.

[26] "Illud etiam diligenter cavendum et omnino fugiendum est, ne in tractanda Mosis doctrina, quicquam affirmate et asseveranter sentiamus, et dicamus quod repugnet manifestis experimentis et rationibus philosophiae, vel aliarum disciplinarum: namque cum verum omne semper cum vero congruat, non potest veritas sacrarum literarum veris rationibus et experimentis humanarum doctrinarum esse contrariam" (Pererius (1607), p. 25). English translation from Drake (1957), p. 186 (slightly modified). The last part of this citation is clearly in line with the contents of the bull *Apostolici regiminis* (for references to the bull, cf. *supra*, §5).

[27] For example, cf. *ibid*., pp. 77-78, where Pererius rejects the opinions of Basilius, Gregory of Nazianzus, and Theodoret on the nature of the first light.

authors of the hexaemeron tradition. Pererius is simply applying it according to the latest findings in natural philosophy.[28]

For example, in commenting *Genesis* 1:9, Pererius reports the opinion of those who thought that the sea is considerably wider than the land, and therefore the water (of the sea) should be naturally located above the earth. However, God perpetually maintains the earth above the water, and in this sense it should also be read the divine command "let the waters under the heaven be gathered together unto one place, and let the dry land appear."[29]

This interpretation – ascribed to Basil, Aquinas, and Ambrosius Catharinus (Lancelotto Politi) – seems to be confirmed by what is said in the second book of the *De generatione et corruptione*. Here, Aristotle claims that the whole of water, being equal in amount to the whole of earth but less dense than the latter, should then be ten times ampler than the whole of earth.[30] Moreover, the interpretation is said to be in line with many passages of the Bible that mention the sea and that are aimed to show and exalt the "argument of the *omnipotentia Dei*." In effect, if the sea were not placed naturally above the earth, those passages would not yield the desired effect of astonishment and marvel (*quod sane non foret mirum, si mare non esset altius terra*).[31]

Pererius rejects this interpretation on all fronts. First, he cites Thomas Cajetan, who concurs with philosophers and astronomers in saying that such an interpretation is ridiculous. Cajetan concludes that "saying that the sea is kept above through God's omnipotence so as it does not fall to the ground, is foolish; and it is a sign of childish ignorance to concede without reason such a huge and perpetual miracle" (*dicere, mare omnipotentia Dei teneri ne defluat in terram, ineptum est et puerilis inscitiae, ponere sine causa tantum et tam perpetuum miraculum*).[32] This conclusion is obviously in line with

[28] Cf. Robbinson (1912), pp. 2 and ff. As for the Augustinian principle, Chenu notices that Andrew of Saint Victor "declared that before hasty recourse to miracles (*ad miracula confugere*) one must exhaust all the possibilities of natural explanation – a venerable Augustinian principle, but one which from now on became newly fascinated to apply" (Chenu, (1997), p. 17).

[29] Cf. Pererius (1607), pp. 113-114: "Fuere multi, et cum primis graves, atque nobiles Theologi, tam de veteribus quam de recentioribus, qui admirandam de situ maris et aquae praestituto illi a Deo, cum dixit aquis '*Congregentur aquae in locum unum et appareat arida*' habure opinationem: opinatur enim aquam maris esse multo altiorem quam est terra, eamque solo Dei praecepto teneri, ne ad humiliora loca quo naturaliter propendet defluens terram universam operiat et obruat."

[30] Cf. *Ibid.*, p. 114. On this important controversy and its Aristotelian origins, cf. Duhem (1913-1959), IX, pp. 79-235, and Grant (1984), pp. 20-32.

[31] "Hoc etiam maxime consentaneum esse sacris literis, ad hunc modum argumentatur: Ubicumque Scriptura loquitur de situ maris, tamquam miraculum quoddam et clarissimum omnipotentiae Dei argumentum magnificat ac praedicat, quod mare non se effundat in terras, easque omnes operiat et obruat. Quod sane non foret mirum, si mare non esse altius terra" (Pererius (1607), p. 115).

[32] *Ibid.*

Pererius's second principle outlined above. Pererius eventually shows that Scripture, along with mathematical and empirical evidence, confirm this conclusion.[33]

But the Jesuit insists. He takes the opportunity to demolish vehemently another interpretation provided by Paul of Burgos, who wanted to avoid the absurdities just described. According to Paul of Burgos, God created in the first day the whole of water in such a way that it covered the earth globe concentrically. But the third day, God divided water from earth so that the center of the sphere of water was separated from the center of the earth globe. In such a way, God provided earth and water with their own globular shape. Also, the two globes did not overlap. Water exceeded on one side and earth on the other. And this is how in *Genesis* 1:9 earth is said to have been separated from water, thereby allowing future profit for creatures.[34]

Pererius goes on to explain the rationale of this interpretation. And, I must say, Pererius's account of Paulus of Burgos's exposition is extremely fascinating, in that it couples astronomy and experience data on tides with a groundbreaking understanding of gravity, that – as we shall see in Chapter VIII – is tightly linked to a particular idea of cosmogony:

> However, Paul of Burgos says that it is impossible to attain proven and certain knowledge of the distance that separates the center of earth from the center of water. Yet it is possible to surmise as likely that the center of water coincides with the center of the Moon's eccentric orb. It is for this reason that water follows the movement of the Moon – as it is manifest from reasons and experiences –, especially during ebb and flow tides. Paul of Burgos adds that, since the water made at the beginning of the world was concentric with earth, it also had a natural capacity and inclination [*naturalis vis et propensio*] to strive towards the center of earth and [accordingly towards the center] of the world. But after the third day, water was separated from earth. And, having so lost its [initial] inclination, water acquired a new and very different inclination. Thanks to this new inclination, water does no longer incline towards the center of earth and of the world, but it inclines naturally [*naturaliter propendet*] towards the center of its own globe, made its own by water when the latter was separated from earth. From that moment until now, all waters, wherever

[33] Cf. *ibid.*, pp. 115-116.

[34] "Haec incommoda ut declinaret Paulus Brugensis, in alteram etiam magis absurdam opinionem incurrit. Ita enim in prima sua additione ad postillam Nicolai de Lyra super hunc locum Geneseos scribit: *In exordio mundi creatum esse a Deo elementum aquae circunfusum et concentricum terrae. Postea tertio die propter utilitatem usumque stirpium atque animantium, ita separatam esse aquam a terra, ut faceret aqua proprium globum, diversum a globo terrae, habentemque aliud centrum quam est terra et mundi centrum. Non quidem ita, ut globus aquae omnino esset extra globum terrae, sed ut eum secundum aliquam partem interfaceret*" (*ibid.*, p. 116).

> they are, have had a natural inclination and motion towards the center of the globe of water.[35]

Unlike the previous interpretation, this one does not appeal to a miracle perpetually carried out by God. In fact, the two elements, water and earth, move naturally (*naturaliter*) towards the center of their own sphere.

Pererius must have noticed this detail. Especially because of this, he must have thought it necessary to clarify that, also in this case, God's omnipotence is unnecessarily exploited to interpret *Genesis* 1:9. Pererius believes that God's creative action is unreasonably complex in Paul of Burgos's account. In his account, in fact, God first creates the world and nature in a certain order, and then decides to change it. Why? Pererius is certain that the answer is but one: because otherwise Paul of Burgos did not know how to explain *Genesis* 1:9. God's omnipotence is therefore used by the exegete so as to please his own ignorance. And this, instead of exalting God's omnipotence, comes out as an insult to God, whose power appears to be inexplicably capricious.

According to Pererius, not only is Burgos's opinion in contrast with the latest scientific findings,[36] but it also turns to the miraculous, just like the other one previously recalled:

> In order to refute these opinions, it suffices to say that their authors can only explain themselves and defend their opinions by resorting to miracles, which are not allowed by Philosophers. And Theologians, too, think that miracles cannot be taken into account without great reason or necessity, especially with respect to the creation of the world. In fact, it is very reasonable to believe

[35] "Quanto autem intervallo distent inter se centrum terrae et centrum aquae, ait [Paulus Burgensis], non posse explorata certaque ratione comprehendi. Posse tamen probabili coniectura existimari, esse idem centrum aquae atque est centrum orbis eccentrici lunae. Propterea quod aqua, ut multis constat argumentis et experimentis, sequitur motum lunae praesertim autem in fluxu et refluxu. Addit Burgensis, aquam initio mundi factam, quia erat concentrica terrae, habuisse tum naturalem vim et propensionem tendendi ad centrum terrae, et mundi. Sed eandem postea tertio die segregatam a terra, deposita prioria propensione, accepisse aliam longe diversam, qua naturaliter propendet, non ad centrum terrae et mundi, sed ad centrum eius globi, quem aqua proprium confecit a terris separata, ad quod centrum omnes aquae ubicumque sint, ab eo tempore usque adhuc, naturalem habent propensionem et motum" (*ibid.*).

[36] "Principio, potissimum e huius opinionis et eius [viz. Burgensis], quam proxime ante tractavimus, fundamentum atque firmamentum est, aquam esse longe maiorem quam est terra: quod falsum esse, et contra potius, terram esse multo maiorem aqua, manifestis firmisque rationibus ostendit Alexander Piccolomineus in libro quem sermone Italico edidit, de Quantitate terrae et aquae; idemque breviter, sed acute ac docte demonstravit Iulius Scaliger in opere exoticarum exercitationum, quod scripsit adversus Cardanum, exercitatione XXXIX..." (*ibid.* pp. 116-117).

> that, in the first establishment and arrangement of all things, God made, arranged, and located all things according to their own natures.[37]

And, after drawing support from Augustine's *The City of God*,[38] Pererius concludes by adding a final remark against Paul of Burgos:

> But in which sense does Paul of Burgos say that before the third day water had a natural inclination, motion, and center, all different from those it had after the third day, when water was separated from earth? From this, one should conclude that water was of a certain kind [*secundum speciem*] before the third day, and of another one after the third day. In fact, if its center, motion, and inclination, are different [before and after the third day], then it is also necessary that the two kinds of water had a different gravity [*gravitas*] and nature. But why are we wasting time with these superfluous arguments, when everything can be easily made clear through the certain judgment of senses and manifest experiences? It is evident in fact that when weights [*pondera*] of earth and water are lift and then let fall, they move perpendicularly and in a straight line towards the center of earth and [accordingly towards that] of the world.[39]

These reflections deserve a great deal of attention, especially when juxtaposed to Galileo's *Dialogue*. The idea of God included therein has been justly associated with the idea of "God as a geometer, creator of a *necessary* order in nature," as brilliantly illustrated by Massimo Bucciantini. But in my view this has also too easily led to the conclusion that it was this very same idea of God that "clashed with the frequent use of

[37] "Verum satis argumenti est ad confutandas istas opiniones, earum auctores non aliter eas tueri, ac seipsos expedire posse, quam confugiendo ad miracula, quae non concessissent Philosophi, nec Theologi, sine magna ratione ac necessitate, inducenda et admittenda censent, praesertim vero in creatione mundi, primaque omnium rerum institutione atque dispositione, in qua maxime consentaneum rationi est, credere Deum res omnes convenientes suis quasque naturis condidisse, disposuisse, atque collocasse" (*ibid.* p. 117).

[38] "Adversos istos etiam multum valet illa B. Augustini in libro septimo capitulo 30 de Civitate Dei sententia: *Sic Deus*, inquit Augustinus, *administrat omnia quae creavit, ut etiam ipsa proprios motus exercere et agere sinat*" (*ibid.*).

[39] "Iam vero, quale est illud quod Burgensis dixit, aquam ante diem tertium aliam habuisse naturalem propensionem, motumque, et aliud centrum, quam post tertium diem habuit, cum a terra est separata? Hinc enim necessario efficeretur, aliam fuisse secundum speciem aquam ante diem tertium, et aliam post diem tertium. Si enim centrum est aliud, alius motus, aliaque propensio naturalis, necesse quoque est, aliam utriusque aquae fuisse gravitatem, aliamque naturam. Sed quid hoc, rationibus supervacue argumentamur, quod certo sensuum iudicio et manifestis patet experimentis? Constat enim, ut terrae pondera itidem etiam aquae, superne delapsa directo et ad perpendiculum in terram, et in mundi centrum deferri" (*ibid.*).

miracles – especially on the Catholic side and in anti-Protestant function – as divine evidence for the true Church."[40]

It is undeniable that Galileo's notion of natural order differs from that endorsed by many Aristotelian natural philosophers.[41] And it is chiefly thanks to a 'mathematized' conception of the order of nature that Galileo's idea of a God-geometer fully emerged. But from this to the conclusion that the order is not contravened by God only *because* God is a "geometer," the step is too short to be historically accurate. My objective here is just to draw attention to one of the many nuances of history hitherto neglected.

Pererius is not Galileo. The two have very different ideas about the order of nature, about nature itself, and about God. And yet they both seem to share the same principle – Augustinian in origin, and (according to Pererius) commonly accepted by "Philosophers and Theologians" – which they both use to understand *how* God arranged the world. A principle that unfortunately happened to be in sharp contrast with Urban VIII's argument that leverages on the *omnipotentia Dei*.[42] All things considered, then, there are good reasons to claim that such a contrast was more than an idiosyncratic clash between two equally headstrong personalities, Galileo and Urban VIII.[43] Contrary to an old opinion somehow endorsed by Wisan, the Galileo affair does not deserve to be reduced to a psychological drama of conflicting characters.

§24.
COSMOGONY AND THE BIBLE

At least two other considerations ought to be gathered from a comparison between Galileo's and Pererius's approach to God's cosmogony. In the first place, in the *Dialogue* Galileo makes it explicit that his cosmogony is fashioned after Plato's cosmogonic myth. The same reference is included six years later in the *Two New Sciences*.[44]

[40] "L'idea galileiana di un Dio geometra, creatore di un ordine *necessario* nella natura, cozzava con l'uso frequente, soprattutto da parte cattolica e ora in funzione antiprotestante, dei miracoli come prove divine della vera Chiesa" (Bucciantini (2003), p. 331).

[41] On this, see Galluzzi (1979b).

[42] For an accurate assessment of the epistemological orientations of pope Urban VIII and Galileo, see Bianchi (2001) and Bianchi (2011).

[43] This is the thesis of Luca Bianchi, which I underwrite: "… la scelta di Galileo di fare di Simplicio il portavoce di Urbano VIII non è riducibile – come credeva de Santillana – a una 'tragica svista,' ma rappresenta una delle numerose spie del fatto che il loro non fu tanto uno scontro personale quanto un autentico conflitto teorico" (Bianchi (2011), p. 214).

[44] Cf. OG, VII, *Dialogue*, pp. 44, 53, and VIII, *Two New Sciences*, p. 284. Among Galileo's contemporaries, Mersenne and Chiaramonti raised some questions about the pertinence of Galileo's reference to Plato (cf.

Although this reference casted several doubts amongst Galileo's contemporaries, and it still does today, it is however important to notice that Galileo refers to Plato explicitly. Contrary to Pererius, Galileo introduces himself as an exegete of Plato, not of the Bible. His cosmogony is presented to the reader as the most accurate interpretation of a myth. A myth, indeed. Just as Pererius applies an historicist kind of interpretation to Moses's words, so too does Galileo with Plato. The difference is that Moses's words were inspired by God as expressions of the divine truth, whereas Plato's account is mythological ("poetical") in inspiration, as recalled by Galileo himself.[45]

To my mind, this provides evidence that Galileo learned and had never forgotten the lesson imparted to him (and Foscarini) by Robert Bellarmine in 1615.[46] Back then, he understood that it was no longer the case to get involved in exegetical matters. I believe that Galileo's reference to Plato in the *Dialogue* and the *Two New Sciences* should be also read in the light of the 1613-1616 events. In 1632 Galileo was indeed extremely careful not to present his cosmogony as an exposition of the *Genesis*.[47] Wisan's thesis falls short in this regard, too: Urban VIII had neither formal nor personal reason to infuriate against the interpretation of a myth.

Obviously, although Galileo associates his cosmogony with a myth, there is no doubt that he is deeply convinced of the truth of his cosmogonic account.[48] As such, it seems fair to assume that, for Galileo, his idea of cosmogony corresponds to the genesis account provided in the Bible. Hence, Plato's cosmogony can be reconciled with the *Genesis*. However, Galileo is prudent and wise enough not to spell that out in the *Dialogue* or the *Two New Sciences*.

There is yet an occasion where Galileo's speculations on cosmogony are more manifestly akin to the Bible. As I will show later (§44), Galileo's first cosmogony, included in the youthful and never published *De motu antiquiora*, echoes themes common to a certain hexaemeron tradition, especially with respect to *Genesis* 1:9. This cosmogony, probably ideated between 1589 and 1592, shares almost nothing with the

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Galilei (1998), II, p. 169). As for modern scholars' views on this point, see at least Sambursky (1962), Barcaro (1983), Dollo (2003), pp. 46-51, De Pace (2005). More on this *infra*, §50.

45 In the *Two New Sciences*: "Il concetto è veramente degno di Platone; ed è tanto più da stimarsi, quanto i fondamenti taciuti da quello e scoperti dal nostro Autore, con levargli la maschera o sembianza poetica, lo scuoprono in aspetto di verace istoria" (OG, VIII, *Two New Sciences*, p. 284). Already in the *Dialogue*, Galileo clarifies that some of his findings on motion are only used "to adorn a Platonic concept" (*per adornare un concetto Platonico*) (OG, VII, *Dialogue*, p. 53).

46 Cf. OG, XII, pp. 171-172. Cf. also Galilei (2009), pp. 157-159. For an English version of Bellarmine's letter, cf. Blackwell (1991), pp. 265-267.

47 More on this *infra*, §50.

48 In fact, according to Galileo his cosmogony can be demonstrated through laborious calculations (cf. OG, VII, *Dialogue*, p. 53; VIII, *Two New Sciences*, p. 284). Drake, Meyer, Büttner, and Bucciarelli have studied Galileo's attempts – contained in Ms. Gal. 72 – to calculate the height from which the planets fell (more on this later, §49).

more mature one of the *Dialogue*. As we shall see, the cosmogony of the *De motu antiquiora* is ultimately brought about by Galileo's attempt to answer the question as to why (*cur*) the elements are where they are and the earth stands still in the center of the universe. It is a geocentric cosmogony that does not concern the order of the planets, and that focuses instead on the order of the four elements. Last but not least, Galileo does not mention Plato.[49]

Paolo Galluzzi has glimpsed a common intent behind Galileo's geocentric and heliocentric cosmogony. Both cosmogonies may respond to a wider project of scientific reformation. They were developed by Galileo to prevent arguments based on the Bible from hampering his scientific project. Already in Pisa, Galileo somehow expected that theologians would have sooner or later risen up against his science.[50]

Galluzzi's thesis is noteworthy. It has the great merit of advancing for the first time an explanation about Galileo's constant interest in the cosmogonic theme. In what follows, I do not mean to put forth an alternative to Galluzzi's suggestion. Again, I just want to lay great emphasis on other nuances of the same history, so as to show that other complementary reasons might have as well led Galileo's interest towards cosmogony.

At Galileo's time it was not unusual for a learned man to reflect upon certain passages of the *Genesis*, and to do so regardless of broader scientific projects. Two letters of the Galilean correspondence yield interesting evidence in this regard. The first one was written to Galileo in April 1614 by Conte Conti, Duke of Poli and brother of the better-known Carlo Conti.[51] The latter must have told his brother that Galileo was working on illustrating the compatibility of the Copernican system with the Bible text.[52] This might explain why Conte Conti decided to inform Galileo about his latest

[49] Cf. OG, I, *De motu antiquiora*, p. 344.

[50] I report here in their entirety two very suggestive passages: "Seppur ancora segnato da incertezze […], il *De motu* viene delineando le direttrici dell'ambizioso disegno di riforma globale della filosofia naturale alla cui definizione Galileo dedicherà cospicue energie nei decenni successivi. Un progetto che costringeva inevitabilmente a fare i conti anche col delicato nodo problematico della genesi dell'universo e delle logiche dei processi utilizzati dal Creatore" (Galluzzi (2011), p. 17). And a few pages later: "Il fatto che i testi che abbiamo analizzato [e.g., the *Letters on Sunspots*] siano stati scritti prima dell'avvio dell'*affaire* galileiana, che indusse Galileo alla stesura delle cosiddette *Lettere Copernicane*, indica che lo scienziato pisano aveva messo a fuoco in precedenza (lo mostra, d'altra parte, il mito cosmogonico del *De motu*), e indipendentemente dalle denunce di empietà che gli saranno rivolte, la necessità di delineare uno scenario dal quale risultasse evidente la compatibilità possibile tra il proprio ambizioso progetto di riforma e il racconto del Genesi biblico, in modo da evitare di aprire, dopo quello con i seguaci di Aristotele, un nuovo delicato fronte conflittuale con i teologi, che pretendevano di imporre il proprio controllo assoluto sulla filosofia naturale, riservandosi l'esclusivo diritto di interpretare il genuino significato dei testi sacri" (*ibid.*, pp. 64-65).

[51] On Carlo Conti, cf. Andretta (1983).

[52] In 1612, Galileo asked Carlo Conti "se la Scrittura Sacra favorisca a' principii de Aristotele intorno la costitutione dell'universo" (OG, XI, *Carlo Conti to Galileo*, 7 July 1612, p. 355).

exegetical findings on the meaning of "*firmamentum*" (*Genesis* 1:4; 1:16).[53] But there is something more. Conte cannot hide a certain excitement about his findings. He believes that they can be also demonstrated through mathematical and natural reasons (*con ragioni matthematiche e fisiche*). He feels thus obliged to beg (twice!) Galileo (*forzato di supplicarla*) to send him, at his earliest convenience, a table with the position of the planets (*una positura dei pianeti*) in the Copernican system. He is indeed convinced that the world is truly heliocentric, and therefore he needs to confront his exegesis with the most reliable astronomical data in order to prove his "literal" reading of the *Genesis*. For the same reason, Conte would like to know something more about Galileo's doctrine of motion, although he does not expect the Pisan to recapitulate his work in a letter. Yet he dares ask Galileo (*ardisco ben di pregarla*) to send him two works, the *Discourse on Floating Bodies* (1612) and the *Letters on Sunspots*, that he already had the chance to read thanks to Federico Cesi, but that now he would like to browse again.[54]

Galileo's reply – if there was any – is unknown. But it is worth noting that Conte Conti did not find it awkward to let Galileo know about his findings on the

[53] Many Renaissance thinkers, including Descartes, devoted themeselves to the understanding of this term. Cf. Mehl (2019), p. 265.

[54] "Per mio trattenimento vo facendo alcune considerationi sopra il genesi, e parmi haver trovato il senso litterale per capire quello che Moisè intende per firmamento: che sia (ciò è) un corpo con tutte le sue dimensioni, il quale passando per il centro dell'universo, occupi tutto lo spatio che si comprende sotto i tropici, dentro al quale, come dentro ad una scattola (per dir così), fussero poi collocati i pianeti e la terra che noi habitamo, e ciascuno faccia il suo moto sopra i poli del zodiaco. Da che cavo che l'arco iride, dato da Iddio a Noè per segno di non volere inondare mai più il genere humano, sia un segno di ciò per natura propria demostrativo, perché mentre quest'arco puol apparire, è impossibile che si facci diluvio, perché è segno che necessariamente suppone che non siano più l'acque in quel loco nel quale, per la narratione litterale di Moisè, è forza che fussero collocate quando Iddio creò il mondo; e non potendosi il diluvio fare naturalmente senza quell'acque, ne segue per necessità che l'apparenza dell'iride dimostri necessariamente che non si farà più diluvio. Tutto questo ch'io ho detto di sopra, si prova (secondo me) alla lettera con il testo di Moisè, e si comprova con ragioni matthematiche e fisiche e con diversi lochi della Scrittura che confermano l'istesso: di modo che non mi pare che possa replicarsi. Ma io non me estendo a dirne le ragioni a V. S., né meno farlene le figure, perché passeria il termine di lettera se io volesse trattarne distintamente come conviene; ma spero in Dio ch'haverò pur fortuna un giorno di rivederla e poterla servire, et all'hora a bocca confido di provarle questo mio pensiero per verissimo. In tanto son forzato di supplicarla a contentarsi di farmi gratia di mandarmi una positura de i pianeti conforme all'opinione ch'ella ha, ponendo il sole nel centro; perché, sì come io credo senz'altro, per quello che V. S. mi ha honorato d'accennarmi altre volte (che per ciò io ci ho dopo fatta consideratione), ch'in questa maniera stia veramente la positura, così voglio fare le demostrationi mie con questo supposito: ma per non errare nella positura degl'altri pianeti, son forzato (come ho detto) a supplicarla che me la vogli mandare, non la ricercando già d'accennarmi ancora qualche cosa de i moti, perché, sicome strapassa la mia speranza di poter ottenerlo, conoscendo molto bene di non meritar tanto, così voglio fugire la nota seco di troppa presuntione. Ardisco bendi pregarla a farmi gratia, se puole, di mandarmi quelle due operette che V. S. fece, che l'una tratta delle cose che galleggiano sopra l'acqua, e l'altra delle macchie o nuvoli all'intorno del sole, perché, se bene io hebbi fortuna di legerle, ch'il S.r Prencipe di S. Angelo [viz. Federico Cesi] me le diede, nondimeno desidero sommamente di poterle di novo ben godere, perché all'hora fui impedito, ché me privò de' libri chi haveva ahutorità di comandarmi, e li volse per sé" (OG, XI, *Conte Conti to Galileo*, 11 April 1604, pp. 47-48).

Genesis. He also trusted that one day the two of them would meet again (*haverò pur fortuna un giorno di rivederla*), and that Galileo would be inclined to listen to what he had to say on the *Genesis*. Perhaps Conti knew that Galileo was also interested in the *Genesis* (?).

Another letter is interesting in this regard. In 1627 Castelli holds a stimulating correspondence with Giovanni Battista Baliani. The latter was already known to Galileo, as in 1615 Baliani started an exchange of letters with the Pisan.[55] But now, in 1627, Castelli had contacted Baliani. He offers a precious gift to Baliani: a handful of Galileo's writings. An offer that cannot be refused. Baliani accepts without hesitation. Apparently, amongst the papers enlisted by Castelli, there is one that draws Baliani's attention. It is "the discourse that reduces passages of the Holy Scripture to natural questions" (*il discorso che riduce passi di Sacra Scrittura in quistioni naturali*). This has been interpreted as a reference to the *Letter to the Grand Duchess Christina*.[56] And I too am convinced that this is the most plausible conclusion, given that in the Galilean corpus there is no trace of such a "discourse." Unfortunately, the letter where Castelli informed Baliani of this "discourse" has not come down to us. But, from what we know about the circulation of the *Letter to the Grand Duchess Christina*, it is indeed very likely that by 1624 Baliani had never heard of or read about the *Letter*, and so he mistakenly referred to it as to a discourse. If this is the case, this would be the first reference to Galileo's *Letter to the Grand Duchess Christina* posterior to 1615 and prior to 1632.[57] Also, it would be the only reference where the *Letter* is recalled as a "*discorso*" in lieu of the more generic "*scrittura*."[58]

But what matters to me the most here, is Baliani's following comment:

> I thank you [viz. Benedetto Castelli] a lot for the offer you make me about the things of Signor Galileo, and I accept it. The discourse that reduces passages of the Holy Scripture to natural questions will be very dear to me – for I too have sometimes applied my soul to that end – especially if it is about the first chapter of the *Genesis*.[59]

[55] Cf. OG, XII, *Giovanni Battista Baliani to Galileo*, 17 June 1615, pp. 186-188.

[56] Cf. Damanti (2010), p. 131. Bucciantini referes generically to the *Copernican Letters* (cf. Castelli (1988), p. 99, nt. 3).

[57] This clashes with Ottavio Besomi's opinion that from 1615 "fino al 1632, la *Lettera a Cristina* non affiora più nel carteggio galileiano" (Galilei (2011), p. 15). Obviously, there is a chance that Castelli referred to Galileo's *Letter to Castelli*, as pointed out by Damanti (cf. Damanti (2010), p. 131, nt. 1).

[58] Cf. Galilei (2011), pp. 14-15.

[59] "Dell'offerta che mi fa delle cose del Signor Galileo, ne la ringrazio grandemente, e l'accetto; e il discorso che riduce passi di Sacra Scrittura in quistioni naturali, al che anch'io ho applicato l'animo alle volte, massimamente se fosse del primo capitolo della genesi" (OG, XIII, *Giovanni Battista Baliani to Galileo*, 28 May 1627, p. 360).

Baliani, who seems to be in the dark about the events behind the *Copernican letters*, is not at all surprised that Galileo might have devoted himself, and in a disinterest manner, to a natural-philosophical understanding of Scripture. Moreover, he would be particularly content to see how Galileo reads the first chapter of the *Genesis*. That is, Baliani is interested in Galileo's scientific account of Moses's cosmogony. As if it was customary for any natural philosopher of the time to "apply his soul" to the cosmogonic theme!

However, I am convinced that there may be another and deeper reason for Galileo's recurrent interest in cosmogony. And this reason can be inferred from a second observation that occurs when returning to Pererius's *On the Genesis*.

§25.
Cosmogony and Gravity

As we have seen, one of the criteria used to interpret the *Genesis* consisted in relying on the latest scientific knowledge available. It is also for this reason that Pererius rejects Paul of Burgos's exegesis. After pointing out that Paul of Burgos unnecessarily resorted to God's omnipotence, Pererius shows that his account of *Genesis* 1:9 is manifestly against the evidence provided by mathematicians and natural philosophers.

One of the points of contention concerns the notion of gravity (*gravitas*) insofar as it involves the category of natural motion (*naturalis propensio et motus*). According to Paul of Burgos, in the third day God diverted the natural inclination of water. Initially, water moved naturally towards the center of the element earth. In the third day, water was then endowed by God with a new center of gravity, which coincides with the center of the sphere of water. From then till today, the element water has moved naturally toward that center. Yet Pererius notices that, not only does this explanation clash against daily experience, but it is also contrary to what natural philosophers know about gravity. In fact, gravity is a source of natural motion because it relates to the nature, the essence, of the elements. This means that a dislocation of the natural place of water is tantamount to a modification of the nature of water. And this, in turn, makes God's action in Burgos's account a fully ontological one. It is a divine surgery on the nature of things, an inexplicable mutation of their DNA. Furthermore, it is a miracle that portrays God in the fashion of a moody ruler of the world. Pererius does not need to involve Plato or the idea of God as a geometer to conclude that God would never change (without a good reason) the natural order of things, i.e., their very same nature. Quite the contrary, Pererius's conclusion is heavily Aristotelian in inspiration. It is an Aristotelian standpoint on gravity that impedes him from conceiving of God as a demiurge that gradually arranges the world by sorting out an initial situation of chaos and disorder.[60] The same Aristotelian standpoint suggests to Pererius that God acts in the most rational and 'economic' way possible, just like nature:

> … if water were above the sky, it would be impossible to deny that water would be there against its nature and violently. But what is violent is not perpetual. Also, it is not believable that God – who in the beginning of the world established all things with great power – placed so much quantity of waters above the heavens, against their natural inclination and impetus [*contra naturalem eorum inclinationem et impetus*]. If nature – as often says Aristotle – does nothing in vain, let alone God, who is the wisest maker of all nature! Therefore, God did not place so much water above the sky, and He has not kept it there violently for thousands of years, especially because it is impossible to think of a suitable and probable use for those waters [above the sky].[61]

Strictly speaking, for Pererius the first chapter of the *Genesis* is not a cosmogony. It is not an account of how God arranged the elements and the planets from disorder to order. From the first instant, the world was indeed created by God as perfectly ordered as it is today. This is clear from several remarks dropped by Pererius. He claims, for instance, that

> one must not doubt that earth was made by God in its natural place. We must believe that God made all things so that they befitted their own natures. He did not establish things in state of violence [*in statu violento*], or against their nature. In fact, it is against the nature of earth, and violent for earth, to be

[60] A similar tendency, albeit not linked to Aristotelianism, was already at play in the Middle Ages, as noticed by Chenu: "Arnold [of Bonneval] had come to the point of refusing to imagine a primitive chaos. He espoused the opinion vigorously expressed by William of Conches in protest against those who, under pretext of exalting the power and wisdom of a God who imposes order upon the universe at will, detracted from the simple play of the laws of nature, sufficient by themselves to explain that order." Chenu interestingly continues by arguing that this disagreement was "the clash of two mentalities, on the one hand the naturalistic idealism of Chartres instinctively picking up the outlook of the *Timaeus*, on the other hand Hugh of Saint Victor with his practical sense of a historical order in which divine and human liberties were at play, over and above any natural determinism" (Chenu (1997), pp. 9-10).

[61] "… si aqua esset supra Coelum, negari non posset eam illic esse contra naturam suam ac violente; atqui nullum violentum est perpetuum; nec est credibile Deum, qui in exordio mundi res omnes quas potenter condidit, tantam aquarum copiam contra naturalem earum propensionem atque impetum, supra Coelos collocasse. Si natura, ut saepe usurpat Aristoteles, nihil facit frustra, quanto minus Deus omnis naturae sapientissimus opifex, frustra tantam aquarum vim posuisset super coelum, et tot annorum millibus violente ibi tenuisset praesertim cum earum aquarum nullus satis idoneus et probabilis usus excogitari possit" (Pererius (1607), p. 101). On the margin: "Deus et natura nihil faciunt frustra."

> outside its natural place. So much quantity of earth cannot be reasonably maintained outside its natural place, unless it is kept up there miraculously.[62]

The world's cosmology is now as it was in the beginning, when God created a perfect cosmos in accordance with the nature of everything. After that, God did not change the order or nature of the world. He intervened by embellishing (*ornari*) the world, starting from the heaven, which is by nature the noblest part of the universe. And when Pererius speaks of embellishments (*ornamenta*), he has in mind light and motion. In the beginning, the whole universe was indeed dark and chaotic, in the sense that it lacked light, which is the primary active quality (*prima qualitas activa*) of the sky or heaven (*coelum*). This light, though, is not trapped in the heaven; it also pours out onto all the bodily parts of the world.[63] And since light is the source of motion, first God provided light, and then, as a consequence, the cosmos was put into motion:

> Since the sky and earth were created unadorned, it was convenient to first embellish the sky, whose embellishment is twofold, namely, motion and light. But light is the primary embellishment, for motion is because of light.[64]

It is an ontological claim that leads Pererius to deny a passage from a disorderly disposition of the world to an orderly one. Provided the Aristotelian correspondence between the *substance* of things and their *location* in the universe, everything that was

[62] "[T]erram factam esse a Deo in loco suo naturali, ubi nunc est, non debet in dubio verti. Existimandum enim est, Deum ita fecisse res omnes, ut naturis earum maxime congruebat; nec fecisse quicquam in statu violento, et contra eius naturam. Est autem contra naturam terrae, eique violentum, esse extra locum suum naturalem. Nec sane potuisset tanta terrae moles extra locum suum naturalem, nisi miraculose velut suspensa teneri" (Pererius (1607), p. 55).

[63] "Perfectis primis mundi corporibus, indigestis tamen atque tenebrosis, lux ante alia omnia primo die a Deo, apte profecto, sapienterque creata est. Etenim lux est prima qualitas activa primi corporis, hoc est, coeli non intra coelum tamen contracta, sed ad omnes res corporeas effusa. Est lux generale principaleque intrumentum causarum coelesium, quo vis omnis syderum, omnisque defluxus et effectus ad nos defertur, et quo uno fit in hoc nostrate mundo quicquid a coelo fit. Et massa illa elementorum et coelorum erat tenebrosa, confusa et vacua: primo de creata luce sublata est tenebrositas; secundo et tertio die, confusio ab aquis et terra est remota; reliquis diebus coelum stellis, aër avibus, piscibus aqua, terra animantibus completa est" (*ibid.*, p. 68). Pererius's reference to the second day, when the "chaos was removed from water and earth" must be contextualized. Pererius does not claim, in fact, that before the second day earth and water were confusely mixed into each other, in the sense that they were not located in their natural place. For Pererius, in the second day God interposed a *firmamentum* between rainwaters and landwaters. That is, God *extended* the airspace that was already separating the two waters from the beginning (cf. *ibid.*, p. 94). More on this subject *infra*, §37.

[64] "Cum Coelum et terra inornata essent creata, decuit primum ornari Coelum, cuius duplex ornamentum est, motus et lumen. Sed principalis est lumen, nam motus est propter lumen" (Pererius (1607), p. 68).

created by God in its own nature, and that thereby began to exist, was also created in its natural place. Afterwards, God supplied the *qualities*, starting from the light and motion of the heavens. But in doing so, He did not alter the nature or order of the things in the world. Such a conceptual framework explains why Pererius banishes expositions that turn to the miraculous:

> … nor is it possible to resort to God's omnipotence and miracles. In fact, it is not proper to assign a role to miracles in the creation of the world, when God established the natures of things, and set up their natural order and laws.[65]

In sum, God's six-day constitution of the world is 'non-miraculous' only in the sense that God does not intervene against the nature of things. It comes almost without saying that the validity of Pererius's second rule is narrowed down only to miracles *against* nature (*contra naturam*). For Pererius, indeed, God does intervene miraculously during the six days, in that He provides light and motion and other qualities that *improve* the natural state of things.[66]

When we turn to Galileo's cosmogonies, from the first one in the *De motu antiquiora* to the heliocentric one of the *Dialogue*, we see a similar pattern at work: God intervenes *on* nature, but He does not act *against* nature. Also, God's creative action is the most rational and 'economic' one, as is also held by Pererius.[67] The real difference is that in Galileo the rationale (*ratio*) of nature changes, and the definition of what is natural undergoes a gradual but constant process of deontologization. In compliance with the epistemological background briefly outlined above, Galileo does no longer regard the *nature of things*; rather, he focuses on *natural phenomena*. The notion of nature itself is tailored by Galileo on a deontologized understanding of natural motion and what causes it, that is, gravity. As such, the idea of what is natural changes and develops as Galileo comes up with new findings on motion. And his idea of cosmogony cannot but change and develop accordingly. For this reason, Galileo's cosmogonies provide us with a wonderful gateway to Galileo's science of motion and its stages of advancement, especially on the conceptualization of gravity. In what

[65] "… nec est recurrendum ad omnipotentiam Dei, et ad miracula quibus in creatione mundi, cum Deus rerum naturas condidit, et naturalem eorum ordinem legesque construit, locum dare non oportet" (*ibid.*, p. 78).

[66] On the distinction between miracles *contra*, *supra*, and *praeter naturam*, which Aquinas already regarded as a 'canonical distinction,' see Bianchi (2009a), p. 318. For a general historical recollection on miracles, cf. Brown (2011).

[67] In this sense, Galileo's idea of God differs much from that of Urban VIII, which was "lontanissima dal modo in cui Galileo si raffigurava il Dio cristiano: un Dio 'architetto' che crea 'in numero, pondere et mensura,' che 'non muta le sue fatture,' che nel rivelarsi, nell'agire, persino nel compiere miracoli sembra sottomettersi al 'principio di economia'" (Bianchi (2011), p. 220). What I have tried to show here is that this is also how Pererius thinks of God (*Deus et natura nihil faciunt frustra*), although his God is not a 'geometer.'

follows, I will therefore attempt to show the scientific roots of the cosmogony problem in the 'tradition' and in Galileo. My chief objective is to emphasize that Galileo's approach to cosmogony is in continuity with a certain tradition where cosmogony is regarded as an important scientific problem. And yet his solutions are groundbreaking because they are based on new understandings of natural motion and gravity.

To conclude, I cannot help but notice that my standpoint on this matter brings me to different conclusions than the one reached by Massimo Bucciantini. The latter has advanced a compelling thesis about Galileo's interest in cosmogony. According to Bucciantini, Galileo appealed to the cosmogonic narrative in order to provide the Copernican system with a "metaphysical foundation." In the absence of a proper understanding of gravity, Galileo was eventually forced to ground the Copernican system in God, that is, in extra-scientific kinds of explanation (at least, this is how I interpret Bucciantini's reference to metaphysics). Otherwise, Galileo would have not been able to address a crucial problem raised in astronomy by Tycho Brahe: granted that the heavens are fluid, what moves the planets? Obviously, the Newtonian key that discloses the secrets of gravity and opens up to a scientific response, was not at Galileo's disposal. His science of motion did not allow him to answer the question. The cosmogony of the *Dialogue* should be therefore understood as the most patent testimony of the defeat (*scacco*) experienced by Galileo as a Copernican natural philosopher.[68]

I depart from Bucciantini's thesis in two respects. First, from his thesis it results that Galileo's interest in cosmogony is essentially Copernicus-centric.[69] Galileo needed to solve the problem raised by Tycho, and he needed to do so in order to validate the Copernican system. But, on the one hand, in the *Dialogue* and the *Two New Sciences*, Galileo's reflections on cosmogony do not stem from the Tychonian kind of problems highlighted by Bucciantini. And, on the other hand, Wisan had

[68] Cf. Bucciantini (2003), pp. 298-306. See the following passages in particular: "anche la nuova cosmologia galileiana non sfuggiva alla necessità di ricorrere a una fondazione metafisica. […] A differenza di Keplero, quella di Galileo non è una scelta volontaria ma uno stato di necessità: se vuole procedere nella costruzione di una scienza copernicana del moto, anch'egli è costretto a misurarsi con l'idea di creazione divina. […] Il ricorso a Dio nasce dunque da uno scacco, dall'incapacità di elaborare una fisica (e una cosmologia) delle cause. Certo, anche per Galileo, come per Keplero, Dio è il demiurgo, è il creatore dell'universo. Tuttavia, mentre Keplero tenta fin dal *Mysterium* di sviluppare un'organica teologia naturale che conduca alla costruzione di una fisica celeste, Galileo rinvia alla creazione divina alla fine del proprio percorso speculativo: la sua spiegazione, insomma, nasce da una rinuncia e dalla difficoltà di costruire una scienza *de motu* e *de motu terrae* fondata sulla gravità come causa del moto."

[69] Sometimes, one has the same impression when reading Bucciantini's considerations on Galileo's science of motion, as though the latter was mainly developed in order to support the Copernican system. I partly underwrite Finocchiaro's opinion on this matter: "He [viz. Bucciantini] also continually speaks of Galileo's 'Copernican science of motion,' giving the impression that Galilean physics was designed to justify a prior commitment to Copernicanism; this is, I believe, the reverse of the truth, which is that it was an Archimedean science of motion, independently justified that happened to have pro-Copernican implications" (Finocchiaro (2008), p. 834, col. 2).

already noticed that Galileo is a cosmogonist before even being Copernican. In fact, his first cosmogony neglects the planets and it is explicitly geocentric. Although Bucciantini's conclusions may apply to the case study provided by Galileo's latest cosmogony, they can in no way help us find out whether there are other and deeper reasons for Galileo's *recurrent* interest in cosmogony.

Second, Galileo himself claims that his cosmogony can be proved by anyone who gets trained in the *scientia de motu* exposed in his *Two New Sciences*.[70] It matters little that this claim amounts to an impossible demonstration. It matters much, instead, that Galileo perceived his heliocentric cosmogony as one of the crowning achievements of his science of motion, rather than as a forced defeat. When applied to the cosmogony problem, his science of motion carried further evidence in favor of the Copernican system.

One must not be led astray by the fact that Galileo's cosmogony requires God. God and His perfect mind as a geometer are not taken as a point of departure for reflections on the "sacred mystery" behind the arrangement of the universe. In this regard, we must notice that Galileo's heliocentric cosmogony shares nothing with that of Kepler. It is not a metaphysical attempt to ground the Copernican system.[71] Quite the contrary, it represents the scientific substantiation of the Copernican system. God's creative action is indeed determined by Galileo in accordance with the principles of his new science of motion. It would be particularly anachronistic to think that a 'scientist' of the early modern period could not venture *qua scientist* – i.e., without involving extra-scientific kinds of explanation – into the role of God in the arrangement of the universe.

[70] "Ma se alcuno avrà simil desiderio [i.e., to find out the height from which the planets fell], potrà per sé stesso, con la dottrina del presente trattato, sodisfare al suo gusto" (OG, VIII, p. 284).

[71] Cf. Barker-Goldstein (2001), esp. pp. 99-103. I find Redondi's opinion on this matter ungrounded (to say the least). Referring to Galileo's *Dialogue* (i.e., OG, VII, p. 27), Redondi claims that "[i]n questa celebrazione della meccanica celeste come opera eletta di Dio è chiaro che Galileo si sforza di emulare Kepler. Nel *Mysterium* (1596) e nell'*Astronomia nova* (1609) Kepler parla infatti del divino libro della natura in chiave mistica, facendo dell'universo il simbolo della Trinità" (Redondi (2011), p. 155, nt. 9). From Redondi's last sentence, it is clear instead that Galileo and Kepler have very different views on how to read the "book of nature" (on the metaphor of the book of nature in Galileo, see Biagioli (2003)).

VII.
COSMOGONY AS A SCIENTIFIC PROBLEM IN THE 'TRADITION'

§26.
From Creation Tales to Philosophical Cosmogonies

Through an image that brings with it a certain (European) perspective, we can say that philosophy arose 'where the Sun rises' (Ἀνατολή). In Miletus, on the Western shores of Anatolia, the foundations were laid for an intellectual enterprise that would have soon taken hold in the rest of Greece. Typically associated with the trio Thales–Anaximander–Anaximenes, the birth of philosophy dates back to the sixth century BC. For this reason, its features are sometimes unfolded against the backdrop of archaic mythological views about the world and – more interestingly for our study – its origins.

Andrew Gregory has devoted a thorough study to ancient Greek cosmogonies.[1] Although his study cuts off around the sixth century AD, his important work constitutes a necessary point of departure for any new assessment of cosmogony, including cosmogonies developed after the sixth century. Gregory's approach is in fact attentive to the "perennial problems" that were raised and addressed by ancient Greek cosmogonists, and that somehow – *mutatis mutandis* – survive still at present day in many of the scientific issues of modern cosmogony.[2] Since he endorses such a long-span comparative approach, it is no surprise that Gregory originally planned to write a further volume on "subsequent cosmogony in Islam and the Christian West."[3] Unfortunately, though, this volume has not yet seen the light of the day. So, I am going to walk an unexplored path, resting only, when possible, on what Gregory has hitherto published.[4]

According to Gregory, what differentiates mythological cosmogonies, or "creation tales", from a "philosophical cosmogony" is that the latter is based on justifications that do away with the arbitrary, thereby departing from indiscriminate appeals to the supernatural.[5] This sort of justification must then be further justified

[1] Cf. Gregory (2007).
[2] Cf. *ibid*, pp. 8-10.
[3] *Ibid*., p. 12.
[4] The author included interesting highlights on cosmogony also in Gregory (2000).
[5] Cf. Gregory (2007), pp. 13 and ff.

ontologically as well as epistemologically. All this requires that a cosmogony responds to certain tenets, which Gregory singles out in "parsimony, invariance, consistency, and a rejection of the supernatural."[6]

Gregory views in the Milesians a first attempt at philosophical cosmogony.[7] Yet their appeal to a steering principle whereby the cosmos is ordered out of a pre-cosmic situation, might suggest to us that they are after all resorting to a kind of supernatural and extra-physical explanation. Also, the Milesians and other ancient thinkers used to compare cosmogonic processes with biological ones, which is neatly at odds with our understanding of how the universe works.[8]

However, Gregory convincingly points out that one of the perennial problems that emerges from ancient cosmogonies is to figure out how cosmogony is *like*. "As we have no direct experience of cosmogony – says Gregory –, we are forced into analogies."[9] Even today, we are sometimes told that the Big Bang can be compared to an explosion. We can then easily figure what the Big Bang is *like* because we have seen, for instance in movies, how explosions look like. The analogy is in this case drawn from a repertory of images that are familiar to us since we were kids. Gregory suggests that biological analogies should be similarly regarded as important resources in ancient cosmogony, during a period when it was not bizarre to use those analogies in order to unfold physical processes.[10]

Gregory goes interestingly further to argue that the lack of a concept of gravity was an important factor that allowed, or at least did not prevent, the adoption of analogies with the living world. If we conceive of gravity in a Newtonian way as a force of attraction between masses, we must concede that the ancient Greeks could not cling onto such an 'a-biological' kind of force in their cosmogonic account. The closest notion to gravity at their disposal was the so-called 'like-to-like' principle, which can "account for some terrestrial gravitational effects".[11] But on a universal scale that principle is of no help to account for the passage from a pre-cosmic state to the cosmic

[6] *Ibid.*, pp. 8, 52, and *passim*.

[7] Of course, Gregory is not the first one who separates "creation tales" from "philosophical cosmogony." Geoffrey S. Kirk and John E. Raven had already devoted a chapter of their famous textbook to 'The Forerunners of Philosophical Cosmogony,' which was revised by Malcolm Schofield in the second edition of the book (cf. Kirk-Raven-Schofield (1983), pp. 7-74). However, it must be noted that the labels 'creation tales' and 'pre-philosophical cosmogony' may be misleading. As Michela Sassi has shown, Hesiod's cosmogony can be seen to be "more than the product of a mythopoeic process," in that "it appears to be the result of a series of systematic choices stemming from an original reflection" (Sassi (2018), p. 37).

[8] Cf. Gregory (2000), p. 10; Gregory (2007), pp. 15 and ff. See also Furley (1987), pp. 21.

[9] Gregory (2007), p. 10.

[10] Cf. Gregory (2000), pp. 34-36; Gregory (2007), p. 11.

[11] Cf. Gregory (2000), pp. 4-5.

one. In fact, that principle alone would generate a division of the universe into perfect conglomerates of alike elements, which simply does not occur in reality.[12]

In this context, the ancient Greeks' (Atomists excluded) appeal to a steering principle ought not be regarded as a relapse into the supernatural. On the contrary, underneath the need to posit one or different steering principles there is the philosophical intent of explaining with parsimony and invariance how the cosmos took shape. We can see that already the Milesians "make a small number of principles work hard to cover all of the phenomena, and they do not invoke further principles."[13] And even if the principal substances that steer the cosmogonic process may be regarded as divine entities, this however does not detract from the fact that their action is invariant, which makes them to all effects akin to natural processes.[14]

We must lay great stress on this point, so neatly noticed by Gregory: what makes cosmogony a philosophical problem is not the absence of the divine, but rather the attempt to provide justification for any kind of principle that might be involved in the genesis of the world. Furthermore, the justification must be consistent with an understanding of nature that takes on an ontological as well as epistemological aspect.

After Heraclitus and Parmenides, for instance, it became problematic to think of something coming to be from what is not. Obviously, none of the ancient Greek thinkers claimed that creation *ex nihilo* was possible. As I showed in chapter IV, the *creatio ex nihilo* doctrine developed out of a precise cultural context, and was entwined with notions, such as that of omnipotence, that were foreign to the ancient Greeks. The Milesians assumed that there is one substance from which other substances come to be. And, as is known, for Parmenides this kind of change or passage from one substance to another is impossible: it would be tantamount to admitting the existence of what is not, which is contradictory. A philosophical cosmogony is receptive to this kind of problems. We see that post-Eleatic cosmogonies are in fact thought out in accord with a view on nature, and its ultimate constituents, which is aimed at preventing a Parmenidean type of criticism.[15] As noticed by David Furley,

> [t]he invention of elements is indeed a notable step in the progress of natural science. It is particularly striking that the step was taken as a response, not to

[12] Cf. *ibid.*, pp. 19-26.

[13] Gregory (2007), p. 35.

[14] Cf. *ibid.*, p. 52. But this point, as many others, is repeated passim (e.g., cf. *ibid.*, p. 17).

[15] In the concluding remarks of the chapter devoted to 'Parmenides and Eleaticism' (cf. *ibid.*, pp. 77), Gregory says that "Parmenides had a huge impact on subsequent cosmogony. As we shall see, Empedocles and the early atomists devise their systems and their cosmogonies specifically to counter some of Parmenides' ideas" (*ibid.*, p. 77).

> any observations of natural processes, but to a metaphysical argument of the most abstract kind.[16]

This observation applies to the four 'roots' of Empedocles as well as to the infinite 'ingredients' of Anaxagoras, and the atoms of Leucippus and Democritus. The problem of change would then take a different turn with Plato and Aristotle, and the doctrine of 'Forms' would add a further degree of sophistication to the understanding of nature. Yet after all these philosophical developments the issues addressed with cosmogony remains structurally the same, and the approach to cosmogony remained focused on invariance and parsimony.

§27. ARISTOTLE *VERSUS* COSMOGONY

Andrew Gregory has certainly brought to the foreground the salient factors that allowed cosmogony to depart from mythological creation tales, thereby entering the domain of philosophy. But I fear that he did not lay enough stress on the most manifest and significant result of this culturally relevant fact. That is, some philosophers rejected cosmogony *tout-court*. What is more alien to mythological or 'pre-philosophical' thought than the complete denial of cosmogony?[17]

We must be careful, though, not to take this denial as a generic expression against the beginning of the universe. I believe it is important not to confound the denial of cosmogony with the controversy on the eternity of time that we can find, for instance, in Aristotle's eighth book of the *Physics*.[18] One thing is to argue against the beginning of motion; quite another one is to argue against the passage from a pre-cosmic to a cosmic (i.e., orderly) state of the universe. In the first case, arguments are made which lean on a certain conceptualization of movement understood loosely as change. This kind of arguments can do without a consistent explanation of local and natural motion. In the second case, instead, arguments are made which leverage (*a*) on certain (onto)logical tenets, or (*b*) on a detailed theorization of natural motion.

Heraclitus and Parmenides may be considered as early exponents of the first kind of approach (*a*). While Heraclitus was the first thinker who denied cosmogony,

[16] Furley (1987) p. 48.

[17] I am not saying that Gregory does not recognize this fact. I am just saying that he does not consider this fact to be the most relevant outcome of the Ancients' philosophical approach to cosmogony.

[18] Cf. *Phys*. VIII, 1-2, 205b11-253a21.

Parmenides relegated cosmogony to 'the way of opinion.' In both of them we can see a first attempt to undo cosmogony.[19]

As for (*b*), as far as I know, this second kind of approach against cosmogony originates with Aristotle. It is only with Aristotle that cosmogony becomes a 'scientific' problem, in the sense that it starts to be seen as an issue that needs to be addressed through a coherent understanding of natural motion.[20] Coherent, in that it must be consistent with experience and with a comprehensive philosophical grip on reality. Such an understanding is indeed, in Aristotle, naturally tied with specific views on ontology, metaphysics, and cosmology. But the bulk of Aristotle's arguments against cosmogony, against a passage from disorder to order, originates in his understanding of the local motion of inanimate things.

This is particularly manifest in a well-known passage of the third book of the *De caelo* (300b 8-301a 22), where Aristotle rails against those who account for the origin of the world (ὁ κόσμος) by calling on the movement of its parts. He points out that they do not say whether that *pre-* and *pro-*cosmic movement is natural or violent. Also, if it is natural, they should clarify what it means for a movement to be natural. Aristotle has indeed already defined movement through the pair of opposites 'by or according to nature' (κατὰ φύσιν) and 'against or contrary to nature' (βίᾳ or παρὰ φύσιν).

One can obviously suppose that inanimate bodies always move against nature. But motion against nature is such only with respect to what is according to nature. Thus, inanimate bodies must first of all have a natural kind of motion. Also, proceeding through pairs of opposites, the Stagirite claims that if there is movement, there must be rest as well. This makes him say that, other than movement by nature, there is also rest by nature. Indeed, one can actually begin by theorizing the existence of rest according to nature, and then go on to infer natural movement, which naturally leads to a state of natural rest. Either case, the conclusion is the same for Aristotle: to each simple body, there is only one natural kind of movement, which leads to a state of natural rest.[21] In short, the fundamental ingredients of Aristotle's doctrine of motion

[19] As for Heraclitus, it is difficult to understand what the actual reason for his denial of cosmogony was. Charles Kahn has casted some doubt about this denial (cf. Kahn (1960), p. 225), whereas Gregory has advanced an interesting hypothesis to account for it (cf. Gregory (2007), pp. 61-62). As for Parmenides, cf. Gregory (2007), pp. 70-77 and the secondary literature cited therein.

[20] Perhaps Gregory should have laid more emphasis on this peculiar feature of Aristotle's denial of cosmogony. Cf. *ibid.*, pp. 163-172.

[21] Cf. *De caelo*, III, 2, 300a20-300b8. As a general remark, it must be noted that the expression 'natural place' was introduced in later readings, mainly Latin, of the *De caelo*. Also, I should like to add that the particular passage I am dealing with does not need to be discussed in light of Aristotle's general notion of 'place,' which has been subject to extensive scrutiny by different scholars (for a recent study, see Morrison (2002)). As for the other important debate concerning Aristotle's definition of nature, namely, whether the nature of simple bodies should be understood as being a principle of motion (cf. Gill (1989), pp. 236-240, and Gill (2009)), a principle of rest (cf. Cohen (1994), and Matthen (2009)), or a principle of both rest and

at this stage are three in the main: (1) the opposition 'by nature/against nature'; (2) the opposition 'rest/motion'; and (3) the definition of natural place as that place where rest is natural and toward which motion is natural.

	ACCORDING TO NATURE	AGAINST NATURE
MOVEMENT	toward natural rest	away from natural rest
REST	in the natural place	outside the natural place

Thus, natural motion goes toward natural rest, and natural rest is what defines the natural place of inanimate bodies. From this, one can conclude that natural motion is always directed toward the natural place. However, this conclusion would perhaps downplay an important feature of Aristotle's doctrine. That is, the location of the natural place is determined by the circumstances that allow a body to be in natural rest. To put it otherwise, the definition of natural place cannot abstract from an actual state of affairs, namely, the presence of a limited number of simple bodies, or elements, that make up the (sublunary) world. If the world were devoid of water, air would naturally rest above earth; thus, its natural place would be above earth.[22] According to Aristotle, earth, water, and air, all have a natural capacity to move toward the center of the world. This capacity is what makes them bodies endowed with weight.[23] And yet, although they all have a natural capacity to move toward the center of the world, their natural place does not necessarily coincide with the center of the world. Given the presence of earth, water rests naturally above earth; and given the presence of water, air rests naturally above water.

This preamble was necessary to introduce another fundamental element of Aristotle's criticism of cosmogony: the notion of *order*.[24] It is important not to banalize Aristotle's conception of order by saying that the (sublunary) world is divided into natural places that determine the direction of natural movements, through which the world is kept in order. This is certainly true, but Aristotle's doctrine is actually more complicated and fascinating than that. Aristotle believes that natural movement *results from* a certain order of the world, which is both cosmological (center and periphery)

motion (cf. Bodnar (1997)), in this case, too, the context I am dealing with allows me to bypass this interesting debate.

22 Cf. *De caelo*, IV, 5, 312b2-19.

23 Cf. *De caelo*, IV, 1, 307b28-308a33. More on this later (§32).

24 Cf. *De caelo*, III, 2, 300b16-30. The conceptual pair natural-ordered can also be found in *Phys.*, VIII, 1, 252a12. As is known, the passage just mentioned is at the core of Helen S. Lang's much debated book (cf. Lang (1998a), p. 3).

and contingent (natural places), as it were. For this reason, Aristotle holds that it is absurd to think that the reverse process is possible, namely, that the order of the world *results from* some kind of movement. In sum, Aristotle links local motion to a peculiar understanding of order, such that outside that order there cannot be the conditions for the realization of any kind of movement.

Obviously, Aristotle's criticism of cosmogony rests on a conceptualization of motion which does not belong to his predecessors. By so doing, he inevitably applies his own categories (natural/enforced motion; natural/enforced rest; orderly/disorderly motion) to theories of motion that probably did not rest on his categories. As Friedrich Solmsen noticed, "Aristotle considers himself justified in applying the concept of ἄτακτος κίνησις [disorderly motion] also to other physical systems, especially to the behavior of Empedocles' elements and to the atoms of Leucippus and Democritus."[25]

To my mind, Aristotle's approach is also revealing of something else. I am convinced that, apart from some exaggeration, Harold Cherniss was right when he pointed out that Aristotle's use of the Presocratics is chiefly 'utilitarian.' This means that when Aristotle leans on previous theories, his "different reports do not stand alone; they form an integral part of some argument which is meant to establish a positive doctrine of Aristotle's system, and the reports and interpretations vary with the doctrine that is being established."[26] When we read Aristotle's criticism of cosmogony under this light, we can see that the refutation of cosmogony gives Aristotle an important occasion to single out the main features of his doctrine of motion.[27] Probably, Aristotle can do so because no one of his predecessors has ever formulated an actual "physical system," as defined by Solmsen. With Aristotle, though, the study of motion receives a systematic and consistent attention. Thus, the chaos left by his predecessors can be filled by Aristotle with his doctrine of natural and violent (or enforced) movement. Also, this doctrine can be exploited further, and elucidated at the same time,

[25] Solmsen (1958), pp. 268-269.

[26] Cherniss (1935), p. XII.

[27] As Cherniss wrote, the "Presocratics explanations of motion in the cosmic processes, particularly those of Empedocles and the Atomists, are subjected also to the test of the theory of natural motion and found inadequate because they fail to take account of it" (*ibid.*, p. 188). It must be noted, however, that Aristotle's criticism of cosmogony does not only regard the Presocratics, but it involves Plato as well. His argument appears to be organized thematically, in order to highlight different theoretical issues related to cosmogony. For Aristotle there is no need to regard previous cosmogonies as *historical* achievements. There is no need to contextualize them in order to show their flaws. Aristotle behaves as a 'scientist'; he is no historian. Referring to the *Timaeus*, he argues that Plato forgot to specify according to which kind of movement, whether natural or violent (*viz.* enforced), the elements were moving before the demiurge intervened (*De caelo*, III, 300b13-25). Aristotle wants to show, since Plato says that the elements were moving disorderly before the world was ordered, he is already presupposing the existence of the actual order of the world. For it is only within an already-formed cosmos that, according to Aristotle, natural and enforced motion and rest can be defined. And a cosmogony which presupposes the existence of a cosmos, like that of Plato, is plainly contradictory.

by refuting any attempt to cosmogony. It is not by chance that such a refutation appears only in the *De caelo*, that is, in a treatise about the cosmos. It should be clear by now that the real nature of motion can be expounded only in parallel with the correct understanding of the actual structure of the world. Perhaps, the controversy on cosmogony in the third book of the *De caelo* is also revealing of the extremely *cosmologized* approach of Aristotle's doctrine of motion.[28]

§28.
Cosmogony in the Pisan Controversy on the Motion of the Elements. Girolamo Borro

With Aristotle, cosmogony becomes a problem that needs to be solved in compliance with a coherent understanding of local motion. For the sake of brevity, I referred and will continue to refer to this problem by using the appellative 'scientific.' So, when I speak of cosmogony as a scientific problem, I am referring to a kind of problem that must take account of a certain understanding of local motion. Because of this, cosmogony itself can now be regarded as a narrative that responds to a certain theory of motion. If the cosmogonic narrative is contradictory, then too is its underlying theory of motion. This also means that cosmogony can be developed or fully denied according to different views on motion. A cosmogonic narrative or its denial may therefore be used to show the pitfalls of a theory of motion.

If we now take a giant leap in history as to look at the time and milieu more familiar to Galileo, we can see that cosmogony is still treated as a scientific problem. Let us consider the case provided by Girolamo Borro.

Between one inquisitorial incarceration and the other, Borro was a professor of natural philosophy at the Studio Pisano.[29] Galileo perhaps attended one of his courses when he was a student there (1580-1584).[30] In any case, Galileo certainly knew Borro from his book on natural philosophy. The *De motu gravium et levium* ("On the motion of heavy and light bodies") (1575) was in fact known and read by Galileo, who took some of its parts as a critical target in his youthful *De motu antiquiora*.[31] Borro's *De motu gravium et levium* and Galileo's *De motu antiquiora* pertain to the same

[28] Among Galileo scholars, Clavelin has pointed out this important linkage between mechanics and cosmology in the Aristotelian doctrine of motion (cf. Clavelin (1996), pp. 28-37).
[29] For a general introduction to Borro, see Martin (2017).
[30] Cf. Camerota-Helbing (2000a), pp. 323-327.
[31] Cf. OG, I, pp. 333, 367.

subject, for both of them stem from the same Pisan controversy on the motion of the elements. It is very likely that this controversy, hotly debated in Pisa when Galileo was still shaping his philosophical interests, catalyzed Galileo's attention on the problem of natural movement in connection with the definition of heavy and light.[32]

In laymen terms, the controversy on the motion of the elements originated from an apparently simple question: what moves inanimate bodies when they are not forcedly thrown somewhere? Given that the controversy was fomented by the Aristotelians, the question could also sound like the following: what is the motive cause of the *natural local motion* of inanimate bodies?[33] This question involved a series of other issues more or less technical. For instance: is the motive cause of inanimate bodies internal or external to them? If it is external, what is it? And if it is internal, how can this be reconciled with Aristotle's say that 'everything moved is moved by something else'?[34]

These and other questions were framed into a common Aristotelian framework, where inanimate bodies are composed of different simple bodies, also called elements. As is known, the elements are traditionally earth, water, air, and fire. But, less obviously, they cannot be found in nature in their pure state. They are always more or less mixed with each other. This does not mean that pure elements do not exist at all in nature. This only means that they are not naturally at our disposal in their 'pure' state.[35] Nonetheless, they exist and indeed make up all the bodies of the sublunary world. For this reason, a question on the motion of inanimate compounds is ultimately a question on the motion of what constitutes them, namely, the elements.

One of the most interesting and controversial consequences of this view is that one can never study the elements directly, but at most through their compounds. In the absence of chemical or alchemical processes with which to 'extract' artificially a pure element from compounds, natural philosophers are obliged to infer the properties and behavior of the elements through arguments which rested on logically grounded definitions, and sometimes also on experiments (*pericula*) with compounds. During the Pisan controversy, some rudimentary experiments were indeed carried out by natural philosophers.[36] Yet those experiments were after all read and differently

[32] In this regard, Camerota-Helbing (2000a) is the most detailed and important study on the subject.

[33] Cf. Borro (1975), p. 63: "Quaestio igitur est: utrumne simplicia elementorum corpora habeant in se ipsis *congenitum principium intrinsecum sui motus ad locum, non ad alias motionum species, naturalis, non violenti, nec ab arte manantis*, non remotum, et maxime commune, sed particulare, et proximum; non quod tantum est, ut habitus, sed etiam ut substantia, non actu solum primu, sed actu secundo" (my emphasis). In the next chapter (§36-37), I will provide some clarification about the meaning of *habitus* and primary/secondary act.

[34] Cf. Helbing (1989), pp. 146, 154.

[35] Cf. Falcon (2001), p. 56.

[36] Cf. Schmitt (1969), pp. 269-271; Settle (1983), pp. 6-8; Rossi (1989), pp. 105-106; De Pace (1990), pp. 49-58; and Camerota-Helbing (2000a), pp. 334-345.

interpreted through categories provided by an Aristotelian framework that was never put into question. In the *De motu antiquiora*, Galileo too takes the existence of the elements for granted, but he reconceptualizes them within a different physical framework more suited to mathematical treatment (more on this later). It should not come as a surprise, then, that in such a scientific context, which might appear to be quite exotic to us, cosmogony had a critical role in discriminating good theories of motion from inappropriate ones.

Borro devotes some initial chapters of his *De motu* to the refutation of theories of motion that he considered to be inappropriate and therefore erroneous. In this regard, he puts much effort in criticizing those who held the possibility of cosmogony, that is, the dynamic passage from a disorderly universe to an orderly one:

> The Divine Plato in the *Timaeus*, Hesiod in the *Theogony*, and Orpheus in the *Argonautica* [*Orphica*], wrote that before the arrangement of the world the elements were moving without any order in that primeval Chaos that was imagined by Hermes Trismegistus.[37]

Borro is quite explicit about the targets of his criticism. It is worth noting that this passage contains a sort of 'genealogical' view that will emerge more clearly in the second part of the *De motu*, and that makes Trismegistus the ultimate responsible of an abominable cosmogonic myth. According to Borro,

> Hesiod, the Divine Plato in the *Timaeus*, and before him Hermes Trismegistus – the father of all philosophers – in those books whose title is *Pymander* and *Asclepius*, claimed that before the arrangement of the world all elements were moving hither and thither [*fluctuantia… fuisse iactata*] in a hazy and disordered manner, forming some sort of raw and formless mass, which they called Chaos. And they claimed that God, moved by eminent benevolence, artistically cleansed [*expolivisse*] and elegantly disposed of [*digessisse*] that clutter of elements, thereby making it something of that beautiful sort which we [now] see and admire.[38]

[37] "Divinus ille Plato in Timaeo, Hexiodus in Theog[o]nia, et Orpheus in Argonautica scripserunt, elementa ante conditum mundum sine ullo ordine iactata fuisse per medium illud chaos antiquum, quod termaximus finxerat Hermes" (Borro (1975), p. 18).

[38] "Hesiodus, ac Divinus Plato in Timaeo, et ante illum Hermes Trismegistus philosophorum omnium pater in libris, quorum titulus est Pimander, et Asclepius, elementa omnia fluctuantia ante conditum mundum in quamdam rudem molem, atque informem, quam Chaos vocarunt confuse, et inordinate iactata fuisse dixerunt, ac Deum indigestam illam elementorum confusionem, sua praecellenti bonitate artificiose expolivisse, elegantissimeque digessisse, et ad eam, quam cernimus, et admiramur pulcherrimam speciem perduxisse asseverarunt" (*ibid.*, p. 80).

As I shall point out in chapter IX (§44), this passage includes narrative elements that can be also spotted in Galileo's first cosmogony. The idea of an artist-like God who "cleanses" (*expolit*) and "digests" (*digerit*) the primeval chaos is indeed used by Galileo, who talks of God pulling away the "excrements" (*excrementa*) of the world in order not to offend the blessed spirits and not to leave any empty space.

For now, I should like to focus on the fact that the genealogy invoked by Borro – who says with fine sarcasm that Trismegistus is "the father of all philosophers" – is the same as the one propounded by Ficino in the introduction to the *Pymander* dedicated to Cosimo de' Medici.[39] But there is an important difference: on the one hand, Ficino saw in it positive evidence for claiming that the *prisca theologia* was uninterruptedly transmitted from Trismegistus to Plato; on the other hand, Borro interprets the same fact as the repetition of a "horrendous" opinion in natural philosophy:

> Perhaps [those who support that view on Chaos] drew [it] from that horrendous "shadow" that Hermes Trismegistus puts at the beginning of the book entitled *Pymander*. What can the human mind imagine to be more horrendous than the formless and disorderly turmoil of elements? Certainly nothing! Perhaps is that very dark "night" of Hesiod and Orpheus more horrendous than this formless and disorderly turmoil? Obviously not. Consider the works of all ancient philosophers, especially Plotinus the great's [*Magni Plotini*] book whose title is *The Source of Evil*, and Proclus's book [on Plato's Alcibiades] *De anima et daemone*. You will find out that there is nothing worse than that disorderly and formless Chaos, and that nothing more horrendous than that can be thought of. No wonder that Plato, Orpheus, and Hesiod perhaps drew the hazy and disorderly Chaos from that horrendous "shadow" of Trismegistus.[40]

[39] Ficino (1532), pp. 4-5: "Hic [*viz.* Trismegistus] inter philosophos primus, a Physicis ac mathematicis ad divinorum contemplationem se contulit. Primus de maiestate dei, daemonum ordine, animarum mutationibus sapientissime disputavit. Prumus igitur theologiae appellatur est autor. Eum secutus Orpheus, secundas antiquae theologiae partes obtinuit. Orphei sacri initiatus est Aglaophemus. Aglaophemo successit in theologia Pythagoras: quae Philolaus sectatus est, divi Platonis nostri praeceptor. Itaque una priscae theologiae undique sibi consona secta, ex theologis sex, miro quodam ordine conflata est, exordia sumens a Mercurio [Trismegisto], a divo Platone penitu absoluta." See also the Italian translation by Ficino's pupil Tommaso Benci in Ficino (1548). It must be noted that Ficino's 'genealogy' is not always consistent. As written by Christopher S. Celenza, "Ficino is not outwardly consistent in his rendering of the succession of ancient theologians, all of whom contributed to the history of true philosophy's evolution: his ordering changes intermittently, other figures are added on occasion, and so on" (Celenza (2007), p. 85).

[40] "Quod ab horrenda illa umbra, quam Hermes Trismegistus in principio libri, cui titulus est Pimander viderat, forte traxerunt. Quid enim hac inordinata omnium elementorum deformi, malique rationem habente confusione humana ratio excogitare potest horrendius? Certe nihil. Nam Hesiodi, et Orphei obscurissima nox est hac informi, inordinateque iactatione magis horrenda? Minime quidem. Lege omnium

It is remarkable that the adjective "horrendous" (*horrendus*) is repeated five times in a few lines. It is used in a derogative manner in order to emphasize that something farther from the truth cannot exist. But at the same time, I believe that Borro chooses the term "horrendous" because in Latin this term has also a sacral connotation. Something horrendous is awe-inspiring. To my mind, Borro does exploit this term deliberately as to highlight the contrast between theological and philosophical knowledge. In short, he is deliberately and manifestly making a claim that is the opposite of that of Ficino. Hesiod, Orpheus, and Plato, have been probably duped by the terrible and horrendous cosmogonic tale of Trismegistus. According to Borro, this shows well enough that they did not deal with the cosmogony problem as natural philosophers are supposed to do.

Borro's criticism consists in showing that a disorderly pre-cosmic motion can neither be violent nor natural. Had it been violent, there should have been a prior natural and therefore orderly disposition of the world. Had it been natural, instead, one should then admit that before the cosmos there was already a cosmos. In both cases, cosmogonists are assuming the existence of what is to be demonstrated, that is, the order of the world.[41] Borro is basically aligning himself with the same kind of criticism put forth by Aristotle in the third book of the *De caelo* (308b8-301a20). He does not mention only Aristotle, though. He rather prefers to call on Alexander of Aphrodisias:

> If that [primeval] motion is natural, then it must be ordered in: [1] a principle, thanks to which the mobile begins to move; [2] a medium, through which the mobile is moved; and [3] an end, toward which the mobile moves. For not only is nature the cause of order, but it is also ordered by a principle, through a medium, and toward an end, as it is known from what is written in the eighth book of the *Physics*, text 14, and often elsewhere. In fact, such an order is the form of the world, as shown by Alexander of Aphrodisias in the second book of the *Natural Problems*, chapter 19.[42] Hence, while there was that

veterum Philosophorum monumenta, librum praesertim Magni Plotini, cui titulus est Unde mala, et librum Procli de anima, et daemone; et nihil inordinata informique confusione peius, nihil horrendius excogitari posse, invenies: mirandum ergo non fuerit, si Plato, Orpheus, et Hesiodus ab illa horrenda Trismegisti umbra Chaos confusum, atque inordinatum forte traxerunt" (Borro (1975), pp. 80-81).

[41] Cf. *ibid*., p. 18: "Hos ut dicant compellimus: naturane, an vis illum confusionis motum conciliaris? Si vim eumdem conciliavisse velint, motionem illam naturalem demonstrare cogentur, quam hac violenta motione priorem esse oporteat; si violentum illud est, quod contra naturam fit, ut non raro scripsimus, quam cum demonstrare non possint; nec motionem posteriorem, quae nullibi est, demonstrare poterunt: posterius enim sine priori esse natura non patitur, ut dictum est quinto Divinorum particuala duodecima."

[42] Cf. Alexander of Aphrodisias (1541), p. 36. See also the English translation from the Greek by R. W. Sharples: Alexander of Aphrodisias (1994), pp. 16-17.

> primeval Chaos, before the world being arranged, there was the world, because there was already the form of the world, which provides the world with its being [and makes the primeval motion a natural one, as initially supposed]. Who does not see that this is extremely absurd? So absurd that makes you laugh! We will expand on this later, in chapter 44.[43]

Chapter 44 does not exist (at least, I could not find it). But, as I said, Borro returns to the same problem in the second part of his book, Chapter 9. There, Borro strengthens his argument against the followers of Trismegistus. It becomes more evident in many respects that the burden of proof is on their shoulders. First of all, they should have said precisely *when*, *where*, and *how* the pre-cosmic and chaotic motion happened. Moreover, they did not say whether that motion was simple, that is straight or circular, or mixed of the two:

> In my opinion, they were seriously mistaken, because they should have first of all spelled out whence, when, and how that Chaos came to be and became stable. Also, they were mistaken because they did not say anything about what pertains to motion. They did not say what, at that time, caused the disorderly motion of that Chaos, and what that motion was. Was it a straight motion or a circular motion, or rather a mixed of the two? It could not be a mixed one, given that the latter is made out of preceding simple motions, whose combination gives rise to mixed motion, indeed. But those chaotic movements could not be simple, either. For simple motion pertains to the elements and to the sky (as shown in the first book of the *De caelo*). But [in that primeval Chaos] the elements and the sky did not exist yet, being all mixed into each other in a hazy manner. They moved without order, giving rise to a hazy and formless matter, which is evidently not suited to movement. In fact, supposing that that matter is moving, it is necessary for it to be in act. But in order for its motion to be possible, there must be a motive cause [that is, a form], given that formless matter cannot move itself.[44]

[43] "Si motio haec est naturalis, ergo ordinata ab uno principio, a quo mobile moveri incipit, et per unum medium, per quod mobile fertur, et ad unum terminum, ad quem mobile tendit. Natura enim non tantum est ordinis causa, sed etiam ordinata ab uno principio, per unum medium, et ad unum finem: ut notum est ex his, quae literis consignata sunt libro octavo Physico auditu particula decimaquarta, et alibi saepe. Verum hic ordo est forma mundi, ut demonstrat Alexander Aphrodisiensis libro secundo quaestionum naturalium capite decimonono; ergo dum erat illud chaos antiquum, antequam mundus conderetur, erat mundus, quia tunc erat forma mundi, quae dat esse mundo: quod quis non intelligit esse maxime absurdum? Imo huiusmodi ut risum moveat: qua de re copiosius agemus infra capite quadragesimoquarto" (Borro (1975), pp. 18-19).

[44] "Hi graviter (mea quidem sententia) peccaverunt, quod explanare ante debuerint: Chaos ipsum unde, quando, quomodo esse, aut constare coepisse, et quod ne verbum quidem fecerint de illis, quae ad totam

Borro then concludes with another passage that is very interesting for our study. It is in this passage that we can finally see the importance of the debate on cosmogony within the controversy on the motion of the elements.

After a brief remark about the kind of movement one should ascribe to pre-cosmic motion (was it substantial, quantitative, qualitative, or local?), and another one about the fact that the primeval chaos lacks the absolute cosmological coordinates that makes natural motion possible,[45] Borro says that in the pre-cosmic chaos it would be also impossible to distinguish heavy bodies from light ones. Also, it would be impossible for heavy bodies to move away from light ones. If heavy and light bodies are not defined by their own nature, this can only be because there is not a proper principle of motion toward different directions, such as upward and downward, back and forth. But this principle of motion must exist, and it is taken for granted in the controversy on the motion of the elements, whose aim is to understand *what* that principle is.[46]

In sum, Borro concludes that in the initial state of chaos imagined by Trismegistus, Plato, and others, there would not be the conditions for any kind of movement to exist:

> They had to say of which kind that primeval motion was, whether it was natural or violent. They cannot persuade themselves or others that that motion was natural. For they claimed that there was a turbulent and disorderly motion before the origin of nature and before the origin of any other natural and persistent thing. They cannot even persuade about the opposite, namely, that the

motus quaestionem perinerent; A quonam ille tunc temporis fieret inordinatus motus confusionis, et quisnam esset ille: hoc est rectusne, an in orbem, an potius ex utroque commixtus. Mixtus esse non poterat: quoniam mixtus non est, nisi simplices fuerint, e quorum mixtione nascatur, at simplices motus nondum erant, utpote simplicibus elementis distinctis, et caelo quorum proprij sunt motus simplices (ut demonstratum est libro primo de caelo) non existentibus, sed confuse commixtis, nulloque ordine iactatis informisque cuiusdam confusae materiae locum gerentibus; quae motu cieri apta non est; cum actu sit oporteat, quod movetur, ut autem moveri posse videatur, causa movens assignanda erat: quandoquidem informis materia se non moveat" (*ibid.*, p. 81).

[45] Cf. *ibid.* pp. 81-82: "Explicanda etiam illis fuerant motuum genera, id est, num illa omnium confusio ad substantiam, num ad quantitatem, num ad qualitatem, num ad locum conitaretur, quatuor enim ista sunt motuum genera ex libro tertio de Physico auditu, quae cum motore, sine quo non fit motus, explicanda necessario fuerant. Dicere cogebantur, si negocium universum absolvere voluerant, quamobrem motus illius confusio nasceretur, cum omne quod movetur, alicuius gratia moveatur; cur item quaedam sursum, quaedam deorsum, quaedam ante, quaedam pone cierentur: cum in ea inordinata confusione nullae locorum differentiae invenirentur. Dicendum item fuerat illi, cuiusmodi fuisset primus ille motus, num naturalis an violentus: naturam illum effecisse nec sibi, ne aliis persuadere potuissent; quoniam ante originem naturae, ac caeterarum omnium rerum naturae constantium motionem illam turbolentam, atque inordinata introduxerunt; nec contra naturam: quoniam nihil excogitari potest absurdius, quam qui motus contra naturam sit, ut hic motum naturalem antecedat."

[46] Cf. *ibid.*, pp. 14-16.

> primeval motion was against nature. For nothing is more absurd than thinking that motion against nature comes before motion according to nature. Likewise, they imagined without reason that there were heavy and light bodies in that disorderly Chaos which they talked about. In fact, they did not say with respect of what heavy things differ from light ones, how they separate from each other, and what their proper place and motion was. For heavy and light things could not have the same place and motion. Each of them must have had one, in order for heavy and light things to exist. Accordingly, they could have not been disjointed by that chaotic kind of motion, if they [already] had their own place, and if they rested with order in their own place, having each own a disorderly motion toward their own natural place. Hence, [they say that] the world was in a chaotic situation, [but] the world is nothing but the very elegant order of [its] parts, as Alexander of Aphrodisias has very well written in the second book of the *Natural Problems*, chapter 19.[47]

Borro is convinced to have conclusively shown that the primeval chaos imagined by Trismegistus, and revived by Orpheus, Hesiod, and Plato, is just a horrendous chimera. Today we know that Hesiod never spoke about chaos in terms of a messy state of things; [48] and Plato did not draw from Trismegistus. However, as recalled earlier, it was not uncommon at Borro's time to trace an evolution line connecting Trismegistus with Plato, passing through Hesiod as well as other ancient writers. Hesiod, for example, was sometimes associated with Ovid's cosmogony in the *Metamorphoses*. Furthermore, all these authors were more and more often perceived as being Christian in inspiration.[49] Their cosmogony was then interpreted in a Mosaic fashion. It is hardly plausible that Borro was not aware of this Christianizing tradition. His polemic target was most likely a certain theologizing philosophy, which clashed against his non-theological approach to natural philosophy.

Borro does not simply repeat Aristotle's criticism in the third book of the *De caelo*. As we have seen, although he maintains a line of reasoning identical to that of

[47] "Dicendum item fuerat illi, cuiusmodi fuisset primus ille motus, num naturalis an violentus: naturam illum effecisse nec sibi, ne aliis persuadere potuissent; quoniam ante originem naturae, ac caeterarum omnium rerum naturae constantium motionem illam turbolentam, atque inordinata introduxerunt; nec contra naturam: quoniam nihil excogitari potest absurdius, quam qui motus contra naturam sit, ut hic motum naturalem antecedat. Cum item in confusione illa inordinata, quam commenti sunt, gravia esse et levia absque ratione finxissent, cur subticuerunt quomodo gravia et levia distinguerentur, ac alia ab aliis separarentur, et quinam erat proprius ipsorum locus, aut motus. Non enim idem locus, aut motus omnibus esse poterat; alioqui unum, et idem etiam gravia, et levia fuissent; quae motu illo confuso disgregari non potuissent, si proprios locos, et inordinatum motum ad naturalem locum cumdemque proprium, et ordinatam si quietem in proprio loco habebant. Ergo in chaos erat mundus, quem nihil aliud esse constat, quam iste partium elegantissimus ordo, ut optime scripsit Alexander Aphrodisiensis libro secundo quaestionum naturalium capite decimonono…" (*ibid.*, p. 82).

[48] On Hesiod's notion of chaos, see Sassi (2018), p. 35.

[49] I will expand on this later, when I will consider the possible sources of Galileo's first cosmogony (§44).

Aristotle, nonetheless he develops new arguments and refers to different *auctoritates* (e.g., Alexander of Aphrodisias, Proclus, Plotinus). By so doing, Borro shows that the cosmogony of chaos is unacceptable from a scientific standpoint. According to Borro and all those who were involved in the controversy on the motion of the elements, what allows natural motion to take place is a natural capacity to move toward and rest in a certain place. *Gravitas* and *levitas* are responsible for natural motion, and they cannot work in an isotropic universe. They cannot trigger any type of motion in a universe that is not already a *cosmos*, an orderly world in which up and down are absolutely defined. Opposite claims, which are chiefly taken from cosmogonic narratives, are therefore refuted by Borro. It appears that it is within the domain of cosmogony that the most important features and the most visible weaknesses of a doctrine of motion can be easily spotted. Thus, cosmogony falls inevitably and almost naturally within the scientific kind of problems touched upon by a natural philosopher who studies local motion.

§29.
Cosmogony in the Pisan Controversy on the Motion of the Elements. Francesco Buonamici

Another Pisan professor of Galileo was involved in the controversy on the motion of heavy and light bodies: Francesco Buonamici. As already said, he wrote a mammoth work on the subject, which is divided into ten books. In book V, chapter 16, Buonamici criticizes ancient cosmogonies along the same lines as Aristotle's.[50] In my view, his criticism of cosmogony does not add a lot more to the topic than what we have already read in Borro's *De motu*. For this reason, I rather prefer here to focus on another chapter of the fifth book, where Buonamici stressed the connection between a certain view on gravity and cosmology.

In book V, chapter 10, Buonamici clarifies that "heavy and light bodies are such according to nature, not by comparison" (*Quod grave et leve secundum naturam talia sunt, non comparate*).[51] This is an important distinction, which divides the opinion of Aristotle from that of Plato and Themistius. The latter, says Buonamici, though he followed the general outline of Aristotle's natural philosophy, on this point was seriously mistaken, just like Plato. Buonamici does not quote Plato directly, but it is clear

[50] Cf. Buonamici (1591), pp. 471-473. The chapter's title is "*Quod omnia quae recta moventur habeant aliquem motum naturalem*."
[51] *Ibid.* p. 462h.

that he has in mind a precise passage of the *Timaeus*, namely, 63b-e. Here Plato holds that, since 'up' and 'down' are relative to the perspective of the observer, so too are the meaning of 'light' and 'heavy.' Buonamici describes Plato's theory as follows:

> [Plato and Themistius] claimed that heavy is what inclines naturally toward *a certain place* [*suapte natura aliquo vergeret*], whereas light is what moves away *from that place* under its own impulse [*inde suapte impulsu discederet*]. For this reason, since fire is hardly held back and flies away spontaneously from this place, it is said to be light; earth is instead said to be heavy, in that it moves toward us [*ad nos prorepit*]. Likewise, who is placed on the circumference of the world would say that fire is heavy, given that fire has an inclination toward the circumference. But he would say that earth is light, because it moves away spontaneously from the sphere. Because of this, for Plato and Themistius there are not heavy and light things in absolute, but only by comparison.[52]

Buonamici, following Aristotle, does not agree with Plato and Themistius. 'Heavy' and 'light' are terms that refer to something that actually exists in nature; that is, 'heavy' and 'light' are not in the observer's eyes. It means that those terms point out what is in nature, not what is for us (*ad nos*). Hence, their definition cannot be relative to a different position (*positio*), but it must mirror the only, non-relative, point of view admissible in natural philosophy, namely, that of nature. The correct definition of 'heavy' and 'light' depicts the absoluteness of nature, and it provides us with a secure knowledge – a science.[53]

All the variety of effects and movements we observe from whatever place we are located in, they are all manifestation of what is in nature. Therefore, if we define 'light' according to nature, and not according to us, we can describe fire as being light

[52] "Ita enim exposuerunt grave, [id] quod suapte natura *aliquo* vergeret, et contra leve id quod *inde* suapte impulsu discederet. Ideo cum ignis aegre retineatur, et sponte evolet ex hoc loco: dicitur levis; terra, quoniam ad nos prorepit, nominatur gravis. Ita si quis esset in sphaera ignis, quoniam illo propensionem obtinuit, ibi gravis esse diceretur; terra vero, quod illinc sponte discederet, appellatur levis. Quocirca apud Platonem atque Themistium grave et leve nihil erat absolute, sed comparate tantum" (*ibid.*, my emphasis). I have emphasized some words in order to show that Buonamici knew that for Plato heavy bodies do not necessarily move toward the center of the world. However, sometimes he aligns Plato's view with that of the Atomists, according to which all heavy bodies converge toward the center of the world. In my view, when Buonamici aligns Plato and the Atomists, he does it only with respect to the extrusion theory, which he criticizes elsewhere (cf. Buonamici (1591), p. 464, and Helbing (1989), pp. 204-205).

[53] "Apud Aristotelem vero est grave et leve simpliciter, tamquam natura quaedam, habent enim haec in seipsis velut igniculos quosdam motus, atque illos quidem per quod ad certa loca perpetuo concitentur quae certe sunt a natura, neque positione duntaxat, et ut dicit Aristoteles ad nos" (Buonamici (1591), p. 462h). This is an evident, although tacit, reference to the beginning of the fourth book of Aristotle's *De caelo* (IV, 2).

both on Earth and on the sphere of fire. 'Light' is indeed the capacity to move toward a precise place, and to rest therein. Since the place toward which fire moves is always the same, it can be given a unique term: 'up.' Its contrary is 'down,' which is the direction and the place toward which heavy bodies move and rest. Although 'up' and 'down' are terms relative to the observer, when they are associated with the behavior of natural bodies and thought of within a universal geocentric frame of reference, they become univocal terms. And this is what natural philosophers do in order to mirror with their language real differences in nature. The same differences go totally unnoticed in a relativized perspective, such as that of Plato.[54]

As we can see, a certain terminology is applied by Buonamici (*a*) in accord with the behavior of a natural body, which is in turn defined (*b*) in accord with a universal and cosmic point of view provided by cosmology (center and periphery of the world). According to Buonamici and the Aristotelians, both (*a*) and (*b*) are in nature; that is, they do not depend on someone's perspective. It is a fact that fire moves always up toward the circumference, and earth always down toward the center of the world.

It may seem that Buonamici has been able to refute Plato's and Themistius's definition of 'heavy' and 'light.' Their definition is not 'scientific' in that it does not describe nature, but our way of seeing nature. Yet Buonamici recalls that Plato is also known for a further definition of 'heavy' and 'light,' that has more or less to do with the actual (read ontological) composition of a body.

In the *Timaeus*, Plato does also say that a body is heavier than another one when it is less easy to be lifted, because it is bigger and it has more quantity of heavy particles. Thus, a body is called 'heavy' in comparison to a less heavy one, which is called 'light.' In this case, the definition does not only depend on the position of the observer in the world, but it also depends on the quantity of particles that a body contains compared to another one of the same kind, that is, having the same tendency toward a certain place. Also, since Plato has relativized the notion of 'downward,' that tendency might not necessarily be toward the center of the world.[55]

Yet this account from Plato's *Timaeus* is sometimes neglected by Renaissance Aristotelians, who usually followed Aristotle's criticism of Plato's doctrine in the fourth book of the *De caelo*, where it is assumed that all heavy bodies move toward the center of the world.[56] Borro, for instance, argues that a big amount of fire, being heavier than a small one, should rise up more slowly than the small one. Yet experience

[54] Buonamici (1591), pp. 462h-463a, especially the following passage: "Non igitur positione solum, quemadmodum Plato dicebat, verum etiam et supra et infra et grave et leve sunt natura. Atque esse in loco superiore est natura cuiusdam; sic et alterius est esse in loco inferiore. Et eius quod superius esse potest, supra, infra vero eius quod esse potest in infimo loco: illud erat leve; hoc vero grave."

[55] Cf. *Tim.*, 62c-63e.

[56] Cf. *De caelo*, IV, 2, 308b3-28.

tells us the contrary.[57] Borro assumes, like Aristotle, that what is heavy goes toward the center of the world, and this view is then improperly applied to that of Plato.

Buonamici, too, advances a similar criticism.[58] But in the chapter I am dealing with here, Buonamici develops a different argument against Plato's doctrine. As I showed in the passage quoted above, Buonamici knows that for Plato heavy things do not necessarily incline toward the center of the world. That being said, Buonamici's main goal is to show that 'heavy' and 'light' are properties that can be found in nature: they do not depend on us, or on any sort of comparison between quantities of matter. Just like heat and cold are real things in nature, so too heavy and light are real and well-defined properties of bodies. In fact, heavy and light results from the action of cold and heat. What is heavy, is heavy because its matter has been condensed under the action of cold. On the contrary, light bodies are light because their matter has been rarefied by heat. Therefore, a body composed of a large number of particles of matter can be either light or heavy: light, when its particles are hot and rarified; heavy, when they are cold and condensed.[59]

The last point needs some clarification. Buonamici is not resorting to what we may call 'density' or 'specific weight.' According to Buonamici, cold and heat act upon matter by changing it *qualitatively* on an ontological level. That is, they change the nature of matter, not only the ratio between quantity of matter and volume. As Buonamici reasons, cold can be considered to be a privation of heat. This means that a body can be hot in actuality today, but tomorrow it can be cold, that is, hot in potentiality. Also, temperature has different degrees. So too there must be different degrees of heat in actuality and potentiality. Now, the same reasoning applies to heavy and light regarded as qualities present in nature, given that for Buonamici they derive directly from heat and its privation, i.e. cold. The quality of being heavy can be then seen as a privation of another quality that makes things light. So Buonamici can conclude that, just as something is to a certain degree colder than something else, so too earth is heavier than air.[60]

[57] Cf. Borro (1575), pp. 41-42. On this, see De Pace (1990), pp. 9-13.

[58] Cf. *supra*, nt. 52.

[59] "Natura autem quae leve facit, aut grave, calidum est et frigidum, sive actu, seu virtute. Nam calidum extenuat et attollit, frigidum cogit et deprimit" (Buonamici (1591), p. 463b).

[60] "Ex quo de naturis eorum quae sic afficiuntur, ita iudicare licet: ut, quemadmodum calidum praesefert rationem actus, privationis vero frigidum; sic leve sit actus, grave autem vim subeat oppositae privationis. Caeterum sicut inter actus est ordo quidam, sic inter privationis; et ex his aliqua prior, alia posterior est. Quamobrem sicuti prior actus est ratio secundi, consimiler privatio prior habenda est analogice ratio posterioris. Ex hoc vero efficitur, ut gravitas terrae, quae est privatio primi gradus, sit ut ratio gravitatis aquae, quae est gradus secundi. Itaque quod spectat ad motum, terra erit natura prior quam aqua; ideoque motum aquae optimo iure terminabit" (*ibid.*). Obviously, one can take another term of comparison and conclude that water is by nature prior to earth: "Tametsi, quantum est de gradibus actus qui a primo ente derivantur, aqua est longe prior, atque perfectior. Proin aqua item sic iudicari poterit locus terrae: erit enim

The analogy between heat and light and cold and heavy is useful to see in what sense Buonamici refutes the theory attributed to Plato. The *number* of particles contained in a certain body having a certain volume, compared to the *number* of particles of another body having the same volume, is of little aid to define whether a body is heavy or light. Buonamici claims that one should look at the (qualitative) *nature* of the particles contained in each body. The same particles can indeed be heavy or light; and they can be so at different degrees of actuality (or potentiality). By so doing, Buonamici is convinced to have shown that 'heavy' and 'light' are real and distinct qualities inherent in the nature of things, independently from our perspective and from any kind of comparative measuring. Obviously, heavy and light things can be measured via comparison.[61] But this is not what makes them heavy or light.

The most interesting part of Buonamici's criticism comes at the end. Buonamici concludes the chapter by highlighting the interdependency between the order of the universe and the nature of heavy and light bodies.

> Hence, just like in nature the extremities of the world are the lowest and the highest place, so too gravity and lightness can be found in nature. For this reason, all things are in accord with each other, and the fabric of things is wonderful. Outermost things are in accord with innermost things, and what is in the middle is in accord with both outermost and innermost things. All things were arranged with great order by the supreme Maker of everything. The heaviest thing could not be at rest, had not existed the lowest place, which is the center of the world. Nor can an absolutely light thing rest in a place other than the highest one, which is the concave of the sky. Nothing can rest there other than what is absolutely light; just like nothing can rest here, near us, except what is absolutely heavy. The places in the extremities and between the extremities of the world are arranged according to nature. It is surely not because of consuetude or custom that they are as they are.[62]

terrae perfectio, quippe nobilioribus insignita qualitatibus. Sed, cum locus per se sit terminus motus, longe prius et antiquius est, terram esse locum aquae" (*ibid.*). In any case, the result is always the same, that is, heavy and light are two "forms" established by nature, therefore they are not such in relation to us: "Ergo leve et grave sunt duae formae a natura constitutae, non ad nos, ut censuit Plato" (*ibid.*).

[61] Cf. *ibid.*, pp. 500g-501d; on this, see also Helbing (1989), p. 208.

[62] "Ergo et gravitas item ac levitas, ita, ut, sicut in mundo extrema reipsa sunt infimum et supremum in quibus haec secundum naturam manent, sic et illa summa reperiantur. [...] Inde omnia concinunt, et mirabilis est rerum contextus, ac respondent extrema primis, media utrisque, omnia omnibus optimo ordine a summo rerum opifice dispensata. Nec praeter hunc ipsum infimum locum, qui est medium mundi, gravissimum quiescere potest, nec praeter supremum illud, quod est caeli concavum, alibi simpliciter leve consistere valet: neque ubi contra ullum aliud quam simpliciter leve, ut nihil aliud apud nos quam grave simpliciter. Et extrema igitur et media secundum naturam sua loca sortita sunt, non sane quae sint huiusmodi ex instituto, aut propter aliam quandam habitudinem" (Buonamici (1591), p. 463d).

The order of the world is what makes a body heavy or light. Outside the universal framework given by the geocentric cosmos, there could be no heavy or light body. The nature of heavy and light bodies is one with the order of the world. This means that the two things, the order of the world and the definition of 'heavy' and 'light,' cannot be taken separately. This tight linkage is what prevents a natural philosopher from endorsing a cosmogonic view. Just as Borro, Buonamici too believes that it is impossible to conceive of the natural motion of heavy and light bodies outside an already-existing cosmos. Otherwise, why is our world so manifestly orderly? How can it be kept in order if bodies do not move to restore an already-existing order? Hence, there must be an absolute order to which natural bodies abides by when they are moved according to nature. This order pertains to the very structure of the cosmos. Aristotelians such as Pererius, Borro, and Buonamici, have a cosmologized understanding of gravity because they have a cosmologized understanding of order.

§30.
Cosmogony, Order, Nature, and Gravity

From the beginning, in the first book of the *De motu*, Buonamici emphasizes the strong connection between the cosmic order and nature. (A connection that, as we have seen, was already emphasized by Aristotle in the *De caelo*.) After inviting the reader to consider the world as a perfectly ordered whole, Buonamici says:

> If the duty of justice is to distribute to each one according to their merits and to guard each one, and given that this is excellently made by nature, then we can rightly say that nature is the most perfect justice [*iustissima*]. Nature must be regarded as that legislator who was given the laws by God, thereby arranging everything with admirable order, granting each one their own, and guarding [*servat*] that kind of justice called distributive justice. Accordingly, nature is the true *ratio* of things, that is, the true author [*auctor*] of order. Whatever is beyond that *ratio*, it surely is beyond nature.[63]

[63] "Nam si pro merito cuique prospicere ac distribuere iustitiae officium est, cum id optime natura praestiterit, iure iustissima perhiberi potest, et tanquam legislator ille cui leges a Deo dictatae fuerint, ordine admirabili cuncta disponens et cuique suum tribuens, servat illud iustitiae genus, quod distributivum vocant. Sic de natura ipsa confitendum est. Quocirca et ipsa est vera rerum ratio, hoc est verus ordinis auctor et quicquid praeter rationem istam existit, est omnino praeter naturam" (*ibid.*, p. 26g-h). I left the term '*ratio*' untranslated, as I am not totally sure on how to translate it into English. On this term, see Fattori-Bianchi (1994), including Galluzzi's paper on "*ratio*/ragione in Galileo."

It is nature that, just like a legislator, maintains and guards (*servat*) the original commands or laws given by God.

At first glance, this idea of nature is not so far from that exposed by Galileo in the *Copernican Letters*. Nature is described by Galileo as being "the most obedient executrix of God's commands." Nature does not care about human understanding; she "is inexorable and immutable" and "never transgresses the terms of the laws imposed on her."[64]

Buonamici tells his readers something alike: there is an order in the world which is established by God and that is perpetually maintained by nature. In this regard, the metaphor used by Buonamici is very illustrative. It shows that: (1) without laws and rules there would be anarchy and chaos, as much in the cosmos as in human affairs; (2) the way nature operates to maintain the order of the world is good in itself, just like that of a legislator who abides by a distributive kind of justice; (3) every God-given law is there for a good reason, so too the cosmos is rightly ordered by God and kept so by nature; (4) if something is not regulated by the law (*praeter legem*), it is also beyond justice; likewise, when something happens that is not regulated by the *ratio* provided by nature (*praeter rationem*), it is outside the realm of nature (*praeter naturam*).

As it appears, Galileo was obviously not the first one to apply the legal terminology to the realm of nature.[65] Also, I fear that laying much stress on the fact that, according to Galileo, nature is independent from human understanding, would not contribute enough to differentiate his and Buonamici's view on nature. As we have seen, Buonamici puts a lot of effort in distinguishing what is by nature (*secundum naturam*) and what is according to us (*ad nos*). He is convinced that a natural philosopher should always inquire into what is in nature regardless of the human representations of it.

It is clear that, in a period where nature is conceptualized in close connection with the idea of order, different understandings of nature might emerge when different ideas of order take hold. But even in such a situation, the same metaphor could be used to describe two very different notions of order and nature. The metaphor may be used to express a generic idea of nature as guarantor of universal regularities. That being so, it is important for us not to focus only on the metaphor itself, but especially on the meaning of the terms involved in the metaphor (such as 'law' and 'order').[66]

[64] These expressions are from the *Letter to Castelli* and in the *Letter to the Grand Duchess Christine* (cf. Galilei (2008), pp. 104, 116 [= OG, V, pp. 283, 316]). See also OG, XV, pp. 24-25. On the qualification of nature as "inexorable," see Stabile (1994), pp. 56-57, Stabile (2003), and Hamou (2008).

[65] See Van Dyck (2018).

[66] Obviously, I am not saying anything new in this regard. Paolo Rossi had already emphasized that it is important to focus on "i mutamenti e le differenze di significato di termini come *natura*, *legge*, *ordine*,

Given the aims of the present work, there is a far more interesting remark that can be drawn from the foregoing. As we have seen, it is meaningless to think of cosmogony within the conceptual framework provided by the Aristotelian natural philosophy. Heavy and light bodies, and their local motion too, are by definition linked to a certain order of the world, which is geocentric. The only possible way to rethink the origin of the cosmos in terms acceptable to a natural philosopher, is to link the behavior of heavy and light bodies to a different idea of order, which does no longer overlap with cosmology. A non-cosmological idea of order, or a decosmologized idea of order (if we think of it in contrast with the Aristotelian one outlined above), is what needed to allow something natural – that is, responding always to a certain *ratio* – to happen independently from the existence of a cosmos. In this case, it becomes possible to rethink cosmogony in natural philosophy. But according to Borro and Buonamici, this is exactly where Plato and other ancient natural philosophers failed. They were not able to put forth a theory of heavy and light (which is also a theory of local motion) whereby to account for the cosmological order of the world. On the contrary, the Aristotelians could bypass that issue, as they linked heavy and light to the center and extremity of the world, namely, to a geocentric order of the world.

As we shall see, Galileo notices in the *De motu antiquiora* that the Aristotelian linkage between physics and cosmology does not tell us *why* (*cur*) the cosmos is geocentric. It just takes it to be a natural fact, needing no further explanation, that heavy things move toward the center of the world.[67] In its formulation, this further question – why? – leads to a cosmogonic account with which to illustrate a decosmologized kind of order in nature. It is for this reason, in my view, that Galileo provides a particular cosmogony in the *De motu antiquiora*. Through cosmogony, he strives to show to its Aristotelian counterparts that, not only can a different idea of order and nature (a different philosophy of nature) match with the reality of the geocentric cosmos, but it can even account for its origin and explain why the world is geocentric.

It is paramount to recognize the influence of local controversies on important historical actors like Galileo. As I believe, Galileo was somehow compelled by the same Aristotelians engaged in the dispute on the motion of the elements to make cosmologically coherent his decosmologized reconceptualization of heavy and light

esperienza, *artificialità*" (Rossi (1989), p. 93). And many are the works devoted to these notions. For example – just to mention only one among many – Gregory T. (2007) gathers a series of papers where Tullio Gregory shows, *inter alia*, how the notion of nature (including the idea of the book of nature) has changed during the Middle Ages.

[67] "Aristoteles, 8 Phys. t. 32, dum, quaerens cur gravia et levia ad propria loca moveantur, subdit, causam esse quia habent a natura ut sint apta ferri aliquo, et hoc leve quidem sursum, grave autem deorsum" (OG, I, *De motu antiquiora*, p. 252).

bodies. As I shall attempt to show, in Galileo this resulted initially in a geocentric cosmogony grounded in a non-Aristotelian understanding of gravity.

As we have seen in Pererius's commentary on the *Genesis*, God and nature do nothing in vain. Buonamici, too, takes this as a fundamental principle that can never be transgressed by natural philosophers.[68] Also, the laws of nature are perfect, and a change in their functioning would amount to a crack in the perfect order originally established by God. Something God would not allow without a good reason. As a result, cosmogony, namely, a passage from disorder to order, cannot happen naturally, nature being the guard of the divine order of the world. But, as already said, this holds true only when the divine order is tightened into a cosmological grid. In this case, it is impossible to think of the pre-cosmic motion of heavy and light bodies. This can be done only after developing a notion of heavy and light, or better, of gravity, that is no longer linked to a certain cosmological view but that can nonetheless be in accord with it. From the *De motu antiquiora* onwards, Galileo's very same approach to the problem of gravity takes distance from that of his contemporary Aristotelians. In order to show this, it may be beneficial to first take a look at some of the different theories of gravity that were developed before Galileo.

[68] "Nil igitur frustra natura et Deus efficiunt" (Buonamici (1591)., p. 23d).

VIII.
INTERMEZZO ON GRAVITY

§31.
PRELIMINARY REMARKS

In what follows, I shall attempt to show that what I have been hitherto calling 'gravity' is in fact a very complex notion, which underwent many processes of reconceptualization over a long span of time. I shall provide a preliminary and sketchy account of only a few of these processes, without making any claim for exhaustiveness.

In the secondary literature, the Latin word *gravitas* is usually translated as heaviness, weight, or gravity. These terms are also generally used to describe Aristotle's doctrine of 'heavy' and 'light.' Especially the first term, heaviness (βαρύτης), is employed notwithstanding the fact that Aristotle rarely resorts to it, as he often refers to weight (βάρος).[1] Lest superimposing our categories of thought and our historically-defined notions on authors who lived in another time than ours, it is paramount to adopt a method that allows us to gradually and contextually unveil the meaning of certain notions.

I believe that Pierre Souffrin has more than anyone contributed to the definition of such a method in his inquiries into 'velocity.'[2] He used to leave untranslated those critical notions, such as *velocitas*, that needed historical clarification. By so doing, he could gradually and contextually clarify the meaning of *velocitas* (e.g., average or instantaneous velocity) without assuming it from the beginning. Although I will not apply Souffrin's method as painstakingly as Souffrin did, I will however leave some terms untranslated when I think it necessary.

Galileo scholars are not new to such a method. Paolo Galluzzi's essential work on *momentum* can be taken as a perfect example in this regard. An additional merit of Galluzzi's work is that it is attentive to those processes of reconceptualization that occurred in the encounter of different cultures, such as the Greek and the Latin.[3] While taking Galluzzi's work as an example, I shall also try to follow Tullio Gregory's

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[1] If we exclude Aristotle's spurious works, there are only five occurrences in the entirety of the *corpus Aristotelicum* where βαρύτης can be translated as 'heaviness' (*Met.*, V, 1020b10, 1022b17; *Phys.*, V, 228b30; *De caelo*, I, 273a26; *De Gen. et Corr.*, I, 326a7), and a few other occurrences where βαρύτης denotes harsh taste, moral and rhetorical seriousness, or a baritone sound.

[2] Cf. the second section (*Mouvement et vitesse*) of Souffrin (2012), pp.75-317.

[3] Cf. the first part («*Momento*» *nella tradizione*) of Galluzzi (1979a), pp. 1-149.

observations about the important role of *translators*, who deserve to be put on a par with *authors*.[4]

Given these premises, it is natural that the history of the reconceptualization of certain notions is a history bristling with ambiguities. Not only ambiguities inherent in the scientific terminology of the past, but especially anachronistic ambiguities, that is, ambiguities that stem from projecting our notions onto terminologically similar notions of the past. Why, then, making the effort of climbing such a tall 'Tower of Babel'? Why embarking on a task that seems after all to be unrelated to Galileo's cosmogony?

First of all, in the previous chapter I have shown that there is a traditionally strong linkage between gravity and cosmogony. Now we should try to understand what 'gravity' used to mean in some specific historical instances. This will put us in a better position, later on, to understand how Galileo escaped the logic that prevented Aristotelians from thinking of cosmogony as a physically possible event.

Secondly, and perhaps more importantly, in this chapter I will draw the backdrop against which it finally becomes possible to read Galileo's reflections on 'gravity' without lapsing in unfounded or superficial readings.[5] Sure, the backdrop I will provide is defective in many respects, but we must start from something.[6]

[4] Cf. Gregory T. (2006), pp. 41, 45-46, 54, 58, 89; Gregory T. (2007), pp. 152-153, 162-171; Gregory T. (2016), pp. 8-24, 28-29, 49, 65-66, where Gregory concludes by saying that "dobbiamo liberarci dal pregiudizio che antepone l'autore al traduttore, riconoscendo al primo un'originalità che il secondo non avrebbe…" Thanks to Gregory, I realized the importance of that resemantization process that Tullio De Mauro called 'neosemy' (cf. De Mauro (2006), pp. 99-102). As I shall try to show, I think that a resemantization process made βαρύτης an extremely technical term of the Greek philosophical jargon.

[5] In the next chapter (§45), I will consider Clavelin's and De Pace's interpretations of the *De motu antiquiora*, and I will argue that they rest on a historically superficial understanding of 'gravity.'

[6] Obviously, there are already important works on the subject (cf. Duhem (1905); Maier (1943), pp. 143-180; Maier (1982), pp. 40-60; Clagett-Moody (1952); Overmann (1974), which draws heavily from Koyré (1965); Brown (1978); O'Brien (1981a) and O'Brien (1984)). However, in some of these works the notion of weight is sometimes assumed to be a datum needing no further examination. Just to give a few examples, Anneliese Maier, who focused on medieval controversies on *gravitas*, claimed that "[w]eight (*pondus*) and gravity (*gravitas*) are considered to be identical: weight is nothing more than the hindrance of a tendency toward motion. In this regard the scholastics saw things more clearly than many seventeenth-century natural philosophers" (Maier (1982), p. 55, nt. 15). Her judgment was perhaps too hasty. Joseph E. Brown started his essay by referring to the "implicit" distinction between *pondus* and *grave*, given that "[n]either Aristotle nor his followers made the distinction explicit or observed it scrupulously…" (Brown (1978), p. 180). Brown also attributed the notion of *gravitas* to Aristotle (cf. *ibid.*). In his first splendid work on the *Theories of Weight in the Ancient World*, Denis O'Brien has shown the pitfalls of indiscriminately applying Aristotelian-based understandings of weight and motion to ancient sources. In the light of this, he argued that Simplicius's use of the expression κατὰ (τὴν) βαρύτητα to describe the movement of atoms does not necessarily mean that their movement is directed downward, that is, toward the center of the world (cf. O'Brien (1981a), pp. 171-172). However, O'Brien assumed that βαρύτης is a synonym for weight. As I shall try to show (§33), for Simplicius βαρύτης does not mean weight. My analysis strengthens O'Brien's thesis, and, if correct, it is also a less *ad hoc*-solution than the one advanced by Adam Chalmers, who suggested a sort of semantic reconciliation of all extant evidence on Democritus's doctrine. According to Chalmers, βάρος and its

§32.
ΔΥΝΑΜΙΣ AND ΒΑΡΟΣ
IN ARISTOTLE'S FOURTH BOOK OF THE *DE CAELO*

Aristotle's theory of natural motion is extremely puzzling. As already seen in the previous chapter, in the Renaissance there were controversies on the cause of the motion of the elements. How can the elements move by themselves if they are inanimate bodies? What is their mover? And how can the mover be distinguished from what is moved, given that the elements are simple, homogeneous, and uniform bodies? As of today, these and other questions still leave modern commentators puzzled; scholars have indeed advanced different interpretative solutions.[7] It is not my intention here to recall these interpretations, or to suggest a new solution. I limit myself to notice that Aristotle's account of the natural motion of the elements is, and has always been, open to different readings. Far from being despicable, this sort of ambiguity has proved itself fruitful and positive in the history of science, for it gave room to different readings that introduced new notions and terminology alien to Aristotle, thereby enriching his view in the attempt to solve controversies raised by his own texts. The Latin term *gravitas*, used to denote something responsible for natural motion downward, is one of the novelties introduced by the Latin readers of Aristotle.

Obviously, the notion of something responsible for the natural motion of heavy and light bodies can be found in Aristotle's text. Aristotle calls it a capacity (δύναμις) provided by nature (φύσις) insofar as the latter is the source or principle of motion (ἀρχὴ κινήσεως).[8] Sublunary elements can move naturally because they have a natural capacity for motion along a certain direction. For instance, Aristotle says that a body is heavy because it has an inner capacity to naturally move downward, that is, toward

derivative terms should be read as meaning "unwieldiness" when referred to Democritus's atoms (cf. Chalmers (1997)). As for Duhem's work on statics, see *infra*, §38. The study of 'weight' understood as a culturally determined notion has received renovated attention over the last years. I should like to express my gratitude to Cesare Pastorino, who invited me to participate in the workshop "Weight and Weighing Practices in the Early Modern Period: A Multidisciplinary Perspective" (February 2021). The workshop falls within the research project "The Weight of Things: Quantification of Matter and the Exchange of Technical and Learned Knowledge in Early Modern Europe." The project, headed by Pastorino, is funded by the German Research Foundation (FDG) and hosted at the Technische Universität Berlin.

[7] For some interesting and diverging opinions in this regard, see Machamer (1978), Gill (1991), Cohen (1994), Bodnár (1997), Gill (2009), Matthen (2009).

[8] As is known, nature is for Aristotle the source of both motion and rest (ἀρχὴ κινήσεως καὶ στάσεως) (cf. *Phys.*, II, 192b13-14). However, a body is called 'heavy' or 'light' according to its capacity to move in a certain direction (cf. the passage cited *infra*, nt. 11).

the center of the world.[9] Sometimes, this has been interpreted as meaning that weight is the natural capacity for downward movement.[10] This interpretation is certainly valid. It is commonly based on the following passage of the *De caelo*:

> As for heavy and light, we should investigate what each is and what their nature is and for what reason they have these capacities. For the study of these things is appropriate to discussions of motion, since we call something heavy or light because of a capacity to move naturally. There do not exist names for the activities of these things, unless someone were to think that ῥοπή is such a name.[11]

Limiting our study to the case of heavy bodies, this passage is usually interpreted as follows:

(1) a body is called 'heavy' because of a capacity to move naturally downward;
(2) a body is heavy because it has weight;
(3) thus, weight is the name of the capacity to move naturally downward;
(4) however, we do not have a name for the activity of weight, unless we call it ῥοπή.

Although inference (3) is a possible interpretation of Aristotle's text, it can however be replaced by an equally possible interpretation. From the fact that a body is heavy because it *has* weight, it does not necessarily follow that weight *is* the capacity to move naturally downward. The passage above is open to another interpretation:

[9] Cf., for instance, *De caelo*, IV, 1, 308b14-33.

[10] This is evident, for instance, in Guthrie's translation of the passage quoted in the next note (cf. Aristotle (1939), p. 327: "Our next topic must be weight and lightness…" [= Περὶ δὲ βαρέος καὶ κούφου…]). In general, all those who justly avoid using 'heaviness' to expound Aristotle's doctrine of natural motion call 'weight' the capacity for natural motion. See, for instance, Gill (2009), p. 143: "According to *De caelo* 4.1. we call things 'heavy' or 'light' because they have the capacity (τῷ δύνασθαι) for a certain natural motion. A body is *heavy* if it moves toward the center. A body is *light* if it moves away from the center. Weight and lightness are thus dispositions of bodies to move naturally toward or away from the center of the universe, and such motions spring from a body's own nature." Obviously, this is just a terminological choice, and as such it cannot detract anything from Gill's brilliant essay. It is a matter of terminology, not of contents. However, given that I am inquiring into the processes of reconceptualization, I cannot ignore terminological issues.

[11] *De caelo*, IV, 1, 307b28-33. The English translation is by Ian Mueller (cf. Simplicius (2009), p. 67, slightly modified).

(1) a body is called 'heavy' because of a capacity to move naturally downward;
(2) a body is heavy when it has weight;
(3) thus, a body is said to have weight because of a capacity to move naturally downward;
(4) thus, 'heavy' or 'having weight' are expressions that indicate a capacity to move naturally downward;
(5) however, we do not have a name for the activity of that capacity, unless we call it ῥοπή.

Expanding on this interpretation, we can add that for Aristotle weight is a term that denotes *a particular manifestation* of a natural capacity to move downward. When Aristotle refers to this natural capacity *in bodies*, he uses expressions such as "heavy" (τὸ βαρύ) or "having weight" (τὸ βάρος ἔχον). When he refers to the *extension in matter* of the same capacity, he uses "weight" (βάρος), and sometimes "inclination" (ῥοπή). Being in matter, weight and inclination can be used to denote a certain *quantitative* measure of a natural capacity to move along a certain direction.[12]

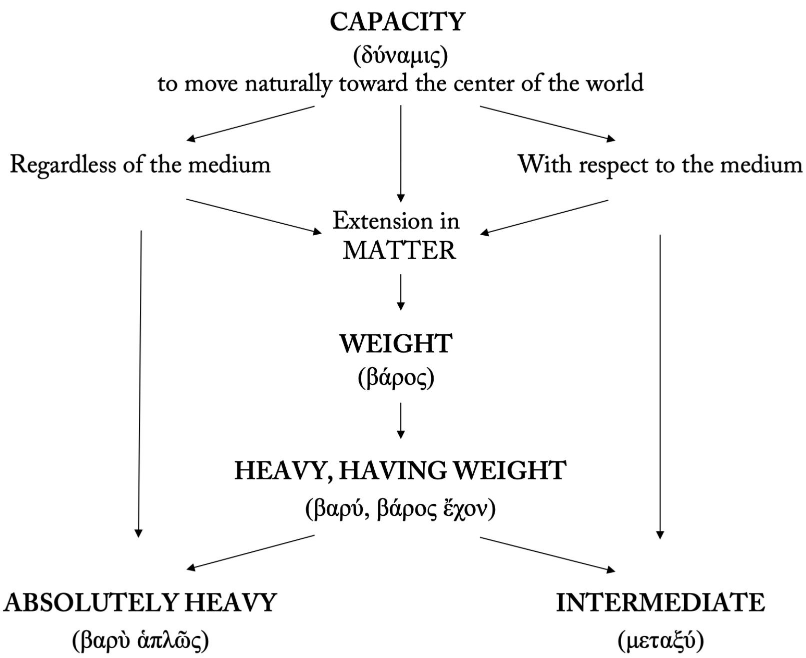
As a cursory remark, I must say that I am perfectly aware that ῥοπή is a difficult term in Aristotle's vocabulary. Even βάρος could be read in different ways. I do not mean to ignore the polysemy of these terms. On the contrary, I am trying to leverage on this polysemy, in order to show that Aristotle's doctrine of 'heavy' and 'light' is open to different, and equally possible, interpretations. My aim is after all to show that ambiguity is perhaps the most beautiful and useful feature of Aristotle's text. It is useful in that it allowed the formulation of a wide variety of scientific theories during a long historical period and within multicultural contexts, where and when the making of science was still considered an eminently bookish and exegetical practice. As I shall try to show (§33-34, 36-37), Aristotle's text was given new and different layers of

[12] Cf., for instance, *Phys.*, IV, 8, 215a25-29, 216a13-20; *Met.*, I, 1052b25 ff. (on this passage, see Cleary (1995), pp. 371-372). On ῥοπή, see Lang (1998b). In his study on "Bodies and Motions," Andrea Falcon has pointed out that Aristotle uses ῥοπή as one of the two paramount criteria (the other one being three-dimensionality) to distinguish mathematical entities from natural bodies: only the latter have ῥοπή (cf. Falcon (2001), pp. 47-57, 64, 72, 75-76, 173-174). Elio Nenci has interestingly shown that Aristotle does no longer associates ῥοπή only with problems concerning the equilibrium on a balance (see Nenci (2018), pp. 149-156). For some interesting, albeit very brief, observations on the ancient linkage between ῥοπή (and the verb ῥέπω) and the balance, see Furley (1989), p. 91. Furley leveraged on these observations to develop his critique of O'Brien's thesis (cf. *supra*, nt. 6). However, Furley perhaps did not consider that, although weight was defined by motion downward, 'downward' became with Plato a relative term. Thus, in authors coming after Aristotle, since they are inevitably coming after Plato, too, the reference to weight as a tendency downward cannot be taken as manifest evidence for motion along a *unique* direction. And this is exactly – if I am not mistaken – the kind of methodological precaution suggested by O'Brien.

ambiguity by his commentators and translators; also, some Aristotelian thinkers were aware of these ambiguities, and tried to sort them out.

Now, let us expand a little bit more on the interpretation suggested above. Consider the following: on the one hand, Aristotle tells us that the velocity of fall is proportional to weight and thus to volume;[13] on the other hand, he says that the kind of capacity to move naturally downward can be determined through (1) *velocity* and (2) *displacement*. For instance, if two bodies are *equal in volume*, i.e., *equal in extension of matter*, and they (1) fall with the same velocity, and (2) get equally close to the center of the world, then they are endowed with the same capacity for natural motion. If these two conditions are not met, then they are endowed with *qualitatively* different capacities for natural motion downward.[14] For instance, the element earth, which is endowed with a natural capacity to move and get close to the center of the world independently of the medium, is called "absolutely heavy" (βαρὺ ἁπλῶς). Water and air, whose capacity to get close to the center of the world is absent in certain media, are called "intermediate" (μεταξύ).[15]

At this point, it is possible to lay out a table that, with some approximation, may help us frame Aristotle's view in accord with the interpretation just suggested:



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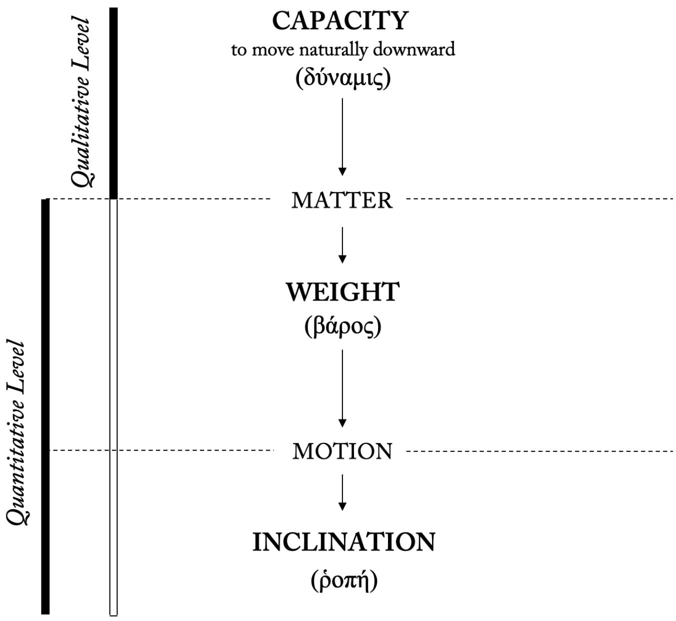
[13] Cf. *De caelo*, II, 8, 290a1 ff.; II, 13, 294a15, 294b6; III, 5, 304b15 ff.; IV, 2, 308b16 ff.; IV, 6, 313b16-23.

[14] Cf. *De caelo*, IV, 1, 308a29-33. I think that O'Brien's explanation of the two criteria is only partially reliable. O'Brien splits the two criteria, saying that displacement establishes a qualitative difference, whereas "speed" establishes a quantitative difference (cf. O'Brien (1997), p. 56-57). Yet he did not notice that at least in one case Aristotle asks to compare the speed of two bodies having weight and being *equal* in volume.

[15] Cf. *De caelo*, IV, 1, 308a29-30; IV, 4, 310b16-29, 311b13-18, 312a8-12.

In this interpretation, too, it is correct to say that according to Aristotle downward movement is due to weight, in that downward movement is due to a capacity whose extension in matter is called weight. In this sense, weight can be seen as a certain 'measure' of a capacity to move downward, just as we sometimes conceive of weight as a certain measure of a universal force of attraction between masses called gravity, and we say that weight is due to gravity. Of course, it is important to stress that this analogy is anachronistic, given the differences between the concepts of δύναμις and force.[16] It is enough, in my opinion, to point out that the capacity (δύναμις) to move naturally toward the center of the world and weight (βάρος) are two different, albeit related, concepts in Aristotle's mind.

We must notice that Aristotle uses ῥοπή in a somewhat different sense than βάρος. Although ῥοπή, just like βάρος, denotes a certain quantitative measure of a qualitative capacity for natural motion, it is however used by Aristotle especially with reference to motion.[17] Just like βάρος is the measure of the extension of a certain δύναμις in matter, so too is ῥοπή the measure of a certain βάρος in motion. We can then use these notions to provide a schematic and therefore approximative reading of Aristotle's doctrine of heavy and light, which may help us visualize and distinguish the qualitative from the quantitative 'level.'



[16] This particular kind of anachronism has been emphasized by David Lefebvre in his recent book on Aristotle and δύναμις (cf. Lefebvre (2018), pp. 28-30). One of the objectives of the book is to show that Aristotle innovatively applied 'κατὰ δύναμιν' to the realm of nature, an expression that before him was mainly used to denote the (physical, political, ethical…) capacity of human (or divine) beings to perform an action. Lefebvre notices that δύναμις had been already applied to the realm of inanimate bodies by Alcmeon and Parmenides. But they regarded δύναμις as a motive force, not as a capacity for movement (cf. *ibid.*, pp. 116-140). Thanks to Lefebvre, we are in a better position now to see the flaws of Max Jammer's historical reconstruction of the concept of force, where it is written that "it is the term *dynamis* that generally stands for the force of traction in Aristotelian 'dynamics'" (Jammer (1957), p. 35).

[17] Cf. the passages cited *supra*, nt. 12.

§33.
Βαρος and Βαρυτης in Simplicius's Commentary on the Fourth Book of the *De caelo*

Before dwelling on the particularity of the Aristotelian Latin vocabulary, I believe it is possible to point out a case of resemantization of the Greek word βαρύτης. Aristotle rarely employs this term. In the *De caelo*, he uses βαρύτης only once, as a synonym for βάρος.[18] If my reading is correct, in Simplicius's commentary on the fourth book of the *De caelo* the two terms are used differently. On the one hand, βαρύτης is used to indicate the capacity (δύναμις) of natural motion toward the center of the universe; on the other hand, βάρος indicates a particular 'activity' or measure of βαρύτης, and – probably following a certain reading of *De caelo* IV, 307b32-33 – it is associated with ῥοπή.

In commenting *De caelo* 307b28-308a7, Simplicius links βαρύτης and its contrary κουφότης with terms such as nature (φύσις), capacity (δύναμις), and source of motion (ἀρχὴ κινήσεως). At the outset, Simplicius says:

> Βαρύτης and κουφότης are more proper to natural bodies than the other qualities because the natural motions are due to these, and natural bodies are given form on the basis of these motions.[19]

He then goes on to clarify that, according to Aristotle, what is responsible for natural motion, i.e. βαρύτης and κουφότης, is a capacity (δύναμις) that makes natural bodies heavy or light:

> He [*viz.* Aristotle] calls bodies heavy or light if they have βαρύτης or κουφότης, and he calls βαρύτης and κουφότης capacities [δυνάμεις].[20]

[18] Cf. *supra*, nt. 1. "The forgoing arguments make it clear that there cannot exist an infinite body. It may be said in addition that if there is no such thing as infinite weight [βάρος], that again makes it impossible for any of the simple bodies to be infinite; for the weight [βάρος] of an infinite body must be infinite. (This applies to lightness too, for if infinite weight [βαρύτης] is possible, so is infinite lightness, if the rising body is infinite.)" (Aristotle (1939), p. 47 = *De caelo*, I, 6, 273a21-27).

[19] Simplicius (2009), p. 68 [= *In De caelo*, IV, 676.3-5]. The English translation by Ian Mueller is always slightly modified by me, especially because I need to be consistent with the terminology I have been using so far. For instance, Mueller translates δύναμις as "power."

[20] *Ibid.* [= *In De caelo*, IV, 676.24-26].

A body endowed with a natural capacity to move downward does not move always. This does not mean that when such a body rests in its natural place, it does no longer have its capacity to move naturally toward the center of the world. Just as a man who knows how to build a house does not lose this 'know-how' when he rests in his bed, so too a body endowed with βαρύτης is always capable of moving naturally downward, even when it rests in its natural place. When such a body moves downward, it *exerts* its natural capacity to move, which is *in this sense* actualized.[21] In another (broader) sense, we cannot say that βαρύτης is not actualized when the same body rests in its natural place. In this regard, Simplicius claims that for Aristotle a body has βαρύτης properly actualized in its natural place.[22] But, as we have said, a body having βαρύτης does not always *exert* and *put into operation* the natural ability or capacity to move downward. So, we should describe the 'operative' kind of actuality as the *activity* of βαρύτης, and say that, although βαρύτης is always in state of actuality, it is not always *active* – namely, it is not always exerting *motion*.

According to Simplicius, Aristotle claims that the activity (ἐνέργεια) of βαρύτης does not have a proper name. However, someone might use the term 'inclination' (ῥοπή) to denote the activity of βαρύτης, as well as that of κουφότης.[23] As I said, throughout the commentary on the fourth book of the *De caelo*, Simplicius identifies the notion of weight (βάρος) with that of inclination (ῥοπή), thereby making weight the operative manifestation of βαρύτης, that is, a manifestation that results from motion.[24]

Simplicius goes on to say that, concerning weight, Aristotle and Plato disagreed only "verbally."[25] Aristotle called the inclination toward the center of the world

[21] "Aristotle points out correctly that things which share [in βαρύτης and κουφότης] are called heavy or light and their capacities are βαρύτης and κουφότης, but that there does not exist a name for the activities – as in the case of heat the activity is heating, and in the case of house building it is building a house - unless, he says, someone were to think that 'inclination' [ῥοπή] is one word indicating the activity of both βαρύτης and κουφότης" (*ibid.*, p. 69 [= *In De caelo*, IV, 677.4-8].

[22] "So if what moves toward the center is heavy and what moves toward what is above is light, it is also necessary, first, that things in their proper places have βαρύτης and κουφότης (or rather only have them in actuality [κατ᾽ ἐνέργειαν] there)…" (*ibid.*, p. 93 [= *In De caelo*, IV, 698.5-7]).

[23] Cf. *supra*, nt. 21.

[24] For instance, commenting on *De caelo*, IV, 5, 312b24, Simplicius says that "[o]ne should notice that in the case of the words 'if everything had a greater inclination' [εἰ πάντα ῥέπει μᾶλλον] that they are spoken as if inclination [ῥοπή] is weight [βάρος]. This is also how Plato uses the term when he says that everything which moves toward what is proper to it is heavy in that it inclines to that" (Simplicius (2009), p. 124 [= *In De caelo*, IV, 726.18-20]. On Simplicius's reference to Plato, see Simplicius (2009), p. 166, nt. 362. There are many passages where Simplicius identifies weight with inclination, especially when it comes to his interpretation of Plato's doctrine of weight. According to Simplicius, "Plato, reckoning that 'weight' [βάρος] means the same thing as 'inclination' [ῥοπή], says that, just as all things have an inclination toward their proper place, so too they have weight…" (*ibid.*, p. 113 [*In De caelo*, IV, 716-34-36].

[25] "For Plato calls this kind of inclination weight, differing with Aristotle verbally because Aristotle calls the inclination to the center weight and calls the center below, and he calls the inclination to the periphery

weight, and the contrary lightness. Instead, Plato called weight any kind of inclination toward the natural place, because he understood inclination as a universal desire of like for like. As long as there is such a desire, there is also an inclination, that is motion, toward a natural place; hence, there is weight. But as soon as that desire ceases, that is, when the body reaches its natural place, then the body has no weight.[26]

Simplicius agrees with Plato on this last point, whereas he disagrees with Aristotle, who thought that air has weight in its natural place. Simplicius empirically refutes Aristotle's opinion by referring to an experiment also performed by Ptolemy: on an equal-arm balance scale, an inflated bag is as heavy as an uninflated bag. At any rate, it is worth noting that here Simplicius refers to a problem concerning inclination (ῥοπή), desire (ἔφεσις), and weight (βάρος).[27] Simplicius has no objections against Aristotle's and Plato's opinion that βαρύτης persists in the natural place of heavy bodies.[28]

While Aristotle distinguishes between two capacities to move toward the center or the extremity of the world, Plato refers in general to the capacity that each body has to move toward a natural place (wherever it may be), and calls it βαρύτης. Wherever it is directed, it is always a natural capacity of the same kind that enables a body to move naturally. This capacity can be called βαρύτης, whose activity and motion, namely its natural inclination, gives rise to weight. Desire steers each body toward their natural place and therefore makes it possible for a body to have weight. The act of going back to the natural place is what makes a body heavy, and the actual "transportation" (ἀγωγή) can happen only thanks to βαρύτης, which is also responsible for the state of rest of each body in their natural place. As Simplicius puts it:

> [Plato] says that the elements have weight [βάρος], but not in the sense that all of them move toward the center with the heavier ones sinking down and

lightness, in accordance with ordinary usage. But Plato says that what is common to them, the inclination, is the same as weight, and it seems to me that shortly hereafter [viz. *De caelo*, IV, 5, 312b24] Aristotle has said this spontaneously" (*ibid.*, pp. 108-109 [= *In De caelo*, IV, 713.2-7]).

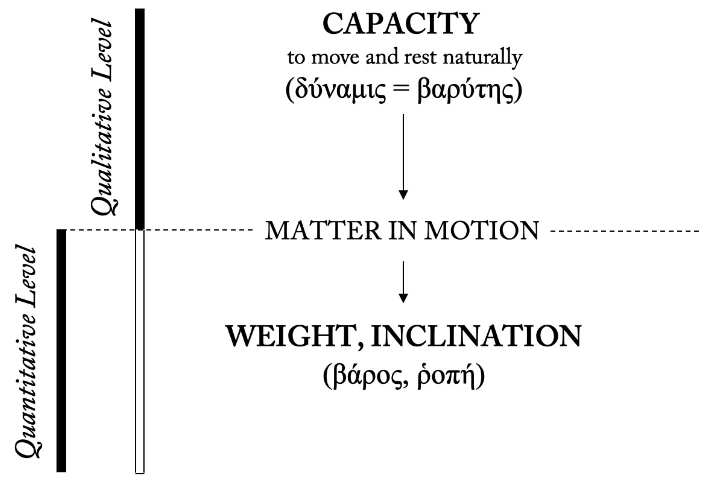
[26] Cf. *infra*, nt. 29.

[27] Cf. Simplicius (2009), p. 106 [= *In De caelo*, IV, 710.14-711.16], where Simplicius concludes as follows: "And if the truth lies with my experiment it is clear that the elements would be without inclination in their own places and none of them have either weight or lightness, as Ptolemy agrees in the case of water. And this would not be unreasonable. For if natural inclination is a desire for a thing's proper place, if anything were to reach its own place it would no longer desire it or have an impulsion toward it, just as what has been satiated does not desire nourishment."

[28] It must be noted that Simplicius interprets the problem as follows: do intermediate elements have βαρύτης or κουφότης in their natural place? According to Simplicius, Aristotle solves the problem by observing that air replaces the space earlier occupied by water, and this means that air has weight (βάρος), given that downward movement is due to weight. Hence, air has βαρύτης in its natural place (cf. *ibid.*, p. 120 [= *In De caelo*, IV, 722.22-723.16]).

> the less heavy being pushed out and rising above the heavier ones and as a result being called light, but rather in the sense that all have a motion toward their proper place because of βαρύτης [διὰ βαρύτητα]. In fact, desire [ἔφεσις] guides [ἄγει] each thing toward what is of the same kind, but the transportation [ἀγωγή] is because of βαρύτης [διὰ βαρύτητος]; and the permanence [ἡ μονή] in the proper place is thanks to this capacity [διὰ ταύτης δυνάμεως].[29]

In my view, this passage provides a good example of Simplicius's consistency in using a certain vocabulary. Βάρος and βαρύτης indicate two different notions. Βάρος, just as desire, is conceptually paired with natural motion and it depends on βαρύτης. The latter is therefore conceptually prior to βάρος and it is understood as a capacity for both natural motion and rest. In sum, Simplicius first notices that for Aristotle the weight of an element and its natural capacity to move are two different concepts, weight being a particular manifestation of that capacity. Then he identifies weight with inclination. Finally, he terminologically as well as conceptually distinguishes weight from its source (i.e., βαρύτης), and employs the same terminology to describe, compare, and sometimes reconcile, Aristotle's view with that of Plato.[30]



[29] *Ibid.*, p. 73 [= *In De caelo*, IV, 680.26-681.2].

[30] We must always bear in mind that Simplicius's exegetical aim is to reconcile Plato's and Aristotle's views. Before examining a preliminary digression in Simplicius's commentary on the *Physiscs*, Pantelis Golitsis has noted that "cette digression liminaire fait déjà apparaître une importante spécificité exégétique de Simplicius: celle qui est animée par le souci de mettre en harmonie tous les éléments susceptibles de fonder la conviction d'une divergence irréductible au sein de la philosophie des Hellènes." (Golitsis (2008), p. 55). After having examined in detail this and other digressions by Simplicius (cf. *ibid.*, pp. 89-124), Golitsis notices that "Simplicius tenait à exalter la précision du langage philosophique du Stagirite. *La même précision lui permet à la fin de son exégèse de rejoindre Platon et Aristotle* dans une démarche éminenment théologique qui veut magnifier l'éternité de l'universe, à l'encontre de toute prétention des auteurs chrétiens" (*ibid.*, p. 124, my emphasis).

As we have seen, Simplicius claims that for Plato each element is endowed with βαρύτης, that is, a capacity to move toward its kindred whole and rest therein. Simplicius then introduces an important feature of Plato's doctrine. He says that βαρύτης is present in both the elements and their wholes. However, the elements, taken as portions of their whole, are also endowed with κουφότης:

> [Plato] says that fire is heavy just like earth, and each of them rests in its proper place because of its own βαρύτης and is pulled away from its proper place to the degree that it is light. Accordingly, βαρύτης alone belongs to the entireties [of the elements], since they do not abandon their proper places and are not pulled away from them. But κουφότης also belongs to portions [of the entireties], and because of this they are also constituted so as be transferred to places other than the natural ones.[31]

This means that κουφότης is for Plato the capacity of a body to be removed from its natural place. Since the portions of a totality – not the totality itself – are endowed with κουφότης, they can be dislodged from their natural place. Any element can be pulled away from its natural place "to the degree that it is light," that is, according to the κουφότης that belongs to it.

In my view, Simplicius provides his readers with two doctrines that are more than verbally divergent. At closer inspection, they rest on two irreconcilable understandings of natural place. If the natural place of the elements is taken to be a region within a geocentric cosmos, say the center or the extremity of the world, then one may think that the elements move toward the center or the extremity in that the center or the extremity are their natural places. Accordingly, one may be tempted to split natural movements into two categories: one toward the center, and another one from the center up to the extremity. Two different capacities must then be responsible for these two natural movements toward the center and away from it. According to Simplicius, this is how Aristotle reasons when he resorts to βαρύτης and κουφότης.

However, there may be another way to describe natural motions toward natural places. One can assume that a body's natural place is *in* the center or *in* the extremity of the world. Nonetheless, the body does not move toward the center or the extremity because its natural place *is* the center or the extremity of the world. Simply, it moves there because it is there that its kindred whole is located. Its kindred whole may be in the center, in the extremity, or anywhere else, *as long as god and nature decided it to be so*. In this sense, there is only one natural kind of movement, namely, that through

[31] Simplicius (2009), p. 73 [= *In De caelo*, IV, 681.2-7].

which a body returns to its kindred whole, whose location in the cosmos is set out by god. Hence, there is no need to involve two different capacities, but one is enough to account for the natural motion and rest of each element. For this reason, in Simplicius's reading, Plato says that βαρύτης alone is responsible for the natural motion and rest of the elements. What changes is the desire that steers each element toward its kindred whole. But the motion with which every element returns to its entirety is due to the same βαρύτης.

Notwithstanding Simplicius's effort to reconcile the views of Aristotle and Plato, he however points out some important differences between their understanding of heavy and light. These differences can be summarized with some approximation into two different tables:

SIMPLICIUS'S READING OF ARISTOTLE

	βαρύτης	**κουφότης**
δύναμις	Capacity to move toward the center of the world	Capacity to move toward the extremity of the world
ἐνέργεια	Motion toward the center of the world. Also called ῥοπή	Motion toward the extremity of the world. Also called ῥοπή
ῥοπή	Inclination *qua* motion toward the center of the world. Also called βάρος	Inclination *qua* motion toward the extremity of the world. Also called κουφότης

SIMPLICIUS'S READING OF PLATO

	βαρύτης	**κουφότης**
δύναμις	Capacity to move toward the natural place and/or rest therein. It belongs to parts and entireties	Capacity to be pulled away from the natural place. It belongs to parts only
ἔφεσις	Desire of the parts to reconnect with their natural place. It gives rise to ῥοπή	None
ῥοπή	Motion steered by desire. Also called βάρος	None

It is worth noting that for Aristotle, it is one thing to be heavy, that is, to have a capacity to move naturally toward the *center of the world*, and it is quite another one to move naturally toward a *natural place*. When the water that lies under air is removed, then air can move naturally toward the center of the world and fill the place previously occupied by water. According to Aristotle, this shows that air has weight in its natural place. But Simplicius, who follows his own interpretation of Plato, believes that having weight means moving naturally toward a *natural place*, not toward the *center of the* *world*. How, then, can air move naturally toward the natural place of water? Evidently, says Simplicius, air does not replace water *naturally*, but *by constraint* because there can be no void.[32]

While in Aristotle's view the natural place is defined according to natural capacities for motion, and natural capacities are in turn defined according to a precise division of the world into center and periphery, in Plato's view (as interpreted by Simplicius) a natural place is determined exclusively by god and nature. Hypothetically speaking, if god had decided to arrange the cosmos in such a way that the Moon was where the Earth is usually located in a geocentric cosmos, and vice versa, this would still be an orderly setting of the world. In this hypothetical case, if a portion of earthy matter were pulled away from the Earth, it would *not* return to the center of the world, but it would move naturally to its whole, that is, the eccentric Earth. In this view, the notions of order, natural place, and natural motion, are not defined according to *a priori* cosmological coordinates, such as the center and extremity or periphery of the world. Natural motion is that kind of motion that restores the order (whatever it may be) of the world established by god:

> [I]f god and nature were to transfer the Earth to where the Moon is now, because this is where it ought to be, then a clod of earth would move there, since the parts would also receive this same capacity [δύναμις] as the entirety does from *cosmogony* [δημιουργία].[33]

On the one hand, as we have seen, Aristotle's doctrine of heavy and light prevents any kind of cosmogony. On the other hand, Plato's doctrine of heavy and light requires a cosmogony, for natural places are established by god through a cosmogonic process, and heavy and light are properties defined with reference to motions toward or away from a natural place, wherever it may be.

To conclude, I would like to lay much stress on an important consequence of Simplicius's understanding of weight and βαρύτης. Having distinguished the former from the latter, Simplicius's conception of 'being heavy' does no longer need to be paired with 'having weight.' In order to be heavy, a body does not necessarily need to

[32] "[O]ne should understand that, just as air and water move up by constraint, so too they move down by constraint when what lies under them is removed, because there is no void; for it is not reasonable that when the elements are in their proper places they would have a natural inclination either up or down, since what has a natural inclination somewhere has an inclination to its proper place" (*ibid.*, p. 122 [= *In De caelo*, IV, 724.24-27]).

[33] *Ibid.*, p. 90 [= *In De caelo*, IV, 695.3-6], my emphasis.

be endowed with βάρος or ῥοπή.[34] A body can be called 'heavy' also when it rests in its proper place, because 'heavy' is now defined according to βαρύτης. For this reason, though a body in its natural place has no βάρος or ῥοπή, that body is nonetheless heavy in that it can rest there thanks to βαρύτης. It is important to bear this in mind in order to understand the meaning of *gravitas* in certain Aristotelian thinkers of the late Renaissance (see §37).

§34.
Climbing the Tower of Babel. William of Moerbeke and *Gravitas*

In the *De caelo*, Aristotle uses βάρος and βαρύτης as synonyms. However, it seems that one of his most notorious commentators, Simplicius, used the two terms differently. It should be interesting to see how this terminological distinction, which highlights an important conceptual distinction, entered the Latin vocabulary.

Simplicius's commentary on the *De caelo* was translated for the first time into Latin from the original Greek by William of Moerbeke around 1271.[35] Moerbeke also translated Aristotle's *De caelo*, but before he accomplished his translation some parts of the *De caelo* were already circulating in Latin translations from Arabic and Greek. In the Renaissance, new Latin translations of the *De caelo* were brought out. The most used ones were mainly the following two: the old version (sometimes revised) by William of Moerbeke, and the most recent one by John Argyropoulos.[36] However, as the commentators of Aristotle became more and more acquainted with the Greek language, they used to intervene at their own discretion – even with small variations – on the Latin translations of Aristotle's *De caelo*. As for Simplicius's commentary on the *De caelo*, to my knowledge Moerbeke's translation was at Galileo's time still the only one available to scholars. Since this was a commentary certainly known by late-

[34] Falcon has shown that Aristotle takes ῥοπή to be an essential feature of natural bodies (cf. *supra*, nt. 12). If my reading of Simplicius's text is correct, it may suggest that for Simplicius βάρος and ῥοπή are no longer sufficient conditions for distinguishing natural bodies from mathematical ones.

[35] A first partial translation into Latin was completed by Robert Grosseteste between 1235 and 1253, and by Moerbeke himself in 1265 (cf. Allan (1950); Bossier (1987), pp. 293-301, and Simplicius (2004a), p. X).

[36] Cf. Copenhaver (1988). Important insights on the Renaissance translations of Aristotle's works is also in Bianchi (2007). Argyropoulos's translation of the *De caelo* was used, for instance, by the Coimbra philosophers (cf. *Conimbricenses* (1603)). Lucillo Maggi Filalteo (1510-1570) explicitly criticizes those translations, like that of Moerbeke, where ῥοπή is "very barbarously" translated as "inclination": "Graece ῥοπήν placuit momentum vertere, alij propensionem, alij barbare nimis inclinationem. Censui animadvertendum hoc verbum ob gravem quaestionem, ne videlicet gravitas, et levitas sint formae et substantiae, an momenta, et facultates, potentiae elementorum" (Filalteo (1565), p. 594). On Filalteo, see Baldi (2011), *passim*.

Renaissance natural philosophers, including Galileo,[37] it may be convenient to take a look at some parts of Moerbeke's translation.

A cursory reading suffices it to notice that all the occurrences of βάρος and βαρύτης are equally translated by Moerbeke as *gravitas*. For example, consider the following comparison between the Greek and the Latin, followed by a translation into English from the Greek and the Latin respectively:[38]

[**Β**]**άρος** δὲ πάντα μὲν τὰ στοιχεῖά φησιν [*viz.* Πλάτων] ἔχειν [...] ὡς πάντων τὴν μὲν ἐπὶ τὸν οἰκεῖον τόπον φορὰν διὰ **βαρύτητα** ἐχόντων· ἄγει γὰρ ἡ ἔφεσις ἕκαστον πρὸς τὸ συγγενές, ἡ δὲ ἀγωγὴ διὰ **βαρύτητος**· καὶ ἡ ἐν τῷ οἰκείῳ τόπῳ μονὴ διὰ ταύτης ὑπάρχει τῆς δυνάμεως.[39]	**Gravitatem** autem omnia quidem elementa, ait [*viz.* Plato], habere, [...] tanquam omnibus eam quidem quae ad proprium locum lationem propter **gravitatem** habentibus. Ducit enim appetitus unumquodque ad cognatum, deductio autem per **gravitatem**, et quae in proprio loco mansio, per hanc virtutem existit...[40]
[Plato] says that the elements have **βάρος** [...] in the sense that all have a motion toward their proper place because of **βαρύτης**. In fact, desire guides [ἄγει] each thing toward what is of the same kind, but the transportation [ἡ ἀγωγή] is thanks to **βαρύτης**; and the permanence in the proper place is thanks to that same capacity.	[Plato] says that the elements have ***gravitas*** [...] in the sense that all have a motion toward their proper place because of ***gravitas***. In fact, desire guides [*ducit*] each thing toward what is of the same kind, but the transportation [*deductio*] is thanks to ***gravitas***. And the permanence in the proper place is thanks to that same capacity.

William of Moerbeke's translation into Latin is verbatim. The reader who is able to read both Greek and Latin can easily notice that Moerbeke provides a word-by-word translation of the original. No wonder that in the Renaissance, when only Simplicius's commentary on the first book of the *De caelo* was extant in the original Greek, Bessarion asked Alexius Andronicus Bisantius to translate the remaining parts into Greek from the Latin version provided by Moerbeke. The *editio princeps* of Simplicius's commentary on the *De caelo* was indeed based on Bisantius's retranslation.[41] And yet, notwithstanding the methodic precision of Moerbeke's translation, Moerbeke does not think it necessary to use two already existing Latin terms, such as *pondus* and *gravitas*,

[37] Cf. OG, I, *De motu antiquiora*, pp. 288, 387.
[38] English translation from Simplicius (2009), p. 73, slightly modified.
[39] *In De caelo*, IV, 680.26-681.2
[40] Simplicius (1563), p. 236 [mistakenly written as 238], coll. 1-2.
[41] Cf. Simplicius (2004a), pp. XI-XVII.

to translate βάρος and βαρύτης. After all, he had already translated Aristotle's *De caelo* where he used *gravitas* in every occurrence of βάρος and the only one of βαρύτης. But, if my reading is correct, while this choice is reasonable when it comes to Aristotle, it is less reasonable when it comes to Simplicius.

According to Moerbeke's translation cited above, Plato says that all the elements have *gravitas* in that their natural motion is caused by *gravitas*. Each of them has a desire (*appetitus*) that orientates their natural motion toward their kindred whole. However, desire is not responsible for the natural motion toward the kindred whole. In fact, natural motion is only by virtue of *gravitas*. Besides, it is thanks to the same capacity (*virtus*) which is responsible for natural motion – i.e., *gravitas* – that each element rests naturally in its kindred whole (*cognatum*), i.e., its natural place (*locus proprius*).

Although it may seem to be tautological to say that each element has *gravitas* because its natural motion is caused by *gravitas*, the Latin passage makes perfect sense when taken, not as an explanation, but rather as a description:

(1) Each element has *gravitas*;
(2) *gravitas* is responsible for natural motion and natural rest;
(3) desire provides the direction toward the natural place;
(4) desire is not responsible for either natural motion or natural rest.

Propositions (2) and (4) are clear-cut about the fact that *gravitas* and desire are not the same thing. This can also be noticed in the original Greek. It is a paramount distinction, as it shows that desire (ἔφεσις, *appetitus*) alone cannot make a body heavy. To be heavy, a body must have a natural motion, namely, a motion (φορά, *latio*) steered by desire and enabled by what Simplicius calls βαρύτης and Moerbeke translates as *gravitas*. But here comes the trouble in the Latin version. For the aim of the original text is not to describe a situation, but to provide an explanation of Plato's claim that all elements are heavy. The explanation is pivoted around the notion of natural motion and what makes it possible. If we translate weight (βάρος) as *gravitas*, then we have that a body has *gravitas* (βάρος) in that it has a natural motion toward its natural place. Since natural motion is possible because of a capacity that Moerbeke does equally translate into *gravitas* (βαρύτης), then we obtain the following tautological explanation: a body has *gravitas* (βάρος) because of *gravitas* (βαρύτης). In order to fully understand this point, let us now read the final part of the passage cited above:

[**Β**]**άρος** δὲ πάντα μὲν τὰ στοιχεῖά φησιν [*viz.* Πλάτων] ἔχειν […] ὡς πάντων τὴν μὲν	**Gravitatem** autem omnia quidem elementa, ait [*viz.* Plato], habere, […] tanquam omnibus eam quidem quae ad proprium locum

ἐπὶ τὸν οἰκεῖον τόπον φορὰν διὰ **βαρύτητα** ἐχόντων· ἄγει γὰρ ἡ ἔφεσις ἕκαστον πρὸς τὸ συγγενές, ἡ δὲ ἀγωγὴ διὰ **βαρύτητος**· καὶ ἡ ἐν τῷ οἰκείῳ τόπῳ μονὴ διὰ ταύτης ὑπάρχει τῆς δυνάμεως. διὸ καὶ τὸ πῦρ βαρύ φησιν ὥσπερ καὶ τὴν γῆν, καὶ μένειν ἑκάτερον ἐν τῷ οἰκείῳ τόπῳ διὰ τὴν ἑαυτοῦ **βαρύτητα**, ἀποσπᾶσθαι δὲ ἐκ τοῦ οἰκείου, καθ'ὅσον κοῦφόν ἐστι· διὸ τοῖς μὲν ὅλοις **βαρύτητα** μόνον ὑπάρχειν· οὐ γὰρ ἐξίστανται τῶν οἰκείων τόπων οὐδὲ ἀποσπῶνται· τοῖς δὲ μέρεσι καὶ κουφότητα, καθ'ἣν καὶ ἐπὶ τοὺς παρὰ φύσιν τόπους μεταπίπτειν πεφύκασιν.

lationem propter **gravitatem** habentibus. Ducit enim appetitus unumquodque ad cognatum, deductio autem per **gravitatem**, et quae in proprio loco mansio, per hanc virtutem existit, propter quod et ignem gravem ait, sicut et terram. Et manere utrunque in proprio loco propter suiipsius **gravitatem**, abstrahi autem ex proprio secundum quod leve est, propter quod totis quidem **gravitatem** solum existere creditur, non enim exeunt ex propriis locis, neque abstrahuntur. Partes autem habentes levitatem secundum quam et ad ea quae praeter naturam loca transcendere nata sunt.

[Plato] says that the elements have **βάρος** […] in the sense that all have a motion toward their proper place because of **βαρύτης**. In fact, desire guides each thing toward what is of the same kind, but [*a*] the transportation is thanks to **βαρύτης**; and [*b*] the permanence in the proper place is thanks to that same capacity. For this reason, he says that [*a*] fire is heavy just like earth, and that [*b*] each of them rests in its proper place because of its own **βαρύτης** and is pulled away from its proper place to the degree that it is light. Accordingly, **βαρύτης** alone belongs to the entireties, since they do not abandon their proper places and are not pulled away from them. But κουφότης also belongs to portions [of the entireties], and because of this they are also constituted so as be transferred [μεταπίπτειν] to places other than the natural ones [παρὰ φύσιν].

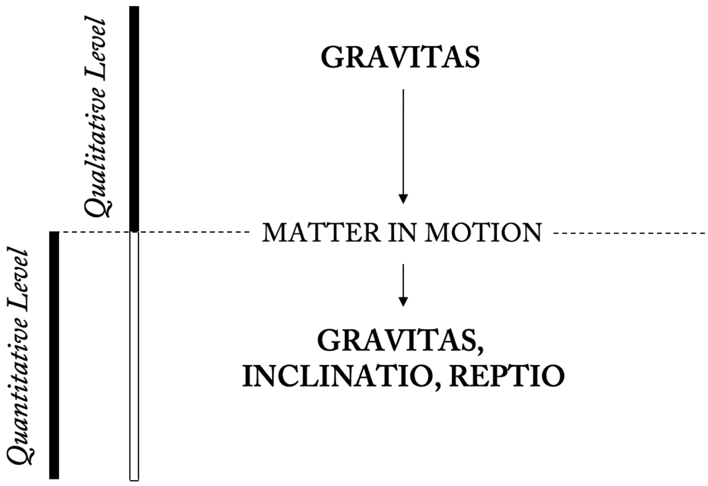
[Plato] says that the elements have ***gravitas*** […] in the sense that all have a motion toward their proper place because of ***gravitas***. In fact, desire guides each thing toward what is of the same kind, but the transportation is thanks to ***gravitas***. And the permanence in the proper place is thanks to that same capacity, so that he says that fire is heavy just like earth. And [he says that] each of them rests in its proper place because of its own ***gravitas***, but it is pulled away from its proper place to the degree that it is light, and because of this it is to believe that ***gravitas*** alone is in the entireties, since they do not abandon their proper places and are not pulled away from them. But the parts were generated with *levitas*, according to which they can also move [*transcendere*] toward places other than the natural ones [*praeter naturam*].

Some terminological as well as conceptual nuances about βάρος and βαρύτης go lost in the Latin translation. To say it better, the conceptual nuances remain, but they are now encased into a single term, *gravitas*, which is for this reason open to different readings.

For instane, since portions, i.e., the elements, and entireties are equally described in Latin as having *gravitas*, all this can be read as meaning that, not only the elements, but also their entireties have weight. But this reading does not seem to be supported by the Greek text as it leads to a contradiction. The contradiction probably arises because (*a*) the weight of bodies – which is βάρος and implies natural motion – and (*b*) the capacity for natural motion – which is βαρύτης and does not always imply natural motion – are indicated with the same term: *gravitas*.

William of Moerbeke does not mind that, from Aristotle up to Simplicius, a process (probably more) of reconceptualization of Aristotle's terminology may have taken place. The ambiguity with which *gravitas* is charged in Moerbeke's translation makes it inevitably difficult for the Latin reader to understand Simplicius's exposition of the fourth book of the *De caelo* and his interpretation of some parts of the *Timaeus*.

Furthermore, since Simplicius identifies βάρος with ῥοπή, then in Moerbeke's translation there may be another layer of ambiguity concerning *gravitas*:



At any rate, it is worth noting that Aristotle's and Plato's different views on natural place (and, therefore, on the conception of natural motion toward it) are still perfectly clear in the Latin translation. As we have seen in the previous section, contrary to Aristotle, and in line with a particular interpretation of Plato's doctrine, Simplicius claims that a clod of earth moves naturally toward the center of the world because there is where its kindred whole is located. So, its natural motion is not directed toward the center of the world *qua* center; rather, it is directed toward the center of the world because its totality occupies the center of the world. But if god had decided to arrange the world differently, such that the Earth was far from the center of the world, say where the Moon is now, then a clod of earth would return to the Earth after being pulled away from it:[42]

[42] English translation from Simplicius (2009), p. 90, slightly modified.

εἴποι δὲ ἄν τις, ὅτι, ἐὰν ὁ θεὸς καὶ ἡ φύσις μεταθῶσι τὴν γῆν, ὅπου νῦν ἐστιν ἡ σελήνη, ὡς δέον οὕτως, οἰσθήσεται καὶ ἡ βῶλος ἐκεῖ· λήψεται γὰρ καὶ τὰ μέρη παρὰ τῆς **δημιουργίας** ταύτην τὴν δύναμιν, ἣν τὸ ὅλον.[43]

Dicet autem utique quis quod si deus et natura transposuerint Terram, ubi nunc est Luna, ut opportunum sic, fertur et gleba illa. Sumunt enim et partes a **conditore** hanc virtutem quam habet totum.[44]

> But someone might say that if god and nature were to transfer the Earth to where the Moon is now because this is where it ought to be, then a clod of earth would move there, since the parts would also receive this same power as the entirety does from cosmogony [παρὰ τῆς δημιουργίας] / from the creator [*a conditore*].

Hypothetically, the Earth could be anywhere in the universe, and its parts would still return to it if god had decided it to be convenient when he arranged the universe into an orderly world. In the Latin version, the notion of natural place as a place that is *natural* in view of the fact that it was appointed by god (and nature), is even more explicit. Where the Greek text has δημιουργία, which indicates what the god-demiurge has made, the Latin text has *conditor*, the creator of the universe as a cosmos, namely god himself.

§35.
CLIMBING THE TOWER OF BABEL.
AUGUSTINE AND *PONDUS*

As is known, before Simplicius, Plutarch had already put forth the idea that parts of different entireties return naturally to their own entirety, that is, to the entirety they had been assigned to from the origin (ἀπ᾽ἀρχῆς).[45] However, Plutarch does not frame this view within a consistent doctrine of heavy and light. He claims that it is not unreasonable to think of the Moon as being constituted of earthy matter, having parts as heavy as those of the Earth. But we cannot find in Plutarch a general definition of weight as a property shared by the portions of all entireties.[46]

43 *In De caelo*, IV, 695.3-6

44 Simplicius (1563), p. 241, col. 2.

45 Cf. *De fac.*, 924e-f.

46 I do not mean to underestimate the role of Plutarch in the Renaissance reconceptualization of *gravitas*. However, I believe that until now its role has been overestimated. Among Galileo scholars, Michele Camerota and Mario Otto Helbing have interestingly suggested a linkage between various Renaissance authors' notions of *gravitas* and that of Plutarch (cf. Camerota-Helbing (2000b), pp. 112-116). For connections between Galileo and Plutarch's *De facie*, see Fabbri (2012) and Bakker-Palmerino (2020). My only objection

Curiously enough, before Simplicius we can find something close to such a definition in a very influential Latin author: Augustine of Hippo. In the work of Augustine, there is also an interesting use of the words *pondus* and *gravitas*, which might have been employed to denote different concepts. Let us start with a passage that includes all these elements:

> If we were stones, or waves, or wind, or flame, or anything of that kind, lacking both sensation and life, yet we would not lack a kind of desire [*appetitus*] towards our own proper place and order [*ordo*]. For the movements [*momenta*] of weights [*pondera*] are like the loves [*amores*] in bodies, whether they are carried downwards by *gravitas*, or upwards by *levitas*. For the body is borne by weight [*pondere*], as the soul by love [*amore*], wherever it is borne [*quocumque fertur*].[47]

In this passage, Augustine attempts to show what love (*amor*) is in ensouled bodies by analogy with the functioning of weight (*pondus*) in inanimate (i.e., non-ensouled) bodies. Just like ensouled bodies, inanimate bodies have a sort of desire (*appetitus*) that leads them toward their own natural place and order (*ordo*). Augustine says that the different loves (*amores*)[48] of ensouled bodies are just like the different *momenta* of inanimate bodies endowed with weight, no matter if the *momenta* incline (*nitantur*) downward by reason of *gravitas* or upward by reason of *levitas*. Wherever (*quocumque*) it is directed, each inanimate body is guided (*fertur*) by weight (*pondus*), just like love guides souls.

against the fascinating paper by Frederik Bakker and Carla Rita Palmerino is that they (especially Bakker in part II.2 of the paper) take for granted that Plutarch's 'cohesion theory' is a 'gravity theory.' I believe that the real problem, indeed, is to understand whether cohesion (at a distance) does always determine weight. If I am not mistaken, Plutarch is not explicit in this regard: he does not explicitly say that the parts of the Sun, stars, or planets other than the Earth and the Moon, are heavy due to συμφυία. Among Copernican scholars, Anna De Pace is perhaps the one who has insisted the most on the dependence of Copernicus's doctrine of *gravitas* on Plutarch (cf. *infra*, §39). However, as I have written in Malara (2020a) [published in January 2020, but submitted at the end of August 2019], until now no one has ever drawn attention to Simplicius's commentary on the fourth book of the *De caelo*. Thanks to my observations, De Pace has recently used some passages of Simplicius's commentary to advance a hypothesis involving Galileo and Simplicius (cf. De Pace (2020), pp. XXXIII-XXXVI, and my criticism *infra*, §45).

[47] "Si essemus lapides aut fluctus aut ventus aut flamma vel quid huiusmodi, sine ullo quidem sensu atque vita, non tamen nobis deesset quasi quidam nostrorum locorum atque ordinis appetitus. Nam velut amores corporum momenta sunt ponderum, sive deorsum gravitate sive sursum levitate nitantur. Ita enim corpus pondere, sicut animas amore fertur, quocumque fertur" (*De civ. Dei*, XI, 28).

[48] "Cur ergo et in nobis ipsis non et ipsum amorem nos amare sentimus, quo amamus quidquid boni amamus? Est enim et amor, quo amatur et quod amandum non est, et istum amorem odit in se, qui illum diligit, quo id amatur quod amandum est. Possunt enim *ambo* esse in uno homine…" (*ibid.*, my emphasis).

This beautiful passage is certainly open to different interpretations. According to Paolo Galluzzi, for instance, this passage shows that Augustine endorses an Aristotelian standpoint about the elements.[49] In fact, they are said to be driven downward or upward because of two different reasons, that is, *gravitas* and *levitas*. If by 'downward' Augustine means 'toward the center of the world,' and by 'upward' he means 'toward the extremity of the world,' then *gravitas* and *levitas*, as well as the elements, are definitely understood by Augustine within the cosmological frame of reference provided by Aristotle. However, Augustine does also say that all elements have weight, wherever they are directed to. Even those inanimate bodies that move upward by reason of *levitas* are said to have weight by Augustine. I do not see how this can be fittingly associated with the traditional Aristotelian doctrine of elements, where fire has no weight at all.

Denis O'Brien has interpreted Augustine's view as being "Aristotelian and Stoic in origin."[50] He has examined the passage above and others alike in the light of the following one:

> The body by its own weight inclines towards its own place. Weight makes not downward only, but to his own place. Fire tends upward, a stone downward. They are urged by their own weight, they seek their own places. Oil poured below water, is raised above the water; water poured upon oil, sinks below the oil. They are urged by their own weights to seek their own places. When out of their order, they are restless [*inquieta*]; restored to order, they are at rest [*ordinantur et quiescunt*]. My weight is my love; thereby am I borne, wherever I am borne [*quocumque feror*]. We are inflamed, by Thy Gift we are kindled; and are carried upwards; we glow inwardly, and go forwards.[51]

In this and other passages, O'Brien has seen what he calls the doctrine of the "double weight of the soul."[52] It is double in that it is *bidirectional*; it can go upward as well as downward. O'Brien then has suggested to link this view with that of Iamblichus

[49] Cf. Galluzzi (1979a), p. 11, where Galluzzi says that "il riferimento alla teoria aristotelica degli elementi è esplicito."

[50] Cf. O'Brien (1981b), p. 425.

[51] "Corpus pondere suo nititur ad locum suum. Pondus non ad ima tantum est, sed ad locum. Ignis sursum tendit, deorsum lapis. Ponderibus suis aguntur, loca sua petunt. Oleum infra aquam fusum super aquam attollitur, aqua supra oleum fusa, infra oleum demergitur; ponderibus suis aguntur, loca sua petunt. Minus ordinata inquieta sunt: ordinantur et quiescunt. Pondus meum amor meus, eo feror, quocumque feror. Dono tuo accendimur et sursum ferimur; inardescimus et imus" (*Conf.*, XIII 9, 10). The English translation is based on E.B. Pusey's translation available online (https://faculty.georgetown.edu/jod/English-confessions.html; accessed last time in October 2020). Cf. O'Brien (1981b), p. 425.

[52] "La théorie d'une 'double' pesanteur…" (*ibid.*, p. 425 and *passim*).

reported by Simplicius in his commentary on Aristotle's *Categories*, which O'Brien has translated into French as follows:

> Une telle distinction [de la pesanteur et de l'absence de pesanteur] apparaît aussi, dit-il [c'est-à-dire Jamblique], dans les quantités incorporelles. En effet, si l'on considère l'âme comme étant une quantité-en-soi, alors, dans la mesure où elle penche vers le corps, elle aura une **pesanteur** [**ῥοπὴν** ἕξει], celle vers le bas, et dans la mesure où [se retirant] des choses d'ici-bas elle penche vers l'intelligible, [elle aura une pesanteur] vers le haut. En revanche, l'intellect est une quantité **sans pesanteur** [**ἀρρεπὲς** ποσόν].[53]

The term "pesanteur," that is, weight or heaviness, translates the Greek term ῥοπή. This choice is justified by O'Brien by referring to the fourth book of the *De caelo*, where, as we have seen, Aristotle says that ῥοπή may be used to denote the activity of the capacity to move naturally toward a certain direction. O'Brien interprets this capacity to be weight, and its activity to be a manifestation of weight, hence weight itself.[54] This is indeed a possible reading of Aristotle's text. And yet, even in this case, one must notice that for Aristotle the capacities of heavy and light bodies to move naturally toward a certain direction are two, because two are the directions: one toward the center of the world, and the other one toward the extremity of the world. If we agree that the first one is weight, the second one must be lightness. Each of them has an activity that one may call ῥοπή. However, Aristotle would never claim that the ῥοπή of lightness is weight. In fact, fire has a ῥοπή upward, but it is nonetheless an element absolutely devoid of weight.[55] So, unless Iamblichus says that ῥοπή must be always understood as weight (which is possible), it is arbitrary to think that ῥοπή unequivocally means weight. It would be better to say that, just as corporeal quantities may be with or without inclination toward a certain place, so too are incorporeal quantities. When the soul inclines toward corporeal bodies, the soul has an inclination that can be understood as going 'downward.' On the contrary, when it inclines toward the

[53] *Ibid.*, p. 426 [= Simp., *Cat.*, 128.32-35]; bold emphasis is mine.

[54] "Ῥοπή est le terme qu'utilise Aristote pour désigner l''actualisation' de la pesanteur, conçue comme capacité de se mouvoir dans les deux sens, vers le centre ou vers la péripherie de l'universe…" (*ibid.*, p. 426, nt. 9).

[55] This is in accord with what O'Brien says in another essay on Aristotle, where he translated ῥοπή as weight, but immediately clarified that this "translation is *inevitably tendentious*, for although ῥοπή is the nearest that Aristotle can get to a generic term embracing both 'heavy' and 'light,' and corresponding therefore to 'weight' in English, nonetheless ῥοπή more properly describes the 'activities' of things heavy and light, i.e. their movements up and down, and not the inherent property or nature which leads to this behaviour, as Aristotle himself tells us in the opening lines of his account of heavy and light in book four of the *De Caelo*" (O'Brien (1997), p. 50, nt. 13, my emphasis).

intellect, it has an inclination 'upward.' Yet the intellect, unlike the soul, can be considered as a quantity that has no inclination whatsoever (ἀρρεπὲς ποσόν).[56]

I do not exclude that Augustine, when he wrote the passages cited above, was to some extent influenced by Iamblichus. However, there is at least an important difference between Iamblichus and Augustine that O'Brien has rightly emphasized. It seems indeed that for Augustine everything is endowed with weight. Weight is in fact a sort of desire that leads each thing toward their natural place, wherever it is. If we accept O'Brien's translation of ῥοπή, for Iamblichus there are some quantities devoid of weight (e.g., the intellect), but Augustine does not consider this case.[57]

At any rate, my interpretation departs from that of O'Brien on a fundamental point: I do not think that weight is *bidirectional* in Augustine's view. Weight, just like love, is *multidirectional*. For weight is not defined according to two absolute directions, up or down, the extremity or the center of the universe. Augustine says that weight is toward the *proper place* of each thing, *wherever* it is. Also, Augustine does not define what 'upward' or 'downward' mean. So, it may be that for Augustine the natural or proper place of each thing need not be in the *center* or in the *extremity* of the world. Accordingly, love can lead toward many different places and directions.

However one interprets Augustine's view on weight, it is noteworthy that we can find in it the same features already seen in Simplicius's account of Plato's doctrine of heavy and light. Augustine provides a general understanding of weight (*pondus*) as a desire (*appetitus*) whose motion (*momentum*) is carried by *gravitas* or *levitas*. Simplicius, instead, speaks of weight (βάρος) as the motion itself (ῥοπή) which is always caused by βαρύτης and steered by desire (ἔφεσις). These recurring features can be used to outline a synoptic table:

AUGUSTINE	SIMPLICIUS	SIMPLICIUS *LATINUS*
gravitas	**βαρύτης**	***gravitas***
levitas	**κουφότης**	***levitas***
pondus	**βάρος**	***gravitas***
momentum	**ῥοπή**	***inclinatio, reptio***
appetitus	**ἔφεσις**	***appetitus***

[56] Although the English translation by Frans A.J. de Haas and Barries Fleet includes the term 'gravity,' I believe that it is more 'neutral' than the one provided by O'Brien: "Such a difference is evident also in the case of bodiless quantities. For if someone were to posit the soul as a per se quantity, it will have downward thrust where it inclines towards the body, and upward thrust where it inclines away from the lower world towards the intelligible. But intellect is a quantity without gravity" (Simplicius (2001), p. 107).

[57] Cf. O'Brien (1981b), pp. 427-428.

Last but not least, in Augustine it is more evident that the ultimate goal of weight is to restore the order (*ordo*) originally established by God. And the order is always associated with a state of peace and rest:

> [T]he perfection of every single thing is established, according to the measure appropriate to it, not so much in the entirety of which it is a part as in Him from whom it derives its very being (it is also from Him that the entirety itself derives its being); and only there may it finally come to rest, may it attain, that is, the order of its own *momentum*. […] [A]nd the same bodies do not rest in their place, unless they arrive there because moved by the desire [*appetitus*], as it were, of their weight, so that once they have reached it, they can rest.[58]

This interesting view is sometimes coupled by Augustine with a well-known passage from the *Wisdom* (11:20), where God is said to have disposed all things by (or in) measure, number, and *pondus*.[59]

§36.
CLIMBING THE TOWER OF BABEL. AVERROES AND *GRAVITAS*

As the *corpus Aristotelicum* received further attention in the Latin world, we assist at the consolidation of a technical vocabulary in natural philosophy. But this does not mean that each concept was paired with one and only one term. Rather, there were a range of terms that were employed to denote the same concept. It is however almost certain that *momentum* did only enter the vocabulary of Aristotelian natural philosophers in the Renaissance.[60] In any case, even before the Renaissance, natural philosophers felt it necessary – probably on the basis of *De caelo* 307b28-308a4 – to give different names to the capacity to move naturally toward the center of the world and the activity that stems from that capacity.

In this regard, an interesting case is provided by Averroes. In his commentary on the *De caelo*, Averroes underlines a linguistic discrepancy in the use of certain terms.

[58] "[R]ei cuiusque perfectio non tam in universo, cuius pars est, quam in eo, a quo est, in quo et ipsum universum est, pro sui generis modulo stabilitur, ut quiescat, id est, ut sui momenti ordinem teneat. […] [E]t ipsa corpora non manent in loco, nisi quo sui ponderis tamquam adpetitu perveniunt, ut eo conperto requiescant…" *De Gen. ad lit.*, IV, 18.34.

[59] Cf. *De Gen. ad lit.*, IV, 2.7, where Augustine, after having mentioned *Wisdom* 11:20, says that "mensura omni rei modum praefigit et numerus omni rei speciem praebet et *pondus omnem rem ad quietem ac stabilitatem trahit*…" (my emphasis).

[60] Cf. Galluzzi (1979a), pp. 41-149; Copenhaver (1988), p. 110.

He says that the term employed by the Greeks to denote a capacity to go downward has another meaning in Arabic. Its Arabic translation does indeed denote the activity of that capacity, not the capacity itself, which actually has no name in Arabic. Unfortunately, the original versions of these passages by Averroes is not extant. We can however read the Latin translations: one from the Hebrew, and another one from the Arabic. The Latin translation from the Hebrew was made by Paulus Israelitus, and it concerns Averroes's paraphrasis of the first chapter of the fourth book of the *De caelo*. The Latin translation form the Arabic was conducted by Michael Scot, and it is the beginning of Averroes's comment on the same chapter of the *De caelo*.

In the summary, Averroes says that

> in the Greek language, as Aristotle says, *gravitas* and *levitas* are two names that denote the capacities [*potentiae*] thanks to which [heavy and light] bodies are moved. On the other hand, we do not have a name for their movements, as Aristotle himself says. Yet in the Arabic language it seems that these names are used the other way around [that is, *gravitas* and *levitas* are used to denote the bodies' movements, whereas there is no name for their capacity]. However, here we use these names to denote their capacities.[61]

This is an important passage, which was also included in Zimara's *Tabula*, a sort of 'Averroistic encyclopedia' that circulated in the Renaissance.[62] *Gravitas* and *levitas* are terms that indicate the capacities for natural motion of heavy and light bodies. Capacity is translated from the Latin *potentia*. This was not the only term used to denote *gravitas* or *levitas*. There were indeed many synonyms for *potentia*, including *potestas*, *habitus*, *virtus*, and *vis*. They were all valid words to express in Latin the meaning of what Aristotle calls δύναμις φυσική in the *Categories*, that is, a capacity that stems from nature.[63]

As we have seen, for Aristotle the capacity for natural motion stems from nature insofar as the latter is the source of motion. The Latins begin to refer to the essence or nature of elements as to the *forma substantialis* that makes an element what

[61] "[I]n Graeco idiomate, ut Aristoteles loquitur, gravitas, et levitas sunt duo nomina significantia potentias, quibus haec corpora moventur, ipsorum vero corporum motus nullum, ut inquit, nomen effertur. In Arabica vero lingua videtur horum nominum usus esse in contrarium. Nos autem hic utimur his, ut eiuscemodi potentias denuntient" (Averroes (1550), p. 108r, col. 2).

[62] "Gravitas et levitas, ut tradit Aristoteles, in graeco idiomate sunt duo nomina significantia potentias quibus haec corpora moventur, ipsorum vero corporum motus nullum, ut inquit, nomen effertur: in Arabica vero lingua usus horum nominum videtur esse in contrarium. Averroes in paraphrasi 4 Coeli, summa 1, cap.1" (Zimara (1564), p. 66r, col. 2).

[63] Cf. *Cat.*, 8, 8b27-29, 9a14-20.

it is. In the Latin translation by Michael Scot, there is a use of *forma* in this sense, and the term *habitus* is employed as the equivalent of *potentia*. Moreover, given that *habitus* indicates the 'having' of a *forma*, the two terms can be used interchangeably.[64] So, the main dichotomy presented by Averroes is between, on the one end, the *forma*, *habitus*, *potentia*, and, on the other hand, the activity (*actio*) that stems from that *forma*, *habitus*, *potentia*.

That being said, what Averroes claims in the commentary differs much from what we have just read in the Latin translation of the paraphrasis. It is not true, according to Averroes, that Aristotle and the Greeks had a name for the form and the capacity, but they did not know how to call the activity resulting from that form and capacity. On the contrary, the form was named after the name of the activity, and this gave rise to ambiguous terminology (*nomina aequivoca*).

> Since we did not find a name proper to the *habitus* from which that activity came, it was necessary for us to transfer the name of the activity to the *habitus* and the *form*. Thus, what Aristotle said – if the translator is not mistaken – means that those names, that is, 'heavy' and 'light,' were used by the Greeks to denote both the form and its activity. So, the explanation of what he says, when he says that 'we did not find agreed names for their actions,' is that they did not find proper names, but only ambiguous names to denote both the form and its activity. And this is not what happens in our language [*viz.* the Arabic]. *And Aristotle does not mean that in his language the form has a name, but the activity does not have it.* For, if he meant this, he would have not started to show that 'heavy' and 'light' are names that denote the capacity and the *habitus*. Also, that [oddity of the Greek language] does not happen often in [other] languages. In this respect, there are four kinds [*modi*] of languages: [1] some languages have proper names for the *habitus*, and other proper names for the activity coming from that *habitus*; [2] some have an ambiguous name that sometimes denotes the *habitus*, sometimes the activity; [3] some have the name for the *habitus*, but not for the activity. And this happens rarely, for the activity is grasped by our sense and therefore it is more manifest than the *habitus*. The latter, instead, is grasped by our intellect on the basis of the activity of the *habitus*. [3] The last kind of language is that the activity has a name, and the *habitus*, from which the activity comes, has no name, just like in the Arabic language, and in many others.[65]

[64] As we shall see in the following sections, *forma*, *habitus*, *potentia*, were also paired with *affectio* and *dispositio*. This terminology, as I said, comes from Aristotle's *Categories*, in particular the part concerning quality. On this, see Pasnau (2011), pp. 536-537.

[65] "[Q]uoniam non invenimus ad habitum, ex quo provenit ista actio, nomen proprium, quapropter necesse fuit nobis transferre nomen actionis ad habitum et formam. Hoc autem, quod dixit, nisi sit error

From my point of view, this is a very interesting passage. Yet, it may seem that I am merely confronting with a linguistic problem that has nothing to do with Galileo and cosmogony. But as I said in the preliminary remarks (§31), a correct understanding of the terminology employed in Aristotelian controversies can allow us to better assess, not only Galileo's own contribution to those controversies, but even that of the same Aristotelians involved, like Borro and Buonamici.

§37.
Climbing the Tower of Babel.
Buonamici and Borro on *Gravitas*

One of the questions that were raised in the Pisan controversy on the motion of the elements was an old issue: does a heavy element have weight in its own natural place? According to Aristotle, the answer is positive. We have seen that this problem was also addressed by Simplicius in his commentary (§33). Simplicius was convinced to have disproved Aristotle's theory both experimentally and logically. For – he says – if weight is a desire, an inclination, an actual motion of a body toward its natural place, once the body has reached its natural place, it does no longer have an inclination, and therefore it has no weight. This solution rests on the assumption that a body has weight as long as it strives toward its *natural place*. But this is not what Aristotle says: according to him, 'being heavy' or 'having weight' means having a capacity to move naturally toward the *center* of the world. On a closer inspection, then, Simplicius's solution rests on a double assumption that cannot be found in Aristotle: (1) a body is heavy because it has a capacity to move naturally toward its natural place *and rest* therein; (2) a body is heavy *and has weight* when it moves and actually inclines toward its natural place. These assumptions may be Platonic in inspiration, but in fact we can find them in some Aristotelian authors as well.

translatoris, significat quod haec nomina, scilicet grave et leve, dicebantur apud eos [scil. Graecos] de utrisque, forma scilicet et actione. Et sic erit expositio eius, quod dixit, sed non invenimus ad actiones eorum nomina instituta, idest nomina propria, sed aequivoca, quae dicuntur de ista forma, et de actione. Et hoc non est in idiomate nostro. *Et non intendit [Aristoteles] quod in suo idiomate habeat forma nomen, sed actio non habet*. Quoniam, si hoc intendebat, non inciperet demonstrare quod hoc nomen grave, et leve demonstrat potentiam, et habitum. Et etiam hoc fere non cadit in idiomatibus. Idiomatum enim sunt in hoc quatuor modi: [1] Quaedam enim habent nomina propria ad habitum, et alia [nomina propria] ad actionem provenientem ab illo habitu: et hoc est melius. [2] Quoddam vero habet nomen aequivocum quandoque demonstrans habitum, quandoque actionem. [3] Quoddam autem habet nomen ad habitum, sed non ad actionem. Et hoc raro invenitur: actio enim est manifestior habitu cum sensu apprehendatur, et habitus intellectu mediante actione. [4] Quartum vero est ut actio habeat nomen, et habitus, ex quo provenit illa actio, non habeat nomen, sicut in Arabum idiomate, et in pluribus" (Averroes (1550), p. 108v, col. 2, my emphasis).

I shall present two examples provided by Albert of Saxony and Francesco Buonamici. Although they use a different terminology, they mean to refer to the same thing, that is, heavy bodies are defined by a capacity (for natural motion and rest) that does not always give rise to weight.

According to Albert of Saxony, in order to say whether a heavy body has weight in its natural place or not, one has to draw a distinction between two possible understandings of *gravitas*.

> In order to reply to this question, I first put forth a distinction. And this distinction is that *gravitas* can be taken in two respects. On the one hand, it can be taken as a certain disposition pertaining to the *habitus* and the capacity [*dispositio habituali et potentiali*] that comes from the form of the heavy body, regardless of the fact that *gravitas* actually inclines [*actualiter inclinet*] toward motion or not. In this sense, *gravitas* might be called *gravitas habitualis* or *potentialis*. In another sense, *gravitas* can be taken as the actually inclining disposition to move [*dispositio actualiter inclinans ad motum*], and in this sense it might be called *gravitas actualis*. The same distinction can be applied to *levitas*.[66]

We are already familiar with the distinction drawn by Albert of Saxony. In short, he invites his readers to conceptually separate the capacity for natural motion, which stems from the nature of heavy bodies, from the activity – which involves motion – of that same capacity. Armed with this distinction, and in analogy with the fact that fire is always hot (*calidus*) but it does not always burn (*comburit*), he can conclude that *gravitas* is always present in a heavy body, but does not always exert weight (*ponderat*).[67] In its natural place, indeed, a heavy body does not actually incline (*inclinat actualiter*). Because of this, it does not have weight.

A clearer terminological distinction between *gravitas* and weight is advanced by Francesco Buonamici. Mario O. Helbing and Michele Camerota have suggested that Buonamici's distinction between *gravitas intensive* and *gravitas extensive* is conceptually similar to our distinction between *specific gravity* and (*absolute*) *weight*,

[66] "Pro respondendo ad istam quaestionem pono primo unam distinctionem. Et est ista quod dupliciter potest capi gravitas. Uno modo pro dispositione quadam habituali et potentiali consequente formam gravis, sive actualiter inclinet ad motum sive non, et illa vocetur gravitas habitualis et potentialis. Alio modo accipitur gravitas pro tali dispositione actualiter inclinante ad motum, et illa vocetur gravitas actualis. Consimilis distinctio potest poni de levitate" (Albert of Saxony (2008), p. 466).

[67] "[I]gnis, ubicumque sit, est calidus actualiter, illud negatur, quia non ubicumque sit actualiter comburit, sicut nec gravitas, ubicumque sit, actualiter ponderat" (*ibid.*, p. 471).

respectively. In my view, this suggestion, albeit heuristically useful, conceals some important features of Buonamici's doctrine of *gravitas*.[68]

First of all, Buonamici resorts to a distinction that we have already encountered. Just like Averroes and Albert of Saxony, Buonamici too distinguishes between, on the one hand, *gravitas* as the capacity (*potestas* or *habitus*) that comes from having a form (*forma*), and, on the other hand, *gravitas* as the activity that stems from that capacity. He calls "secondary act" the movement and actual inclination of *gravitas* toward its natural place, whereas he calls "primary act" the permanence of *gravitas* in the natural place. The secondary act is also defined as the operation or functioning (*operatio* or *functio*) of *gravitas*, and it is regarded as an "imperfect" (*imperfectus*) kind of actuality. The primary act, instead, is defined as a "perfect," "complete," or "absolute" (*absolutus*) kind of actuality.[69]

In Renaissance natural philosophy, the use of this distinction with respect to *gravitas* (and *levitas*) was quite common, as William A. Wallace pointed out in his studies on the Roman College *reportationes*. Wallace expounds the distinction as follows (he prefers "first act" and "second act" over 'primary' and 'secondary act'; he also prefers "power" over 'capacity'):

> The expressions "first act" and "second act" were used by scholastics to distinguish stages of actuation of operative powers. Thus a person who had been prepared to teach but was not yet actually teaching could be referred to as a teacher "in first act," in the sense that he or she had already actualized the power to teach; when the same person was in the classroom actually teaching, he or she would then be a teacher "in second act," for the power earlier acquired would now be actualized, i.e., it would be actuated beyond its initial acquisition, and so put into "second" actuation.[70]

Buonamici abides by the terminology just described, but he adds an interesting, albeit not original, facet. He says that the secondary act may be called *pondus*, because it is an action that concerns a limited extension of matter. Furthermore, since the secondary act is a movement, it can be also called *mo*[*vi*]*mentum*. Both terms are clearly

[68] Cf. Helbing (1989), pp. 205-208, *passim*; Camerota-Helbing (2000a), pp. 338-339.

[69] Cf. *infra*, nt. 72. It is not unlikely that, by so doing, Buonamici is perhaps echoing the distinction between ἐνέργεια and ἐντελέχεια, and implicitly appealing to the second book of the *De anima*, in reference to which the notions of primary or secondary act were usually employed.

[70] Wallace (1981), p. 124, nt. 20. See also Helbing (1989), p. 149, and Wallace (1984), pp. 178-191.

associated because they denote the activity of *gravitas* outside its natural place. Buonamici may be actually drawing from Simplicius when he writes the following:[71]

> For my part, I believe that 'heavy' and 'light' are ambiguous names, as they can mean two things. [1] They can denote the *habitus* contracted from generation, which, while it is being made, moves the mobile toward its own place, and, after it has been made, allows the body to rest in its proper place. [2] But they can also denote the activity whereby the body, while it is outside its proper place, strives to get that place, suppressing and chasing away the impediments [*impedientia*]. If I was asked to give a proper name to this activity, I would call it weight [*pondus*], because it arises in extension and mass [*in extentione ponitur et mole*], not in the intensity [*non in intentione*] of the form of the capacity (about which we shall equally say many things later on, when we shall also explain why the elements do not have weight in their proper place and in their entirety). To conclude, I say that when 'heavy' is used in the latter way, it cannot be ascribed to the elements when they rest in their proper place. For this reason, [weight] is rightly called ῥοπή, that is, *momentum*, which is perceived by reason of pressure and downward movement, and which dies out in the proper place and in the state of natural rest. However, I say that [weight] is caused by another *gravitas*, which is a *habitus*, thus a capacity, whose act is twofold: an imperfect one, which manifests itself in motion; an absolute one, which consists of being at rest.[72]

Through this definition of *pondus*, Buonamici shows that weight is *not* just the measure of the extension of matter, or simply the quantity of matter, endowed with

[71] As recalled by Camerota and Helbing, "Buonamici, who was a pupil of the distinguished philologist Pier Vettori and an excellent scholar of Greek, admired classical antiquity and despised medieval *Latini* together with their philosophy" (Camerota-Helbing (2000a), p. 331).

[72] "Equidem in iis vocibus grave et leve ambiguitatem contineri censeo quippe quod et habitum significari putem per generationem contrahitur, et dum fit, promovet mobile ad suum locum, postquam factum est, in suo loco constituit; et actum quoque qui in eo consistit, ut extra suum locum manens in illum contendat opprimens, et impedientia propellens, quod si proprio nomine notare velim, pondus appellaverim, quod in extentione ponitur et mole, non in intentione formae potestatis, de quo item multa posthac, ubi etiam docebimus cur elementa in suo loco et in universitate pondus non habeant. Dico igitur de hoc postremo gravis significatu verba fieri, atque hunc elementis in proprio loco negari, et vere dici ῥοπή, quod est momentum, et ex oppressione descensuque percipitur, et proprio loco finitur, et quiete naturali. Quanquam eius auctorem facio alteram gravitatem, qua habitus est, et proinde potestas, cuius item actum duplicem esse affirmo, et hunc qui apparet ex motu, et est imperfectus, atque alterum qui est absolutus et quiete consistit" (Buonamici (1591), p. 469b-c). In his great study on Buonamici, Helbing has unfortunately provided a piecemealed translation of this passage (cf. Helbing (1989), p. 207). Helbing's translation makes it impossible for us to understand the difference between *gravitas* and weight, and it also misleadingly suggests to us that weight (*pondus*) and *gravitas extensive* are conceptually paired by Buonamici. On the contrary, the conceptual pair established by Buonamici is between weight (*pondus*) and *momentum*.

gravitas. He says, indeed, that weight is the *momentum* of *gravitas*, that is, the activity that stems from a capacity to move naturally toward the center of the world. Also, it becomes clear from the passage just cited that, for instance, although two clods of earth have the same capacity to move naturally, the bigger one has more *momentum* than the smaller one. This means that, *outside its natural place*, the bigger clod of earth has more weight, that is, it has a greater *pondus* than the smaller one.

In short, the conceptual pair *pondus-momentum* (namely, weight-movement) shows to us that Buonamici does not think of weight as the extension of *gravitas*; that is, he does not think that (absolute) weight is *gravitas extensive*.[73] Weight is a particular kind of actualization of *gravitas extensive*, one that manifests itself only when the heavy body is outside its natural place. In its natural place, the heavy body does not have any actual inclination or *momentum*. Thus, in its natural place a heavy body has no weight in that it does not exert its *gravitas* (or, as we may perhaps call it, its heaviness). Obviously, a body has an extensively determined *gravitas* even when it lies in its natural place. However, its *gravitas extensive* (quantity or amount of heaviness) has no *momentum* in its natural place, hence no weight. Thanks to this understanding of weight, Buonamici is able to refute Borro's opinion, who followed Averroes in saying that heavy elements have weight in their natural places because the quantity alone of *gravitas* is responsible for weight.[74]

So, at the core of Buonamici's criticism lies a different conception of *gravitas*. On the one hand, Buonamici thinks that, although *gravitas* is a capacity (*habitus* or *potestas*) that stems from the nature or substance of a heavy body, it should not be predicated of the nature or substance of a heavy body. It should be predicated of the place (*ubi*), instead. With some approximation, we can say that for Buonamici *gravitas* is a non-substantial form, a quality, thanks to which nature moves heavy bodies. In this sense, *gravitas* is not the essence (*essentia*) of heavy bodies. *Gravitas* is just an instrument at nature's service.[75] On the other hand, Borro is convinced that, although

[73] On this point, my reading is obviously different from that of Camerota and Helbing.

[74] Cf. Helbing (1989), pp. 208-215; Camerota-Helbing (2000a), pp. 334-340.

[75] "Idcirco putarem ego grave et leve per se considerata significare potestatem, quae referenda sit ad praedicamentum ipsius ubi (ut in quoque praedicamento proprius est actus, atque potestat) quam perficiatur per actum illum qui est esse alicubi, atque eam consequi formam quae respiciat elementi substantiam, quaecunque illa sit. Nam de hac ipsa suo loco plura dicemus, et quoniam est potentia proxima, per quam et movetur elementum secundum naturam, et manet in suo loco, ideo principiis motus interni adnumerari. Veruntamen ea non est natura, quia natura est principium motus a quo caeterae facultates et actus pendent, tanquam caussae secundae et instrumenta" (Buonamici (1591), p. 499d). Short afterwards, Buonamici adds an interesting argument: "Propterea respondetur ad id: Gravitas et levitas sunt principia per quae movetur inanimatum, at principium per quod forma [substantialis] est. Quoniam continet hoc argumentum fallaciam secundum consequens, quicquid enim est forma, est id per quod movetur, sed non contra, quicquid per quod movetur, est forma. Nam movetur etiam inanimum per motum et per aliquid notat rationem instrumenti, et eam quam formalem vocant, unde nuncupatio sumitur, veluti quod albus sit per

there are no names for the substantial form of heavy bodies, one can however indicate it by using the name of the most known *facultas* or *habitus*, namely, *gravitas* (or *levitas*).[76] For this reason, when he says that natural motion is due to *gravitas*, he is not claiming that natural motion is due to a quality or a natural capacity (*facultas* or *habitus*). Rather, he is claiming that natural motion is due to the substantial form, the essence or nature of heavy bodies.[77] Needless to say, these differences between Borro and Buonamici's view on *gravitas* are not original, but fall within an old controversy on the meaning of *gravitas*.[78]

These two views lead to two different understandings of weight. Contrary to Buonamici, Borro believes that the substantial form of heavy bodies is the cause of their natural motion downward. And since heavy bodies *are* heavy in their natural place, they also *have* weight in their natural place. Weight is then regarded by Borro as the extension in matter, or simply the amount, of *gravitas* understood as a substantial form. If, for instance, the substantial form of air in its natural place is *gravitas*, then air must *be* heavy; hence, air must *have* weight in its natural place.[79]

albedinem, et per aliquid primo, atque id est forma. Praesefert etiam ea vox specimen efficiens 2. de Anima t. 37. Et quanvis natura definiatur latione, non ob id seuitur, cum sit eiusmodi gravitas, ut per eam latio fiat; ipsam esse natura, sed a natura proficiscitur latio per gravitatem." I believe that this passage and what follows is a strong and somewhat sarcastic criticism of Borrro's opinion (cf. *ibid*., p. 500[mistakenly printed "100"]e-f).

[76] "Numero autem eorum corporum invento, quae simplicia sunt, et recto motu naturali moventur, investiganda diligentius est tum gravium, tum levium definitio […]. Huius definitionis inventio non satis commoda est: quippe quod via, et ratio, quam tenere in scientia tradenda, et in quavis re definienda debemus, ab illustrioribus, et notioribus nobis rebus *ad eas, quae natura illustriores, clarioresque sunt, progredi soleat*: ut scripsit Aristoteles libro primo Physicorum particula secunda. *Atqui nobis clariore illustrioresque sunt actiones facultatibus…*" (Borro (1575), p. 29, my emphasis); "Motus ergo gravium, et levium corporum simplicium, ex gravitate, ac levitate nascentes, gravibus, et levibus, secundum naturam insunt gravitatis, et levitatis ratione, quae licet propriae, et verae naturae non sint, elementorum tamen naturas necessario consequuntur: etenim saepenumero, cum *rerum naturae propriis nominibus careant, utimur in eis explicandis, vocabulis accidentium*; quae notiora sicuti sunt, et nostris sensibus magis familiaria: a quibus intellecuts cognitionem oriri deprehendimus, et hac ratione motus hic, qui ex gravitate, et levitate proficiscitur, naturalis dicitur: *non quod gravitas, et levitas sint corporum gravium, et levium formae, ac naturae, sed quod accidentia sint, quae ad eorum naturas, quam proxime accedunt: et quae ex ipsismet gravium, et levium naturalibus formis, ac propriis manant, non secus atque ex propriisfontibus: his enim qualitatibus utimus: quia propriis elementorum naturis a maioribus nostris non fuerunt imposita nomina*" (*ibid*., pp. 105-106, my emphasis).

[77] "Eadem est causa quietis terrae, et motus illius. Sed propria terrae natura, quae est gravitas, est causa quietis in terra; ergo propria terrae naatura, quae est gravitas, et est causa motus illius. Gravitas enim et levitas, quamquam elementorum naturae non sunt, accidentia tamen propria esse censentur quae elementorum formas, et naturas necessario sequuntur, et ex principiis primis intrinsecis atque immediatis specierum, ut aquae ex propriis fontibus manant; gravitati et levitati elementorum motus, tum ab Aristotele, tum ab aliis compluribus, quorum nomina supra retulimus, tribuuntur, et *formarum loco usurpantur*, *quia elementorum forma propriis nominibus carent*, ut in principio diximus" (*ibid*., pp. 147-148, my emphasis).

[78] Cf. Maier (1943), pp. 143-180; Galluzzi (1979a), p. 111, nt. 321; Helbing (1989), 154-157.

[79] "Has omnes levitates, et gravitates specie differre (uti diximus) a ratione alienum non est, quia *gravitatem, et levitatem formarum loco usurpamus, quod elementorum formis maiores nostri nomina non posuerint*, et quia *motionum differentiae ex differentibus formis nascuntur;* quae cum elementorum in propriis locis et

As we can see, Borro does not need to leverage on the distinction between *gravitas* and *pondus* to solve the problem about the weight of the elements in their natural place. According to Borro, *gravitas* understood as a capacity for natural motion, and *pondus* understood as the activity of that capacity, are just names, like many others, that do not provide any aid in the controversy on the motion of the elements.[80] What matters is the real cause of natural motion, that is, the substantial form and nature of the elements. For this reason, Borro feels himself justified in neglecting all those names that are employed, at his time, to denote the activity of *gravitas* understood as a capacity. They are but a series of arbitrary names,

> since our ancestors did not give a name to the activities of those capacities, unless perhaps someone thinks that the activity of *levitas* and *gravitas* can be called ῥοπή, that is, *momentum*, inclination, weight [*pondus*], or tendency [*nutus*], thanks to which heavy and light bodies are moved upward and downward. Although these names are not totally absurd, they are however of little aid to us. Thus, we will prudently disregard *momentum*, inclination, weight, and tendency, and we will hasten, without beating about the bush, toward something more useful to our cause.[81]

extra propria loca inter se, et mixtorum inter se, et cum elementis *tum infra, tum extra propria loca* specie sint diversae, mirandum non erit, si elementorum inter se *tum in propriis, tum etiam in alienis locis*, et mixtorum ab elementis, et inter se gravitates, et levitates specie sunt omnino diversae: *nam differentiae, quae a formis nascuntur, specierum differentiae nuncupantur*" (Borro (1575), p. 222, my emphasis). As for the reference to the species of *gravitas*, cf. *ibid*, p. 221: "… elementorum gravitates, et levitates inter se specie differunt, ut scripsit Averroes libro tertio de caelo commentatione octava, quod probatur, quia terrae gravitas, et [ignis] levitas sunt absolutae, et gravitas et levitas aeris, et aquae sunt comparatae…"

[80] We must notice that Borro thinks that the distinction between primary and secondary act is not properly understood by some natural philosophers (perhaps a reference to Buonamici?). For Borro says that the primary act is the substantial form itself, not the natural capacity that comes from having that substantial form: "Hoc principium proprium, et particulare illud est, quod in hodiernam hanc quaestionem vocantur dum quaeritur: Utrumne elementorum corpora ab hoc particulari, ac proprio principio moveantur, an vero ab alio extrinseco incitentur. Porro huius primi principij adhuc multa sunt differentiae: et illius, quod actui primo, et illius, quod actui secundo proportione respondet. Quoddam (exempli gratia) in actu intelligendi refert animam, quoddam vero scientiam, quorum utroque intelligimus: *sed hoc alterum est ut substantia, alterum ut habitus*. Principium, quod est *ut substantia*, duobus modis consideratur. Primo ut actus primus, secundo ut actus secundus: *per actum primum nos formam intelligimus efformantem materiam*; dum in nullum opus egredietur, sed feriatur, ac cessat. *Per actum secundum* eamdem formam intelligendam putamus, dum agendo facultatem innatam, et vim propriam exerit: *non autem solam formae actionem, ut alij complures intellexerunt*, quorum errorem libro secundo de anima demonstravimus: ut puer, in cuius corpore anima in est, et dormit, particeps est actus primi, sine secundo: porro cum in eo vigiliae vigent, et primus actus ad aliquod opus egreditur, secundi actus iam factus est particeps. Elementorum quies actuis primo, cuius nullus est usus, et qui ad opus non redigitur; et eorumdem motus actui secundo, qui redactus est ad opus, respondent" (*ibid*., pp. 61-62, my emphasis).

[81] "…cum harum facultatum actionibus a maioribus nostris non sint imposita nomina, nisi forte quis levitatis et gravitatis actionem esse existimet ῥοπήν, id est momentum, inclinationem, pondus, sive nutum, ex quo efficitur ut gravia et levia corpora susque deque concitentur; quod quanquam absurdum omnino non

Paolo Galluzzi has rightly traced this passage back to the beginning of the fourth book of the *De caelo*.[82] A further piece of evidence telling us that perhaps – in opposition to Galluzzi's own opinion – the most useful Aristotelian *locus* to interpret the use of *momentum* in Renaissance Aristotelianism is in the *De caelo*, not in the *Physics*.[83] Having laid a great deal of attention on the latter, and very little on the former, unfortunately Galluzzi has not noticed that both Borro and Buonamici – the exponents of two different kinds of 'Aristotelianism' – understand *momentum* and *pondus* as the activity (*actio*) of a capacity (*facultas*) called *gravitas*. Hence, it is inaccurate, albeit correct, to claim that Borro says "explicitly that the *momentum* of bodies is a *facultas*."[84] In fact, *momentum* is just a name for the activity of a certain natural *facultas* for motion. For the same reason, it is imprecise, although correct, to say that for Buonamici *momentum* is "an inclination that *exclusively depends on weight*."[85] In fact, for Buonamici *momentum* is weight (*pondus*), that is, *momentum* is a certain activity, exertion (*operatio*, *functio*), of *gravitas*.

According to Buonamici and Borro, *momentum* and weight are synonyms; both terms indicate the activity, or movement, of a capacity called *gravitas*. However, Borro thinks that when matter is 'encoded' with the substantial form of *gravitas*, it must also have weight. Buonamici instead, having disjointed the notion of *gravitas* from that of nature, can leverage on the definition of *gravitas* as a capacity whose actuality can be divided into primary or secondary act. Only the latter involves motion, that is, only the latter gives rise to *momentum* and weight.

Exception made for the *Juvenilia* – where *gravitas* is still divided into primary and secondary act[86] –, Galileo's use of *momentum*, *pondus*, and *gravitas* (and their

est, nobis tamen ad has definitiones inveniendas vel parum quidem proderit; ideo hoc momentum, inclinationem, pondus, sive nutum prudentes praeterimus et ad alia, quae hanc nostram causam magis iuvent, omissis ambagibus properamus" (*ibid.*, pp. 29-30).

[82] Cf. Galluzzi (1979a), p. 113, nt. 332.

[83] We must notice that in the *De caelo* alone there are ten occurrences of ῥοπή (II, 1, 284a1, a25; II, 14, 297a28, 297b7, b10, b14; III, 2, 301a22, a24; III, 6, 305a25; IV, 1, 307b33).

[84] Galluzzi (1979a), p. 114: "Inoltre, egli [viz. Borro] chiariva esplicitamente che il *momentum* dei corpi è una *facultas*, la cui intensità determina la direzione (*sursum* o *deorsum*) e la velocità dei moti."

[85] *Ibid.*, p. 117: "Nel nostro contesto [*viz.* Buonamici (1591), p. 417g-h] *momentum* indica 'inclinazione' a muoversi secondo diverse velocità, un'inclinazione dipendente *esclusivamente dal peso* (Buonamici ha in mente, infatti, una bilancia di bracci uguali): il *momentum* cresce perché aumenta il peso" (emphasis in the original text).

[86] "Dico, 2°: qualitates motivae non sunt formae elementorum; tum ob dicta in praecedenti conclusione; tum quia sunt posteriores qualitatibus alterativis […]. Respondet Achillinus, gravitatem et levitatem posse dupliciter considerari: vel in actu primo, et sic sunt formae substantiales elementorurm [cf. the opinion of Borro, *supra*, nt. 80]: vel in actu secundo, idest ratione gravitationis et levitationis, et sic dicuntur qualitates. […] Ad locum Aristotelis respondeo, Aristotelem dicere gravitatem et levitatem esse propriissime differentias, quia ponuntur loco differentiarum ultimarum substantialium, nobis ignotarum [cf. the opinion

correlative terms in vernacular) differ much from that of the Aristotelians. The most interesting difference is that these notions do no longer need to be understood within an act-potency framework. This has important consequences on their meanings. But before seeing that, it is beneficial to dwell a little longer on the tradition of *gravitas* before Galileo.

§38. ANACHRONISTIC AMBIGUITIES. WEIGHT AND SPECIFIC WEIGHT

What has been hitherto examined allows us to draw the following conclusion: it is not true that, as held by Duhem, "the two notions of weight and mass were at that time [*viz.* in antiquity] indistinguishable from each other."[87] Against this view, it suffices to say that Aristotle holds a hylomorphic, as it were, understanding of weight. As we have seen, the Aristotelian notion of 'heavy' or 'having weight' cannot be narrowed down to 'having mass.' Although what has weight, does also have a mass, the opposite is not always true (e.g., a huge mass of fire it totally devoid of weight for Aristotle).

We have also seen that the fourth book of the *De caelo* was in the past a pivotal point of reference for any philosophical discussion concerning weight. Aristotle's terminological ambiguities left room to different interpretations whereby commentators tried to provide conceptually clearer definitions of weight. It is against the backdrop of these exegetical practices that different notions of weight came about in the Aristotelian tradition. Among Greek commentators, Simplicius conceives of weight (βάρος) as the inclination (ῥοπή) of a quantity of matter which is endowed with a capacity for motion (βαρύτης). By so doing, he identifies weight with inclination. In the late Renaissance, a similar point of view is held by Francesco Buonamici, who develops further the distinction between *gravitas* and *pondus*, while associating the latter with movement (*momentum*).

So, we can fairly say that, in principle, some Renaissance Aristotelians like Buonamici started to regard weight (*momentum* or *pondus*) as the amount of *gravitas* in secondary act, that is, in movement.[88] The reason why, on a balance, two equal

of Borro, *supra*, ntt. 76, 77, 79]. Obiicies: gravitas et levitas sunt principium motus et quietis; ergo sunt natura; ergo formae. Respondeo, gravitatem et levitatem esse tantum principia instrumentaria motus [cf. the opinion of Buonamici, *supra*, nt. 75]" (OG, I, *Juvenilia*, pp. 131-132). Wallace did not notice that the last sentence is in line with Buonamici's view on *gravitas*. He traced Galileo's view back to Vallius's opinion in that regard (cf. Wallace (1977), p. 288).

[87] Cf. Duhem (1905), p. 11.

[88] This is obviously an approximation of how *some* Aristotelians understood weight. As we have seen,

quantities of matter, i.e., two equal volumes of matter (given that for the Aristotelians there is no void), exert different weights, is because they are endowed with different species of *gravitas*, that is, different capacities to move naturally toward the center of the world. For instance, the capacity of earth is different than that of water because earth (1) moves toward the center of the world faster than water, and (2) it reaches the center of the world, whereas water halts on the surface of earth. For the sake of brevity, we have called these two criteria, the criteria of 'velocity' and 'displacement.'[89]

We can of course try to explain this understanding of *gravitas* by appealing to the more familiar notion of specific weight. But this explanation may be misleading. For what differentiates the species of *gravitas* is not a ratio between the amount of

Borro's view was different, as he linked weight to the substantial form, which is internal to the body and cannot change according to external factors. A similar view was held by Pererius, who disagrees with those who believe that proximity to the terminus of natural motion gives rise to an increase in weight (*pondus*), which in turn is the cause of the acceleration of falling bodies. In fact, if "augetur gravitas lapidis, ergo etiam pondus," but this is incorrect as well as "contra experientiam" – Pererius claims – given that *gravitas* cannot increase. This can be proven by different "experientiae" where it is evident that weight (*pondus*) itself does not increase while the body is falling (cf. Pererius (1576), p. 445). Pererius argues that a change in velocity does not amount to a change in *gravitas*, and he appeals to the *Mechanical Problems*, problem 19, to expound his view (cf. *ibid*., pp. 445a, 446d). In short, Pererius and Borro do not conceive of weight as the secondary act of *gravitas*, which is brought about by external circumstances that alter the velocity of bodies. Instead, they think that weight is the amount of *gravitas* in matter, where *gravitas* is understood as a substantial form that cannot change, unless the change is substantial. On the link between *gravitas* in secondary act and external factors, see Piccolomini (1600), pp. 180v-185v, especially 183r, where Picollomini, too, recalls the *Mechanical Problems*, problem 19, and associates *gravitas* in secondary act with velocity. These passages from Piccolomini were echoed by Arturo d'Elci in his dispute on floating bodies against Galileo (cf. OG, IV, pp. 156, 158).

[89] According to Buonamici, it is possible to 'measure' these two criteria without involving water, just by placing isovolumetric bodies on a balance: "In primis autem redire oportet in memoriam *aliud esse gravitatum species a differentiis ponderum*; quippe quod pondera sequantur materiae moltitudinem et extent in corporibus, dum alieno in loco detinentur; *gravitas afferat propensionem et monstret quantum quicquam formae consecutum fuerit, ex quo certos terminos in eo intervallo quod a centro mundi ad caelum usque porrigitur, adeptum in suo loco conquiescit* [that is, the criterion of displacement]. Itaque pondus C talentorum ligni maius est quam selibrae plumbi; huius vero gravitas maior, quod lignum in aquae superficie requiescit, mergitur plumbum; illud est quanti; hoc speciem qualitatis praesegerit. *Itaque non accipimus hic pondera et cum humidi pondere comparamus, sed gravitates*. Ut vero discernantur, ita faciemus: conferemus enim de corporibus *aequas magnitudines*, quae si fuerint ponderis aequalis, aeque item graves esse iudicabimus; [magnitudo] quae vincet, eam speciem graviorem esse censebimus. Ideo *si tandundem ligni, aquae et plumbi capiamus*, plumbi pondus erit maximum, minimum ligni; *propterea* lignum in aquis natabit, plumbum demergeretur. Idcirco aqua plumbo levior existimabitur, ligno vero gravior; et e contrario si duarum magnitudinem diversi generis, eiusdemque ponderis illa erit maior quae specie levior, ut si anuli duo, quorum unus sit aureus, alter vero argenteus, idem pondus habuerint, argenteus, quia specie levior, erit etiam maior. Sic Archimedes aurificis fallaciam deprehendit, de quo alio loco dictum est" (Buonamici (1591), p. 492g-h, my emphasis). Helbing's translation of this passage is perhaps misleading (cf. Helbing (1989), pp. 217-218). It must be noted that, in the passage just quoted, Buonamici shows how to distinguish different species of *gravitas* by comparing weight and volume, i.e., without placing bodies in water: the behavior of bodies in water is inferred (*propterea*…) by such comparison. Thus, his account of Archimedes's finding differs from the one Buonamici himself had previously described, which was based on Vitruvius's account (cf. Buonamici (1591), p. 434f-g; Helbing (1989), pp. 180-181).

matter subject to gravitation (i.e., weight) and volume. What makes two bodies differ in kind is a difference in 'gravitation,' so to speak. The (absolute) weight of two equal volumes of earth and water is different because it responds to qualitatively different species of *gravitas*, as though we imagined to put the same mass, the very same material, into two different gravitational fields.

Free of reference to our notion of specific weight or density, we can then approach, read, and understand statements and mental experiments like the following:

> Consider two bodies made of wood that are different in kind and have different *gravitates in specie*. Take two equal portions of them, and divide them along the side into a certain number of equal parts, e.g., twelve. Let us call those parts *puncta*. That being done, drop the *puncta* into water, and check which one is the wood whose more *puncta* sink, and which one is the wood whose less *puncta* sink. Also, see how many *puncta* of one piece of wood, and how many of the other piece, sink. Accordingly, we can then establish the proportion of those *puncta* to each other according to *gravitas*. For instance, two *puncta* of one piece of wood and four of the other one sink. So, we can say that the wood whose four *puncta* sink is as twice heavy *secundum speciem* as the other one whose only two *puncta* sink.[90]

In this passage, Albert of Saxony puts forth an experiment whereby distinguishing a species of wood (but it could be any kind of material) from another one. By dividing a piece of wood into little pieces (*puncta*), one should be able to separate the compound into its components, that is, small quantities of matter endowed with different *gravitates*. In the Aristotelian tradition, wood is usually understood as a compound of earth, water, and air. Albert of Saxony seems to suggest that we only consider the *puncta* endowed with earthy *gravitas*, as they are the only *puncta* that fall in water.

In my view, Albert of Saxony's (thought) experiment can be used to gauge, *from practice to notion*, the distance that separates our understanding of specific weight from Albert of Saxony's understanding of *gravitas in specie*. I believe that the practice described by Albert of Saxony is indeed revealing of a notion of specific weight which differs in many respects from our own. Some technical terms of the past (e.g., *pondus*,

[90] "Nam sint duo talia corpora duo ligna diversarum specierum et diversarum gravitatum in specie; capiantur de eis duae portiones aequales, et quaelibet illarum dividatur secundum latus in aliquot partes aequales, verbi gratia in duodecim, quae partes vocentur puncta; quo facto dimittantur cadere in aquam, et videatur de quo plura puncta submerguntur et de quo pauciora, et ulterius videatur quot puncta submerguntur de uno et quot de alio, et secundum hoc iudicetur proportio eorum ad invicem in gravitate, verbi gratia sit quod unius submergantur duo puncta et alterius quattuor, tunc dic quod illud cuius quatuor puncta submerguntur est in duplo gravius secundum speciem quam illud cuius solum duo puncta submerguntur" (Albert of Saxony (2008), p. 461).

gravitas in specie or *species gravitatum*) have certainly gone through a process of reconceptualization before reaching us.

§39.
COPERNICUS AND *GRAVITAS*

There is another important trend that takes hold in the Renaissance and that concerns the understanding *gravitas*. The term *gravitas* is not only used to denote qualitatively different capacities to move toward the center of the world. It is also used to denote a common desire or tendency of parts to move toward the center of their whole, that is, toward a place appointed by God.

Copernicus is probably the most influent exponent of this view in the Renaissance. In the *De revolutionibus orbium caelestium* (1543), he integrates this view on *gravitas* within a heliocentric cosmology. An interesting feature of Copernicus's understanding of *gravitas* is that the desire of parts is teleologically aimed at preserving and restoring the spherical shape of the planets and the Sun:

> For my part I believe that *gravitas* is nothing but a certain natural desire (*appetitus*), which the divine providence of the Creator of all things has implanted in parts, to gather as a unity and a whole by combining in the form of a globe. This affection (*affectio*) is present, we may suppose, also in the Sun, the Moon, and the other brilliant planets, so that through its operations they remain in that spherical shape which they display. Nevertheless, they swing round their circuits in diverse ways.[91]

There is a hotly debated controversy on the sources of Copernicus's doctrine of *gravitas*. What makes this controversy somewhat urgent is that, depending on the source ascribed to his theory of *gravitas*, the entire natural philosophy put forth by Copernicus in the first book of the *De revolutionibus* may take on different, sometimes antithetical, meanings. Some have attempted to bring Copernicus's natural philosophy back to the mainstream of the Scholastic tradition, by identifying, for example, in

[91] "Equidem existimo, grauitatem non aliud esse, quam appetentiam quandam naturalem partibus inditam a diuina prouidentia opificis uniuersorum, ut in unitatem integritatemque suam sese conferant in formam globu coëuntes. Quam affectionem credibile est etiam Soli, Lunae, caeterisque errantium fulgoribus inesse, ut eius efficacia in ea qua se repraesentant rotunditate permaneant, quae nihilominus multis modis suos efficiunt circuitus" (Copernicus (2015), II, p. 32.12-18). English translation from Rosen (1992), slightly modified.

Oresme one of the thinkers who may have inspired the Polish astronomer.[92] Other scholars, instead, have put much emphasis on the break with the medieval tradition, comparing the Copernican *gravitas* with that advanced or simply mentioned by authors of antiquity, such as Cicero, Pliny, Plutarch, Philoponus, or more recent ones but with a clear Platonic orientation, like Ficino.[93]

I fear, though, that the controversy may be flawed from the start. Although it may well be that only *one* source exerted a decisive influence on Copernicus, nothing in fact speaks against the chance that he was aware of different views on *gravitas* which he then re-elaborated autonomously to make his own.[94] Even at first glance, one can see that Copernicus's understanding of *gravitas* includes some traditional elements that we have already encountered in Simplicius and Augustine, for instance, two very well-known authors also at Copernicus's time. In their writings, we find the general idea that the parts of entireties have a particular desire to reunite with their natural place, which is ultimately established by God himself, who is the author of the cosmic

[92] For a detailed list of the supporters of this opinion, cf. Knox (2005), pp. 179-180, ntt. 115-118, and Knox (2013), p. 59 ntt. 2-4 (slightly different than the list reported in Knox (2005)), and p. 60, nt. 2. Among the scholares cited by Knox there are Aleksander Birkenmajer, Reyer Hooykas, Thomas S, Khun, Anneliese Maier, Paul Moraux, Edward Rosen, Noel Swerdlow and Michael Wolff. As for the particular reference to Orseme, cf. Knox (2005), p. 181, nt. 128, and Knox (2013), p. 61, nt. 6, where Pierre Duhem is cited (among others). I would also include Max Jammer (cf. Jammer (1957), pp. 42-47, 72, 79), and Ronald J. Overman, who wrote that Copernicus "effected as little change as possible in the inherited explanation of gravity" (Overman (1974), p. 6).

[93] Dilwyn Knox has suggested that Copernicus drew from Cicero's *De natura deorum* and Pliny's *Naturalis Historia* (cf. Knox (2005), pp. 189-193; Knox (2012), pp. 130-135; Knox (2013), p. 73, nt. 1). Also, Knox has highlighted some interesting parallelisms between Copernicus's doctrine of natural motion and some passages from the *Sudae Lexicon*, which in turn can be associated with Philoponus's doctrine held in his commentary on the *De anima* (cf. Knox (2005), pp. 205-208, and Knox (2013), pp. 100-105). Furthermore, Knox has compared Copernicus's doctrine of natural motion with some observations by Ficino, in order to show that it is unlikely that the former drew from the latter (cf. Knox (1999), pp. 357-359; Knox (2002), pp. 412-418; Knox (2005), pp. 200-204; Knox (2013), pp. 94-98). As for Copernicus and Plutarch, cf. Krafft (1975), pp. 69-72, De Pace (1998), pp. 331-351, De Pace (2009), pp. 166-177, 196-203, and now De Pace (2020), pp. 302-308. Matiaž Vesel just notices that Copernicus's understanding of *gravitas* is Platonic, regardless of the precise sources from which it was drawn (cf. Vesel (2014), pp. 195-205). André Goddu, although he agrees that Copernicus's view on *gravitas* is similar to that of Plutarch, he is also keen to accept Aleksander Birkenmajer's point of view. At the same time, Goddu seems to welcome Knox's suggestions, especially that concerning the *Suda* (cf. Goddu (2010), pp. 345-352). Last but not least, I would like to mention another interesting suggestion by Knox. The latter has wisely leveraged on the historiographical category of 'Renaissance humanism' in order to avoid the pitfalls of a dichotomic understanding (Aristotelian/Platonic) of Copernicus's doctrine of *gravitas* (cf. Knox (2005), pp. 210-211; Knox (2013), pp. 109-110).

[94] On this point, I partially agree with Michel-Pierre Lerner's opinion, although his judgment is perhaps too harsh. After having argued that Copernicus's natural philosophical doctrine is grounded in astronomical reasonings, Lerner adds: "Dès lors, on peut se demander si les modifications dans le champ de la physique terrestre que Copernic énonce comme conséquences du postulat géocinétique doivent *conceptuellement* quelque chose aux doctrines philosophique non orthodoxes du point de vue aristotélicien qu'il a connues, ou qu'il aurait pu connaître. L'interrogation est la suivant: la plupart des fragments de textes qu'exhument avec force érudition les adeptes d'une *Quellenforschung* appliquée de façon systématique à Copernic peuvent-ils être tenus pour des sources indispensables à la formulation de sa pensée 'philosophique'?" (Copernicus (2015), I, pp. 269-270, original emphasis).

order. Nothing prevents us from assuming that Copernicus grounded his peculiar understanding of *gravitas* on this alternative and nonetheless *traditional* basis. I call it 'traditional' because it was certainly part of a mainstream culture that was essentially eclectic, for it included Aristotelian as well as Platonic elements that circulated together, sometimes irretrievably merging into each other.

The fact that Copernicus draws from such a tradition does not make his use of *gravitas* less groundbreaking. For the first time, indeed, *gravitas* is used to *physically* (not only *hypothetically*) legitimize the heliocentric cosmology. In this light, the clash between continuity and break in the history of science appears to be eminently ideological and therefore flawed. As a matter of fact, the two things, the continuity of a certain element of the tradition and the 'revolution' of that very same tradition, may well go hand in hand. Because of this, apart from pointing out the decisive source from which Copernicus supposedly drew his idea of *gravitas*, perhaps it would be more useful for us to get better acquainted with a wide range of sources that were commonly available at his time. Notwithstanding the great deal of effort and painstaking work carried out by Copernican scholars, it is however surprising that they have hitherto neglected Simplicius's commentary on the fourth book of the *De caelo*, and Augustine's suggestive thoughts on *pondus*.

The *De revolutionibus* is important in our study because it reframes already-existing views on *gravitas* within a more or less consistent doctrine, which is paired with a challenging cosmological view. In a single and well-known Renaissance book, we find the idea that each part of each whole (planets and stars) is subject to *gravitas*, and that there are many different centers of *gravitas* in the universe, all of them ultimately established by God.

IX.
GALILEO'S GEOCENTRIC COSMOGONY

§40.
INTRODUCTION TO THE *DE MOTU ANTIQUIORA*.
REDEFINING 'HEAVY' AND 'LIGHT'

In Galileo's work, the intertwinement between *gravitas* and cosmogony comes to the surface for the first time in a series of writings usually called *De motu antiquiora*, namely, early writings on motion.[1] They can be divided into four parts: (1) a dialogue between two characters named Dominicus and Alexander; (2) a treatise that develops on the same themes discussed in the dialogue; (3) two revisions of the treatise; (4) a series of short memoranda.[2] The debate about the relative chronology of these parts is still open, although the majority of Galileo scholars – and I, too – agree that the dialogue was written before the treatise, which appears to be a more advanced reworking of the dialogue, both conceptually and terminologically.[3] Concerning the treatise itself, there is unanimous agreement as to which of the three versions was written first.[4]

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[1] The original title of these unpublished writings is unknown, given that the manuscript's original cover is lost. Antonio Favaro entitled them "*De motu*" and included them in the first volume of the National Edition (cf. OG, I, pp. 243-419). The title "*De motu antiquiora*" is however mentioned by Viviani's description of Ms. Gal. 71: "un manoscritto del Galileo in più quinternetti in ottavo intitolato fuori sulla coperta *De Motu antiquiora*, il quale si riconosce essere de' primi giovenili studj di Lui, e per i quali nondimeno si vede, che fin da quel tempo non sapev'egli accomodare 'l libero intelletto suo all'obbligato filosofare comune delle Scuole" (Viviani (1674), pp. 104-105). Raymond Fredette has conducted the most thorough and careful study on the *De motu antiquiora*. Concerning the title, he suggested that the original title most likely was *De motu antiquiora scripta mea* (cf. Fredette (1969), p. 370, nt. 172; Fredette (1972), pp. 321-348, in particular p. 327). For a detailed study of Ms. Gal. 71, see Camerota (1992).

[2] (1) = OG, I, pp. 367-408; (2) = OG, I, pp. 251-340; (3) = OG, I, pp. 341-343, and 344-366; (4) = OG, I, pp. 409-419.

[3] There are at least four different opinions about the relative chronology of the *De motu antiquiora*. In short, Favaro, Wolwhill, and Olschki argued that Galileo wrote the treatise, then he revised it twice, and finally he wrote the dialogue. Drake, instead, believed that the dialogue was written first, followed by the supposed revisions of the treatise, and then by the treatise itself. Hooper held that Galileo wrote the supposed revisions, then the dialogue, and eventually he wrote the treatise. However, Drabkin, Fredette, and Giusti had shown with convincing arguments that Galileo first wrote the dialogue, then the treatise, which was followed by the two revisions. For a general overview on this debate, see Wallace (1990), Giusti (1998), pp. 427-442, and Fredette (2001), pp. 170-173. The most careful study on the relative chronology of the *De motu antiquiora* is undoubtedly Giusti (1998).

[4] The treatise is divided into twenty-three chapters (usually abbreviated as E23). According to Fredette, the treatise can be further divided into two parts: the first one includes the first thirteen chapters; the second one includes the resting ten chapters (Drabkin had not made this further distinction (cf. Galilei (1960),

As for the memoranda, from my point of view they provide the most interesting insights to the *De motu antiquiora*. Some of them are working notes that Galileo writes down in preparation of some chapter of the treatise; some others are just personal opinions about his own work. But even in the latter case, they can tell us something useful about the *De motu antiquiora*. For instance, Galileo seems to be taken by despair when he writes that

> There will be many who, after they have read my writings, will turn their mind, not to consider whether the things I have said are true, but only to seek in what way, whether rightly or wrongly, they could undermine my opinions [*rationes meas*].[5]

This genuine outburst of anger and discomfort has been seen as the proof that the *De motu antiquiora*, most likely in their treatise version, were initially meant for publication.[6] Yet something must have made Galileo change his mind, because he decided to keep his early treatise on motion in his personal folder.

In order to explain this withdrawal, scholars have offered different and valid reasons, which are generally based on the following argument: in the *De motu antiquiora* Galileo attempts to replace the Aristotelian physics of motion with a new one based on Archimedean hydrostatics; thus, the abandonment of the project displayed in the *De motu antiquiora* has to do, in some way or another, with Galileo realizing that an Archimedean physics is after all unsuited to explaining all natural phenomena.[7]

pp.3-131)). There are two revisions of the treatise: the first one, which concerns only the first two chapters (E2); the second one, which is a rewriting of the first ten chapters (E10). For the purposes of the present work, I do not think it necessary to resort to so a precise annotation, such as E23, E2, and E10. When I will need to refer to the different relative chronology of the treatise, I will simply talk of the first, second or third version of the treatise.

[5] "Erunt multi qui, postquam mea scripta legerint, non ad contemplandum utrum vera sint quae dixerim, mentem convertent, sed solum ad disquirendum quomodo, vel iure vel iniuria, rationes meas labefactare possent" (OG, I, p. 412). The English version of the *De motu antiquiora* is always taken from Fredette's translation, available online at https://echo.mpiwg-berlin.mpg.de/ECHOdocuView?url=%2Fpermanent%2Farchimedes%2Fgalil_demot_094_en_2000&tocMode=thumbs&viewLayer=dict (last accessed on October 2020). In some of the next citations, I have slightly modified Fredette's translation.

[6] Cf. Fredette (1972), pp. 321 and ff. See also Fredette (2001), p. 169, where Fredette writes that the memorandum I have quoted "may be read as implying an intention to publish." Fredette's considerations in this regard has been positively welcomed by Paolo Galluzzi (cf. Galluzzi (1979a), pp. 167-168) and Jürgen Renn (cf. Renn (1992), p. 130).

[7] Supposedly, the mismatch between theory (especially the theory of acceleration) and experimental results convinced Galileo to abandon the *De motu antiquiora* (cf. Drake (1978), p. 30; Galluzzi (1979a), pp. 188, 193; Fredette (2001), p. 177. For a general overview on the subject, cf. Guerrini (2011), pp. 102-109, 217 ff., and Salvia (2017), pp. 134-140.

I find no objections to this general argument. I think, however, that there can also be other *complementary* reasons to explain why Galileo did not publish the *De motu antiquiora*. For instance, when Galileo writes the memorandum quoted above, he probably does not know that Giovanni Battista Benedetti had already written and published works that, in their attempt to replace Aristotle's physics through Archimedes, are very similar to the *De motu antiquiora*.[8] Otherwise, Galileo would not call his opinions "*rationes meas*," with no reference to other thinkers such as Benedetti, in a passage that is clearly not meant for publication.[9] As is known, when Galileo found out that Luca Valerio had written a treatise on the center of gravity of solid figures, he decided to hold back the publication of his own treatise on the same subject.[10] It

[8] As is well-known, Alexandre Koyré claimed that Galileo read Benedetti's work before writing his *De motu antiquiora*. However, according to Koyré, Galileo was more "empiricist" and more "Archimedean" than Benedetti was (cf. Koyré (1966), p. 16, nt. 3, pp. 47 and ff.). John L. Heilbron seems to have welcomed Koyré's suggestion (cf. Heilbron (2010), p. 6). More recently, Renn and Damerow have suggested that Galileo knew, through Guidobaldo del Monte, Bendetti's theories when he wrote the *De motu antiquiora*. Yet, in order not to upset his mentor Guidobaldo, who did not agree with Benedetti's view on mechanics, Galileo decided not to mention Benedetti in his own writings (cf. Renn-Damerow (2012), pp. 10, 144-155). Furthermore, Renn and Damerow have pointed out that recent researches (cf. Menchetti (2012)) show that Galileo and Guidobaldo probably met in Tuscany at about 1589. Renn and Damerow further suggested that Galileo and Guidobaldo met together with Jacopo Mazzoni, who, in his *De comparatione*, mentions Benedetti (cf. Mazzoni (1597), p. 190). The three of them, then, "may have discussed Benedetti's *Diversarum speculationum… liber* with the consequence that Galileo reconsidered his work in progress on motion and, in particular, his treatment of motion along inclined planes." Also, thanks to Benedetti, "Galileo may now have taken the Copernican hypothesis much more seriously than before, discussing this as well as other subjects with Mazzoni" (Renn-Damerow (2012), p. 155). Renn's and Damerow's hypotheses are interesting and very well grounded. However, Mazzoni published the *De comparatione* in 1597, and we do not know when, between 1589 and 1597, he became acquainted with Benedetti's work. Also, it must be noted that, according to Renn and Damerow, Benedetti influenced Galileo's composition of the treatise version of the *De motu antiquiora*. The dialogue was therefore written when Galileo had not yet read Benedetti. If that is true, then we have that the basics of the Archimedean theory of motion included in the dialogue and maintained in the treatise were developed by Galileo in complete autonomy from Benedetti. Furthermore, Renn's and Damerow's reconstruction does not account for the memorandum quoted above, nor does it explain why in the first version of the treatise Galileo says that Aristotle "assumes that the speed in one medium is related to the speed in another, as the subtlety of one medium to the subtlety in the other: *this no one up to now has dared to deny*" (OG, I, p. 284: "Ponit enim [Aristoteles], ita se habere velocitatem in uno medio ad velocitatem in alio, sicut subtilitas unius medii ad subtilitatem in altero: *hanc nullus hucusque negare ausus est*" (my emphasis)). If I am not mistaken, Benedetti had already attempted to deny that (cf. Benedetti (1585), pp. 175-180). Why did Galileo ignore a criticism made by Benedetti that has nothing to do with the 'equilibrium controversy,' and that therefore could not discontent Guidobaldo?

[9] I am not the only one who claims that Galileo might have not known Benedetti while writing the *De motu antiquiora*. Raymond Fredette, who has devoted careful studies to the whole *De motu antiquiroa*, is convinced that "Galileo had never even read Benedetti" (cf. Fredette (2001), pp. 179-181). Fredette also leaned on Enrico Giusti's study of Benedetti's *De motu*, at the end of which the Italian scholar says that "l'influenza di Benedetti su Galileo è tutta da provare" (cf. Giusti (1997), pp. 93-96). Other scholars had in the past problematized the link between Galileo and Benedetti (cf. Drabkin (1962) and Grant (1965), Galluzzi (1979a), p. 178, nt. 94).

[10] Cf. OG, VIII, p. 313 (already mentioned *supra*, §2).

may be that something alike happened with the *De motu antiquiora*, after Galileo became acquainted with Benedetti's work.

Another memorandum is particularly interesting for our study of the *De motu antiquiora*. It is the transcription of a passage from Ermolao Barbaro's translation into Latin of Themistius's paraphrasis of the *Physics*. This passage is transcribed and used by Galileo as a reminder for the composition of a chapter of the treatise:

> Themistius, on the subject of text 74 of the *Physics* Book IV says: "It is thus that since the void yields uniformly, but in fact it does not yield in any way (as indeed it is nothing, very clever the man who can fancy the void yielding), thus the result is that the differences of heavy and light things [*differentiae gravium et levium*], that is, the *momenta* of things, are suppressed, and what follows is that the speed of all things that are moved comes to be equal and indiscriminate." So much for the words of Themistius: which are not only false, but in fact it is their contrary that is true; for it is only in the void that the *gravitates* show their difference precisely and naturally, and it is only there that the swiftnesses [*celeritates*] of their motions show their difference to the greatest extent. Thus, let a chapter be written, in which these things are demonstrated.[11]

Actually, in Ermolao Barbaro's edition, Themistius's opinion is linked with text seventy-five of the fourth book of the *Physics* (i.e., 216a20-26).[12] But Galileo is right to link it to text seventy-four (i.e., 216a12-20)[13]; this perhaps shows that Galileo had a direct knowledge of (certain passages of) Aristotle's *Physics* when he wrote the *De motu antiquiora*. However, his transcription, which is reported again in a chapter of the treatise, is interesting because it contains the term *momentum* used to denote a certain measure of *gravitas* or *levitas* when they are in motion.[14]

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[11] "Inquit Themistius, super t. 74, 4 Phys.: Cum vacuum itaque cedat aequaliter, sed neque cedat quidem (quum enim id nihil sit, subtilis hominis est putare vacuum cedere), ita fit ut differentiae gravium et levium, idest rerum momenta, tollantur, et, quod sequens est, omnibus quae moventur aequalis et indiscriminata velocitas accidat. Haec Themistius: quae quidem nedum falsa sunt, verum eorum contrarium verum est; in vacuo, enim, solum exacte et naturaliter differunt gravitates, et ibi solum maxime differunt motuum celeritates. Scribatur itaque caput, in quo haec demonstrentur" (OG, I, p. 412)

[12] Cf. Themistius (1570), p. 80, col. 2.

[13] "Haec vero ex eorum, quae feruntur, exuperantia. Videmus enim ea, quae ponderis, aut levitatis momentum maius obtinent, si, quod ad reliqua pertinet, figuris non differant, per aequale spacium celerius citari, idque ea proportione, quam magnitudines inter se habent: quare et per inane; quod fieri non potest. Quam enim ob causam celerius feruntur? in plenis enim necesse est, quandoquidem quod maius est, celerius dividit. Id namque quod fertur, aut proiectum est, aut figura dividitm aut moemnto, quod obtinet." This is Argyropoulos's translation, which I took from *Conimbricenses* (1602), p. 78.

[14] Cf. OG, I, p. 294. See also Galluzzi (1979a), pp. 99, 172, nt. 73.

We are already familiar with this meaning of *momentum*. It seems likely to me that Galileo was also acquainted with this use of *momentum*. Yet in the *De motu antiquiora* he never uses this term in such a sense.[15] His use of *momentum* is limited to the meaning of 'little portion of time.'[16] So, *momentum* is used to denote a certain measure, but only with reference to time, never to *gravitas* or *levitas*.[17] To my mind, this might have been done deliberately by Galileo because in the *De motu antiquiora* his understanding of *gravitas* does not fall within the Aristotelian act-potency framework.

As we have seen, *momentum* was used by natural philosophers such as Borro and Buonamici to denote the 'activity' of a capacity (*habitus*, *facultas*, *potenetia*, *potestas*, *vis*, *virtus*, etc.), that is, the exertion of a certain capacity for motion. The *momentum* of a clod of earth of a certain volume is greater than the *momentum* of a portion of water of the same volume. Their different *momentum* is the quantifiable exertion of qualitatively different *gravitates*. But in the *De motu antiquiora*, Galileo holds a monistic view of *gravitas*, that is, Galileo does not make qualitative differences between different species or kinds of *gravitates*. All bodies are more or less heavy, because they are all made of the same matter which is endowed with the same *gravitas*. Yet some bodies are denser than others. This means, for Galileo, that some bodies contain more matter, i.e., have more *gravitas*, than others have *in the same volume*. So, although one cannot say that a body is absolutely heavier than another one, for Galileo it is however possible to say that a body is always heavier than another when the comparison of their *gravitas* is with respect to equal volumes. Thus, two bodies can be said to be: (1) equally heavy, (2) one heavier than the other one, and (3) vice versa, provided that their volume is the same.[18] For us, readers of today, it seems that Galileo is talking about specific weight. However, I am convinced that using this notion to understand Galileo's *De motu antiquiora* may be a misleading shortcut.

In any case, an important conclusion can be gathered from what has been said: in the *De motu antiquiora*, Galileo does not need to use *momentum* to denote a certain measure of *gravitas*. In a monistic view of *gravitas*, where there is no qualitative difference between *gravitates*, all differences in *gravitas* are but quantitative. Even 'qualitative' differences between different kinds of material can be narrowed down to a different density, which is now understood as a certain proportion between amount of matter and volume. Most importantly, *gravitas* is no longer conceived of as a

[15] Cf. *ibid.*, pp. 153-197.
[16] Cf. OG, I, pp. 390-391 [= *dialogus*], 327 [= first version of the treatise].
[17] On this meaning of momentum, cf. Galluzzi (1979a), pp. 23-40.
[18] Cf. OG, I, pp. 251-252 [= first version of the treatise], 341 [= second version], 347-348 [= third version], 379 and 386 [= *dialogus*].

capacity for natural motion – *gravitas* is now the *motive force* that causes the natural motions of bodies.[19]

As already said, the Aristotelians used to describe *gravitas* as a *vis*, *virtus*, *potestas*, *facultas*, *habitus*… These were terms denoting a certain δύναμις, that is, an *inner* capacity that *enables* natural bodies to move along a certain direction. In this view, the *efficient causes* of natural motions are *external* to the body, and they were usually, albeit not always, individuated in the *generans* or the *removens prohibens*. Also, the Aristotelian controversies on *gravitas* and on the motion of the elements stemmed from a vacuum left by Aristotle, who did not give a precise definition of *gravitas*. This ambiguity, which was sometimes amplified in Latin translations, led Aristotelian thinkers to provide definitions of *gravitas* whereby to account for its ontological status, in order to understand its role in natural motion without exceeding the principle '*omne quod movetur ab alio movetur*.' So, although there were different ideas on *gravitas* and natural motion, those ideas equally fell into a theoretical framework that obliged Aristotelian thinkers to provide an ontological definition of *gravitas* consistent with the essential postulates of Aristotle's doctrine on natural motion.[20]

In the *De motu antiquiora*, there is a total absence of ontological subtleties concerning *gravitas*. Galileo assumes *gravitas* to be an intrinsic force (*virtus intrinseca*) that causes natural motion.[21] Thus, Galileo can neglect efficient causes of natural

[19] "Motus deorsum longe naturalior est motu sursum. Motus enim sursum omnino pendet a gravitate medii, quae mobili accidentalem levitatem tribuit: motus vero deorsum ab intrinseca mobilis gravitate fit. Nulla habita ratione medii, omnia movebuntur deorsum" (*ibid.*, pp. 413-414 [= memorandum]). But see also the first version of the treatise, where Galileo says that "in mobilibus etiam naturalibus, sicut et in ponderibus lancis, potest motuum omnium, tam sursum quam deorsum, causa reduci ad *solam* gravitatem" (*ibid.*, p. 259, my emphasis).

[20] Cf. Maier (1943), pp. 143-183, and Maier (1982), pp. 41-53. Maier shows that an important change occurred in the fourteenth century, when the accent was "shifted from the *generans*, which Aristotle took to be the real mover, first to the substantial form and then to gravity, In the process, the concept of motion caused by an external mover (*ab alio*) was gradually replaced by a concept of intrinsic motion (*ab intrinseco*)" (*ibid.*, p. 51). However, in the sixteenth century, the controversy on the efficient causes of motion was still an important one among the Aristotelians (cf. Helbing (1989), pp. 145-148, and Wallace (1984), pp. 173-178).

[21] One may say that Borro, too, conceived of *gravitas* as the internal mover of heavy elements (cf. *supra*, §37). This is true, but in order to do so, Borro had to show that *gravitas* is a substantial form, and that nature is more in the form than in matter. By so doing, Borro could conclude that there is a mover (the form) and a moved (matter). In short, he had to reinterpret the Aristotelian notion of *synolon* in order to square his (Averroist) view of elemental motion (cf. Helbing (1989), pp. 154-157). This kind of ontological argument is totally neglected by Galileo in the *De motu antiquiora*. This is a crucial departure from the Aristotelian tradition, including that taught at the Roman College. Furthermore, although Borro considered that the elements have an internal cause of motion, he was also convinced that all movements in the sublunary world are originally caused by a "universal cause," namely, the "*caelum*" (cf. Borro (1575), pp. 60-63: "A caelo enim, ut ab universali causa, reliqua omnia, dum naturam, et vitam ita motum etiam habent a natura fluentem: id quod textatus est Aristoteles libro primo de caelo, et mundo particula centesima. Caelum enim omnia continens, cuncta moderatur, et hanc elementorum universitatem *recta ratione*, ordine certo, et constanti constantia movet immutabili: est autem ipsius *certa ratio*, lex naturae, summa quippe vis

motion other than *gravitas*. *Gravitas* understood as a force is a feature of matter *qua* matter, and matter is the same for all bodies.[22] Quantity of matter is now the only criterion needed to measure and distinguish the *gravitas* of a body from the *gravitas* of another one. So, for Galileo there is no longer need to appeal to a different terminology, such as *gravitas* or *momentum*, in order to distinguish a certain *vis* or capacity from the activity of that same *vis*. For the same reason, Galileo does not need to resort to different theoretical categories, such as primary or secondary act. In sum, in the *De motu antiquiora* Galileo has not yet found a reason to exploit the term *momentum* with reference to *gravitas*, but he has some reasons *not* to use *momentum* after the fashion of the Aristotelians.

Before concluding, it may be interesting to examine two other memoranda:

> The definition of 'heavy' and 'light' through motion handed down by tradition is not a good one: for when a heavy or light thing is being moved, it is neither heavy nor light. For that thing is heavy which exerts weight [*gravat*] on something; but what exerts weight on something else is resisted by that thing; hence a heavy thing, when it exerts weight, is not moved: as is evident if you have a stone in hand, which then will exert weight when the hand resists its *gravitas*; but if it is moved downward with the stone, the stone will not then exert weight on the hand. Hence the definition will better be: That thing is heavier which remains under things that are lighter. For if we should say, 'heavy is what remains below, and light what remains above,' we would not be defining well, since above and below are not distinguished in nature, but only with respect to something [*cum sursum et deorsum non re, sed ratione tantum, distinguantur*].[23]

> We call local motion that [motion] in which the center of *gravitas* of the mobile is moved; hence we will not speak of the local motions of the celestial orbs

insita in elementis; cui naturae legi, ceu Imperatori cuidam, dum moventur, elementa parent…" (my emphasis)).

[22] "[E]very body has an internal cause of downward motion, namely its *gravitas* [*cum enim corpus omne internam motus deorusm causam, nempe gravitatem, habeat*]"; "There is a single matter of all bodies, and in all of them it is heavy [*Omnium corporum una est materia, eaque in omnibus gravis*]" (OG, I, pp. 361-362 [= third version of the treatise]).

[23] "Definitio gravium et levium per motum tradita non est bona: nam grave vel leve dum movetur, non est nec grave nec leve. Grave enim illud est quod super aliquid gravat; at ei quod super alio gravat, ab illo resistitur. quare grave dum gravat, non movetur: ut patet si habeas lapidem in manu, qui tunc gravabit quando manus illius gravitati resistet; verum si deorsum cum lapide moveatur, iam lapis in manu non gravabit. Melius ergo definietur: Gravius est quod sub levioribus manet. Nanque si diceremus, Grave est, quod deorsum manet, et leve quod sursum manet; non bene definiremus, cum sursum et deorsum non re, sed ratione tantum, distinguantur" (*ibid*., p. 413).

> since their center of *gravitas*, which is also their center of magnitude, always remains immobile.[24]

Both memoranda show that in the *De motu antiquiora* Galileo makes a special effort to provide a new understanding of heavy and light, along with a new understanding of local motion. As for the latter, Galileo appeals to the notion of *centrum gravitatis* to distinguish local motion from non-local motion. This is a significant departure from the Aristotelian tradition, and an interesting use in natural philosophy of a notion taken from Archimedes,[25] whose importance was already emphasized by Guidobaldo del Monte.[26] But, from another point of view, in that same memorandum Galileo abides by a tradition according to which the planets are embedded in celestial orbs or spheres.[27]

Galileo refers to the center of the orbs in terms of *magnitudo* and *gravitas*: the former denotes the geometrical center of a body, whereas the latter denotes the point of equilibrium of heavy bodies. There were discussions, even at Galileo's time, as to whether the center of *gravitas* of the Earth was also the center of its *magnitudo*.[28] Francesco Buonamici concluded, for instance, that, given that the physical differences preventing the Earth from being a perfect sphere are not appreciable, the center of its magnitude – which can be found out by mathematicians – is also the center of its weight (*pondus*) – which is the only one considered by natural philosophers.[29]

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[24] "Motum localem appelamus illum, in quo mobilis centrum gravitatis movetur: quare caelestium orbium motus locales non dicemus, cum eorum centrum gravitatis, quod magnitudinis etiam centrum est, immobile semper maneat" (*ibid.*, p. 416).

[25] As is known, Archimedes did not give a definition of center of gravity. However, many centuries after Archimedes, Pappus included a definition in the eighth book of his *Mathematical Collections*.

[26] Cf. Van Dyck (2006a), pp. 67-102, Van Dyck (2006b), Renn-Damerow (2012), pp. 102-104.

[27] For an account of the medieval and late-sixteenth century opinions on the nature of the celestial orbs, cf. Grant (1994), pp. 324-270.

[28] Cf. *ibid.*, pp. 622-624, and Grant (1984).

[29] "Hoc loco succurrit ut advertamus, medium sive centrum mundi simpliciter esse unum, medium vero terrae multiplex, aut enim medium magnitudinis, aut ponderis, illud quidem, unde eius extrema distant aequaliter, ut si terra ab omni sinsili qualitate sevocaretur eiusque solum quantitas spectaretur more mathematico; ponderis autem, unde ratio sumitur aequilibrij, ut in neutram scilicet partem superata agitetur, sed undique tantundem valeant omnes, e denique puntum auctore Pappo intrapositum, unde si grave cogitaretur appensum; si moveretur, inter movendum posituram eandem profecto servaret. Cum caeteroqui medium mundi sit tale virtute; quoniam finiat motus naturales corporum gravium: utrumne vero caeli ipsius posthac diceretur. Accidit autem, ut si quantitas sola terrae spectetur propter exuperantiam montium et terrae cavitatum, non sit idem utrunque medium, sed quoniam montes non efficiunt in tanta mole terrae, neque beneficio magnitudinis, neque ponderis aliquam differentiam sensilem [...]. Adhuc insensilis erit ad reliquam terrae magnitudinem illa exuperantia. Quid igitur efficient montium altitudines in tanta distantia. Quocirca quanvis medium hoc mathematice sumptum, non idem sit cum centro et medio ponderis: nihilominus apud physicum qui solummodo rerum sensilium habet rationem, idem accipi possit" (Buonamici (1591), pp. 457d-458e). On Buonamici's reference to Pappus's definition of center of gravity, see Helbing (1989), pp. 201-202, and Helbing (2008), p. 192.

However, in the *De motu antiquiora* Galileo extends this kind of disquisitions to the case of the celestial spheres, because – unlike the Aristotelians - he endows the celestial spheres with *gravitas*. For this reason, after having defined local motion as the motion of the bodies' *centrum gravitatis*, Galileo can conclude that the motion of the 'heavens' is non-local. Since local motion is the main subject of the *De motu antiquiora*, perhaps it is not by chance that Galileo does never discuss planetary motion therein.

The first memorandum quoted above is also interesting, for it shows that the *De motu antiquiora* deal with the issues raised within the controversy on the motion of heavy and light bodies. Just as Borro and Buonamici, Galileo too believes that the understanding of local motion must rest on a correct understanding of what it means to be 'heavy' and 'light.' As we have seen in the previous chapter, Aristotle called 'heavy' and 'light' those bodies that have a certain capacity to move naturally downward or upward. Latter Aristotelians called that capacity *gravitas* or *levitas*. They also distinguished their primary act from their secondary act. Some of them, like Buonamici, went so far as to claim that only *gravitas* in secondary act, that is, while in motion (*dum movetur*), gives rise to weight. Because of this, the secondary act of *gravitas* was sometimes called *actus gravitandi* by other Aristotelians.[30]

In the light of this, it is possible to perceive the enormous philosophical distance that separates Galileo's standpoint from an Aristotelian understanding of 'heavy' and 'light,' and the effort he puts forth against the traditional view.[31] Galileo is indeed convinced that, while in motion (*dum movetur*), a body does not exert *gravitas* (*gravitat*), and while it exerts its *gravitas*, it does not move. Galileo does not need a dynamometer to demonstrate this. He thinks that his conclusion is shown by experience. Perhaps we can better understand his reasoning by making the classic (for us) example of a man that, while falling from a building, does not feel his own weight. However, from this Galileo does not conclude that the falling body does not have *gravitas*. As he claims throughout the *De motu antiquiora*, a falling body is always carried downward by an inner *gravitas* (*intrinseca gravitas*). His remark, then, is aimed at showing that nothing can be said to be heavy or light in absolute terms; hence, the need of a new definition of 'heavy' and 'light.' This is in line with what I believe to be the main objective of the *De motu antiquiora*: to find a stable set of operations whereby

[30] For some interesting expressions in this regard, cf. Malara (2020a) and the literature cited therein.

[31] Wallace noticed that some Jesuit thinkers of the Roman College argued that "the definitions of light and heavy that are given in terms of rest, that is, *standing above and below*, are to be preferred to those given in terms of motion, since *they better characterize the nature of the elements*, whose *perfection* consists more in rest than in motion" (Wallace (1984), p. 169, my emphasis). As we can see, the argument with which it is shown that the 'static' definition of heavy and light is to be preferred is different from that given by Galileo. First of all, Galileo does not appeal to ontological arguments. Also, he explicitly says that a definition grounded in the notions of 'above' and 'below' is ill-posed.

distinguishing 'heavy' from 'light' and delimiting the conditions in which *gravitas* can be used to explain local motion.

In what follows I shall attempt to show that, although in the *De motu antiquiora* the hydrostatic model provides Galileo with a criterion (i.e., the comparison of equal volumes) to distinguish 'heavy' from 'light,' his use of *gravitas* to account for local motion turns out to be inconsistent with certain postulates of the hydrostatic model.

§41.
GRAVITAS AND THE SCIENCE OF MOTION

As anticipated, in the *De motu antiquiora* Galileo departs from the Aristotelian doctrine of *gravitas* and *levitas*. He is convinced that all bodies are more or less heavy. The different *gravitates* of bodies can be determined quantitatively; thus, there is no need to appeal to distinctions based on the assumption that there are qualitatively different species of *gravitas*. To the arguments raised by Aristotelian natural philosophers, and by Aristotle himself, according to which a monistic theory of *gravitas* would imply absurdities such as a big amount of fire being heavier than a small quantity of earth, such that fire would fall downward more swiftly than earth, Galileo replies appealing to Archimedes and the notion of density. The latter is understood by Galileo as the ratio between quantity of matter and volume. The reason why, for example, a big quantity of fire does not fall is that fire is less dense than air; thus, fire is extruded upward by air. An enormous volume of fire is lifted upward by an equally enormous volume of air, for the latter contains more quantity of matter than the former; that is, air is always heavier than fire when their volume is the same.[32]

The idea of something lighter being extruded upward by something heavier cannot be found in Archimedes. Galileo is aware of this. He knows that this is an idea held by "ancient philosophers" (*antiqui*), namely, the Atomists. As he will say years later, Archimedes had never defined the meaning of *gravitas* and *levitas*, nor did he use the extrusion theory developed by the Atomists.[33] It is likely, then, that in the *De*

[32] Cf. OG, I, pp. 290-294 [= first version of the treatise], 386-387 [= *dialogus*].

[33] Cf. the *Discourse* on floating bodies (1612), where Galileo argues against Buonamici's criticism of Archimedes (on Buonamici's criticism, see Camerota-Helbing (2000a), pp. 358-363). According to Galileo, Buonamici had wrongly attributed to Archimedes the extrusion theory developed by the "ancients" and held by Democritus and Plato (cf. OG, IV, pp. 80, 84-85; reference to Democritus at p. 133). Galileo adds that, "avvegnaché Archimede né neghi né ammetta la leggerezza positiva, né pur ne tratti, onde molto meno si debbe inferire ch'egli abbia negato che ella possa esser cagione e principio del moto all'insù del fuoco o d'altri corpi leggieri…".

motu antiquiora the doctrine of Archimedes is already *consciously* integrated by Galileo with an atomist view on matter, and, therefore, on 'heavy' and 'light.'[34]

Armed with Archimedean hydrostatics and Atomism, Galileo is able to refute the objections raised by Aristotle and the Aristotelians against the monistic doctrine of *gravitas*. It must be noted that, although the Aristotelians would have never accepted the 'extrusive' role of the medium, they agreed that a body of a certain volume displaces an equal volume of medium. The well-known anecdote about Archimedes and the crown was indeed interpreted as a proof of the impenetrability of matter.[35]

Now, Galileo demands his reader to consider (*a*) the *gravitas* of a certain body having a certain volume, and (*b*) the *gravitas* of the volume of the medium displaced by that body. This may be understood as an appeal to specific weight. However, this assumption might lead us astray in our attempt to understand what Galileo means by *gravitas* in the *De motu antiquiora*. As already shown by Romano Gatto, *gravitas* is never used by Galileo to denote the specific weight of bodies.[36] On the contrary, it is mainly used to denote the (absolute) weight of bodies:

> The *gravitates* of unequal volumes of *equally heavy* bodies have to one another the ratio which the volumes have.[37]

By *equally heavy* (*aeque gravia*) Galileo denotes bodies that have the same specific weight; thus, *gravitas* here means what we call 'weight.'

This understanding of *gravitas* allows Galileo to expound natural motion by analogy with the balance. Granted that one has to consider equal volumes when

[34] The number of studies on Galileo's notion of matter in connection with Atomism is tremendous (for some examples, cf. Galluzzi (2011), p. 1, nt. 1). In this regard, I am convinced that Paolo Galluzzi is right in saying that Carla Rita Palmerino's essential considerations on the subject should be extended to include the *De motu antiquiora* (cf. *ibid.*, pp. 112-113, and Palmerino (2011)). Although the physics of the *De motu antiquiora* is undoubtedly Archimedean, I believe that Galileo could have never worked out a geometrical (i.e., Archimedean) treatment of physics without pairing hydrostatics with Democritus's take on heavy and light, which involves the extrusion theory.

[35] Cf. Helbing (1989), pp. 180-181.

[36] Cf. Galilei (2002), pp. XCI-C.

[37] "Gravitates inaequalium molium corporum *aeque gravium* eam inter se habent proportionem, quam ipsae moles" (OG, I, p. 348 [= third version], my emphasis). This sentence is presented as a "*lemma*" by Galileo, followed by its demonstration. In the first version of the treatise, Galileo says that "ea dicenda erunt inter se *aeque gravia*, quae, cum fuerint aequalia in mole, erunt etiam aequalia in gravitate" (*ibid.*, p. 251, my emphasis; see also pp. 264, 349-350). We can find the same definition in the *dialogus*: "ea dicuntur esse *aeque gravia*, quae, cum sint aequalis molis et in eodem medio, eiusdem erunt gravitatis" (*ibid.*, p. 378, my emphasis). Romano Gatto has rightly pointed out that "con le espressioni *aeque gravia*, *gravius*, *minus grave*, Galileo definisce inequivocabilmente corpi che hanno peso specifico uguale, ovvero peso specifico l'uno maggiore o minore dell'altro" (cf. Galilei (2002), p. XCIII).

comparing the weight of bodies and media, Galileo can explain the motion of heavy bodies by analogy with the motion of different weights on a two-arm balance. For instance, a certain volume of fire has less weight than an equal volume of air, therefore fire is lifted upward by air. This is similar to what happens when the lighter weight (*pondus*) on one arm of the balance is lifted up by the heavier weight on the other arm of the balance. Also, on a balance we can see that a body is heavier than another one because it exceeds in weight the other one. By analogy, a body is heavier than the medium because, considering two equal volumes, the body's weight exceeds that of the medium. Galileo singles out three cases: the difference between the weight of a body's volume and the weight of a medium's equal volume may result in an excess in weight of (*a*) the body, (*b*) the medium, or (*c*) none of them. In case (*a*), the body moves downward; in case (*b*), the body is lifted by the medium; in case (*c*), there is no movement at all. These three cases can also be elucidated by analogy with the balance.[38]

Furthermore, Galileo adds that there is a proportion between the *excess in weight* (*excessus gravitatis*) of a falling body and the velocity of fall of that body. As a result, only in void a body would fall at a velocity that is proportional to the *full extent* of its weight. In fact, in void there would be no weight at all to be subtracted to the weight of the falling body.[39]

Galileo scholars have already noticed that in the *De motu antiquiora* the velocity of fall in void is said to be proportional to (absolute) weight. Some of them have also underlined that this conclusion is at odds with another one held by Galileo in the *De motu antiquiora*; that is, in the same media and in void, bodies of the same kind but different in volume fall at equal velocity.[40] From this conclusion, it seems that for

[38] Cf. OG, I, pp. 257-260, 274-276 [= first version]. The analogy with the balance is dropped in the other two versions.

[39] "In pleno enim mobile movetur celeriter secundum excessum suae gravitatis super medii, per quod movetur, gravitatem; et ita in vacuo movebitur secundum excessum suae gravitatis super vacui gravitatem: quae cum nulla sit, erit excessus gravitatis mobilis super gravitatem vacui *tota ipsius mobilis gravitas*; quare celeriter movebitur secundum totam suam gravitatem" (OG, I, p. 281 [= first version of the treatise], my emphasis); "Dicebat enim [Aristoteles], gravia in pleno eam in suis motibus servare proportionem quam gravitates; in vacuo vero minime, sed omnia eodem tempore moveri. Sed, e contra, in vacuo servabunt proportiones suarum gravitatum, cum excessus super medium sint *totae gravitates mobilium*; in pleno, vero, hanc proportionem non servabunt, ut supra demonstratum est" (*ibid.*, p. 402 [= *dialogus*], my emphasis).

[40] "Dicimus ergo, mobilia eiusdem speciei (eiusdem autem speciei vocentur quae ex eadem materia, ut plumbo vel ligno etc., conflantur), quamvis mole differant, tamen eadem cum celeritate moveri, nec citius descendere maior lapis quam minor. [...] In vacuo demum eadem demonstrationem utentes quam in pleno posuimus, demonstrabimus, mobilia specie eadem, mole vero diversa, eadem celeritate moveri in vacuo" (*ibid.*, p. 263, 283-284 [= first version]); "Cum deinde velocitatum proportio inter haec collecta fuerint, haec eadem proportio servabitur inter mobilia eiusdem generis, quamvis deinde mole quantumvis differant: tanta enim cum velocitate descendit plumbi frustrum cuius gravitas sit 10 libras, quam plumbi frustrum cuius gravitas sit 100 libras. [...] [D]ico, eandem etiam in vacuo rationem habendam esse; nempe mobilia quae

Galileo the velocity of fall in a medium is proportional to the *excess in specific weight*. This is how almost all Galileo scholars usually explain the dynamics of the *De motu antiquiora*.[41] But, if this is Galileo's original reasoning, he should have concluded that in void the velocity of fall is proportional to specific weight, not to weight, as he also claims. What is, then, the reason of such an inconsistency?

First of all, it is important to remind that Galileo *cannot* work directly with specific weight, that is, the ratio of two non-homogeneous quantities, such as weight and volume. Euclid forbids such an operation.[42] Galileo is therefore obliged to find the mathematical constraints that allow him to use weight and volume. As already said, the criterion or 'rule' is provided by hydrostatics, and it consists in allowing *only* the comparison between the weights of bodies *equal in volume*. Galileo is indeed convinced that it is nonsensical to compare the weight of bodies *different in volume*, for they displace a different weight of the same medium. And this would jeopardize the study of the proportion between the velocity of bodies that differ in weight. In fact, the weight of the medium is the term of comparison without which the comparison between bodies that differ in weight does not make any sense. Hence, if the term of comparison is different, it would be impossible to compare the velocities of bodies that have different weight, as there would be no proportion between them.[43]

But if one considers equal volumes, then it is possible to say that, in the same medium *m*, the velocity of fall of *a* is to the velocity of fall of *b* (where *a* and *b* are bodies of different kind) as the *excess in weight* of *a* over *m* is to the *excess in weight* of

fuerint eiusdem materiae, licet inaequalia magnitudine, eadem ferri celeritate: quod eodem prorsus modo, quod in pleno, demonstrabitur" (*ibid.*, pp. 403, 404 [= *dialogus*]).

[41] As far as I know, only Pierre Souffrin and Maarten Van Dyck have rejected this view. Souffrin did it cursorily (cf. Souffrin (2012), p. 316); whereas Van Dyck has provided well-grounded arguments (cf. Van Dyck (2006a), pp. 199-204). As I shall soon argue, I believe that Van Dyck is right, and that in the *De motu antiquiora* "Galileo is undeniably reasoning with the *actual volumes* of the moving bodies, and measuring the force by the difference in (absolute) weight for *these* volume" (*ibid.*, p. 201, emphasis in the original text used to underline that in the *De motu antiquiora* Galileo does not conceive of specific weight as weight per *unit* volume).

[42] Cf. Giusti (1992), and Napolitani (1998), pp. 190-196.

[43] This is spelled out in clear terms in the *dialogus* (cf. OG, I, p. 403). I report here only the English version: "Let there be, for example, a mobile [*a*] whose *gravitas* [in air] is 8; and let the *gravitas* of an amount of water equal in volume to the said mobile be 3; then it is manifest, from the things that have been said, that the swiftness [in water] of the said mobile will be as 5: but if you take another mobile, such as *c*, whose volume were twice that of *a*, and whose *gravitas* [in air] were less than twice the gravitas of *a*, namely 12, and the *gravitas* of an amount of water equal in volume to *c* were 6, then the swiftness [in water] of *c* would be as 6. However, it must not be said that *c* will go down faster than *a*; *because then the ratio would no longer hold good, since the mobiles differ in volume* [*quia tunc non valeret proportio, cum mobilia differant in mole*]. But *if we want the ratio to hold good* [*si volumus ut ratio valeat*], let us take half of *c*, so that its volume is equal to the volume of *a* […]. Hence it is evident that when we reason on the subject of the swiftness or slowness of mobiles, it is necessary to have in mind those mobiles whose difference depends solely on *gravitas*, although they are equal in volume" (my emphasis).

b over *m*. In void, *m* is equal to zero; thus, the velocity of fall of *a* is to the velocity of fall of *b* as the *weight* of *a* is to the *weight* of *b*. This conclusion is consistent with a rule derived from the hydrostatic model, which is *consistently* applied to a situation where hydrostatic rules do not apply. Accordingly, the conclusion states that in void, *contrary* to what happens in a medium, velocity is proportional to the full weight of a body. It is the rule itself, let us call it the '*excess-in-weight* rule,' that enables Galileo to conceive of the plausibility of two different scenarios, as it were, hydrostatic (in a medium) and non-hydrostatic (in void).

There is another important rule used by Galileo. He shows that the weight of *a* is to the weight of 2*a* (where *a* and 2*a* are bodies of the same kind) as the weight of *m* is to the weight of 2*m*; that is, in bodies of the same kind, the proportion between weight and resistance (i.e., the weight of the medium) does not change as the volume changes.[44] Let us call this the '*weight-resistance* rule.' Armed with this rule, Galileo says that *equally heavy* bodies, that is, bodies of the same kind, fall at equal velocity in the same medium independently of their volume. This, too, is a conclusion (apparently) consistent with a rule derived from the hydrostatic model.[45] However, it is clear that, contrary to the *excess-in-weight* rule, this rule cannot be extended to a situation where hydrostatic rules do not apply. In fact, if *m* is equal to zero, this would mean that the weight of *a* is to the weight of 2*a* as zero is to zero. There is no proportion. Thus, even in this case, a rule inferred from the hydrostatic model would correctly suggest that void is an exception to the hydrostatic model. That is, void may exist, and motion in void is possible but it follows different rules. Contrary to what happens in a medium, it is plausible that in void the velocity of bodies is proportional to their full weight.

All this makes me believe that the inconsistency raised above is not given by the fact that Galileo derives the possibility of motion in void from rules suited to hydrostatics, that is, suited to situations that do not involve void. I do not think that the hydrostatic model should prevent Galileo from conceiving of motion in void; on the contrary, it opens to such a possibility on the basis of mathematical rules borrowed from Archimedes.[46] Because of this, the Archimedean hydrostatic model adopted by

[44] Cf. *ibid.*, p. 264 ("… ergo eandem habebit proportionem gravitas trabis et gravitatem aquae a se attollendae, quam gravitas parvi ligni ad gravitatem aquae a se attollendae; et eandem facilitate a magna trabe superabitur repugnantia multae aquae, qua a parvo ligno parvae aquae resistentia vincetur").

[45] I will soon point out why this conclusion is only *apparently* consistent.

[46] For a different view, cf. Galluzzi (1979a), p. 172, and nt. 73. According to Galluzzi, the hydrostatic model applied to natural motion "comportava una conseguenza assai importante, che Galileo si guarda bene dall'evidenziare: se i moti nell'acqua costituiscono un modello trasferibile ai moti in ogni altro tipo di mezzo, ciò significa che non si dà il vuoto." Monica Ugaglia has welcomed Galluzzi's considerations. According to Ugaglia, "il vuoto [è] un concetto esterno al modello idrostatico, mentre Galileo farà l'errore di estendere

thinkers such as Benedetti and Galileo cannot be compared, and is not an unwitting or naïve return, to the basic hydrostatic assumptions underlying Aristotle's doctrine of motion.[47] In the *De motu antiquiora*, the existence of void is not arbitrarily assumed; rather, it is derived from a mathematical hydrostatic model which makes void a plausible, although not surely existent, *limit case*.

Thus, the real inconsistency, as I believe, is that Galileo thinks it possible to apply the *weight-resistance* rule to a situation where there is no resistance at all, such as in void. In the *De motu antiquiora*, Galileo believes that non-isovolumetric bodies of the same kind fall with the same velocity in void, and he also believes that this can be demonstrated through the *weight-resistance* rule.[48] Given that this rule does not apply to bodies in void, Galileo is clearly led astray by an arbitrary conviction. Perhaps, he assumes that *equally heavy* bodies must always fall at *equal velocity*. (For him, I recall it, '*equally heavy*' are bodies of the same kind.) By definition, then, Galileo may have assumed that *equally heavy* bodies fall with the same velocity in void.

Another inconsistency is given by the fact that the *weight-resistance* rule provides a case in which it is possible to compare the weight of non-isovolumetric bodies placed in the same medium. It is the case of bodies of the same kind, or *equally heavy*, as Galileo would say. Since there is a proportion between the increase in volume and the increase in weight of bodies of the same kind, the same proportion is maintained with respect to the weight of the medium. For this reason, and in accord with the same premises assumed by Galileo,[49] it is possible to compare the weight of bodies of the same kind, even when their volume is not the same. In short, it is possible to apply the *excess-in-weight* rule notwithstanding the different volume of *equally heavy* bodies. Given that the weight of a is to the weight of $2a$ as the weight of m is to the weight of $2m$ (*weight-resistance* rule), then the velocity of fall of a is to the velocity of fall of $2a$, as the *excess in weight* of a over m is to the *excess in weight* of $2a$ over $2m$ (*excess-in-weight* rule). Thus, the velocity of $2a$ is twice the velocity of a. The result contradicts (again) the assumption that *equally heavy* bodies fall with the same velocity.[50] But now the contradiction does not concern a limit case; it concerns the very same hydrostatic underpinnings of Galileo's science of motion.

ad esso risultati ottenuti all'interno del modello, come ad esempio il confronto delle velocità di due corpi" (Ugaglia (2004), p. 222).

[47] I am referring to Ugaglia's thesis exposed in Ugaglia (2004) and Ugaglia (2015). Although I do not agree with Ugaglia, I think that her thesis and her analysis of Aristotle's doctrine of natural motion are very suggestive and deserve to be studied carefully.

[48] Cf. *supra*, nt. 40.

[49] Cf. *supra*, nt. 43.

[50] Cf. Van Dyck (2006a), pp. 203-204, and nt. 583.

In conclusion, in my view the inconsistency of a science of motion fashioned after Archimedean hydrostatics is that the set of operations (the mathematical rules) allowing a certain use of *gravitas* (weight) yield results that are at odds with the fundamental assumption drawn from the same hydrostatic model, namely, *equally heavy* bodies (i.e., bodies of the same kind) fall at equal velocity. After all, this assumption, although inspired by Archimedean hydrostatics,[51] is nothing but a revised version of the same general assumption underlying Aristotle's doctrine of natural motion.

§42.
STABILIZING *GRAVITAS*

In the *De motu antiquiora*, Galileo attempts to build a new science of motion pivoted around a monistic understanding of *gravitas*. His attempt is unsuccessful, in that it clashes with the assumption that *equally heavy* bodies fall at equal velocity. And yet, all is not lost.

First of all, thanks to Archimedean hydrostatics, Galileo can think of motion in void as possible, thus he does not regard the existence of void as absurd. Secondly, and more importantly, Galileo *stabilizes* the notion of *gravitas*, which is *no longer defined through motion and velocity*. In fact, given that bodies of the same kind but different in volume have a different *gravitas*, and granted – as Galileo believes – that bodies of the same kind fall at equal velocity, then velocity cannot be used to determine whether a body has more or less *gravitas* then another one of the same kind. Galileo suggests, then, an alternative method, which I have already cited[52] as evidence that by *gravitas* Galileo meant weight:

> The *gravitates* of unequal volumes of *equally heavy* bodies have to one another the ratio which the volumes have.

This "*lemma*" – which is demonstrated by Galileo immediately afterwards – establishes a proportion between *gravitas* and size or volume (*magnitudo*) in bodies of the same kind. Provided that a_1 and a_2 are bodies of the same kind, then

[51] According to Van Dyck, this assumption may be explained in connection with Galileo's experience with the hydrostatic balance: "It is the hydrostatic balance which had shown him that all bodies of the same material are equally affected by a medium. Moreover, […] the properties of bodies on a balance were closely linked with their 'speeds' on the balance. Galileo's argument in *De motu* should be seen as a *failed attempt to mimic the cogent reasoning behind the irrelevance of volume for a hydrostatic balance, with the results now translated to speeds*" (my emphasis).

[52] Cf. *supra*, nt. 37.

$$\textit{gravitas}_{a1} : \textit{gravitas}_{a2} = \text{volume}_{a1} : \text{volume}_{a2}$$

By so doing, Galileo is not only defining what '*equally heavy*' means; he is also tying the notion of *gravitas* to another precise quantity, namely, volume. Within a monistic view of *gravitas*, where matter can only be heavy, this means that *gravitas* is *directly* proportional to quantity of matter. Thus, Galileo *stabilizes* the meaning of *gravitas*, that is, he formalizes it by making it proportional to properties supposed to remain stable *in any possible condition*.[53]

And yet, in the *De motu antiquiora*, Galileo claims that there is a proportion between velocity and *gravitas* on different inclined planes – a proportion that he finds out by applying the model of the balance to the study of the inclined plane.[54] His conclusion, then, is that on different inclined planes, the same body has a different *gravitas* which gives rise to proportionally different velocities. But this conclusion is inconsistent with Galileo's idea that the *gravitas*, i.e., weight, of the same body is proportional to volume and quantity of matter.

It seems that in the *De motu antiquiora* Galileo does not make a clear-cut terminological distinction between, on the one hand, *gravitas* as an *internal* force directly proportional to quantity of matter, and, on the other hand, the *external* factors that affect *gravitas* in certain circumstances, e.g., on different inclined planes. Later, he would replace "*gravitas in plano*" with *momentum* (or *momento*, in vernacular), thereby avoiding terminological as well as conceptual ambiguity.[55]

[53] Obviously, the proportion between weight and volume in bodies of the same kind is known since antiquity. It is already present in the so-called *scientia de ponderibus* (cf. Clagett-Moody (1952), pp. 29, 43, *passim*). We can also find it in Aristotle and in later Aristotelian thinkers (cf. §38, nt. 89). However, we should not forget that for the Aristotelians a volume of air has weight *only in certain conditions*. In water, the same volume of air has lightness. Thus, the Aristotelians cannot tie weight to quantity of matter alone. As I said in §38 against the view held by Duhem, for Aristotle and the Aristotelians the notions of weight and mass are not at all indistinguishable from each other. According to them, a mass of water or air has weight only in certain circumstances, and a mass of fire is deprived of weight in any possible circumstance. If we think that all bodies of the sublunary world are compounds of simple elements, sometimes including fire, we can see how difficult it is to apply Duhem's claim to Aristotle and the Aristotelians. Yet, in my view, Duhem's claim can be perfectly applied to Galileo's view. Only within a monistic view of *gravitas*, linked with an atomist view of matter, weight and mass are interchangeable notions. And this, in my view, may also have important consequences in determining the approach to what Renn and Damerow have called 'challenging objects' (cf. Renn-Damerow (2012), *passim*).

[54] Cf. OG, I, pp. 296-302 [= treatise, first version]. Many scholars have written about Galileo's analysis of the inclined plane in the *De motu antiquiora*. For a general overview, and a peculiar (and in my view very interesting) position in that regard, cf. Souffrin (2012), pp. 211 and ff.

[55] Cf. Galluzzi (1979a), pp. 199 and ff.

Obviously, the ambiguity comes again to the surface when Galileo confronts with Aristotelian thinkers who are used to employ the same terminology to denote different concepts.[56] As shown in the previous chapter, some Aristotelians used *momentum* to denote a certain exertion (*functio* or *operatio*) of *gravitas*. According to them *gravitas* cannot change, but its activity, its secondary act, can be affected by external circumstances (e.g., by the medium).[57] So, some Aristotelians like Buonamici were already using, before Galileo, the term *momentum* to describe the efficacy of *gravitas* in certain circumstances. But, contrary to Galileo, for them *gravitas* did not mean weight. The latter was in fact fully identified with *momentum*. However, not all Aristotelians agreed on this conceptualization of weight. Perhaps, it was the interplay between qualitative and quantitative notions that prevented them to agree on how to formalize the notion of weight.

§43.
GRAVITAS AND COSMOGONY

In the *De motu antiquiora*, Galileo strives to redefine 'heavy' and 'light' independently of their motion. To this end, he resorts to the hydrostatic model provided by Archimedes and coupled with the extrusion theory of the Atomists. A body cannot be defined as absolutely heavier than another one. However, if the comparison is between bodies of the same volume, then it is possible to establish which one is heavier. The ratio between quantity of matter and volume, which Galileo calls density (*densitas*), is the criterion whereby understanding whether a body is heavier, less heavy, or equally heavy than another one.

As we can see, the definition of 'heavy' and 'light' provided by Galileo in the *De motu antiquiora* is not framed within a cosmological system. Although Galileo assumes it to be true by "experience" (*sensus*, *experientia*) that the Earth rests in the center of the world, he does not use this cosmological state of affair as a point of departure to distinguish what is heavy from what is light. Thus, having untied the definition of

[56] Cf. *ibid.*, pp. 238-246.

[57] Francesco Piccolomini puts it as follows: "dico gravitatem et levitatem esse duplicem, una internam et essentialem, altera *externam et adventitiam*. Prima per motum non variatur, nisi varietur temperamentum vel densitas. Altera variatur, et crescit per motum, quia corpus, quod per medium movetur, quo diutius movetur, eo magis agitatur corpus medium per quod movetur, et ob id magis a tergo impellitur: et *haec potius est impulsio, et actio gravitatis, quam proprie gravitas*: hanc gravitatem non reciperet corpus, si moveretur per inane, quia per medium a tergo non impelleretur" (Piccolomini (1600), p. 183r, my emphasis). As I have already said (cf. *supra*, §38, nt. 88), Arturo D'Elci drew from Piccolomini to write his reply to Galileo's discourse on floating bodies.

'heavy' and 'light' from a cosmological view, Galileo can now raise an important question, which is repeated in every version of the *De motu antiquiora*:[58]

Dialogus OG, I, p. 374	*Treatise I* OG, I, p. 252	*Treatise II* OG, I, p. 342	*Treatise III* OG, I, p. 344
AL. – Supponatur itaque, primo, sic a natura constitutum esse, ut graviora sub levioribus maneant: quod quidem ita esse, *sensui* **manifestissimum est**. DO. – Hoc quod supponis, **verissimum quidem esse** ***sensu*** **depraehendimus**; sed causam **cur** talem ordinem servaverit natura, et non potius conversum, intelligere vellem.	Gravium itaque loca esse illa quae mundi centro magis accedunt, levium vero quae magis distant, ***sensu*** **quidem quotidie intuemur**; quare talia determinata loca illis a natura praescripta esse, non est quod dubitemus: sed in dubio quidem revocari potest, **cur** talem ordinem in distribuendis locis prudens natura servaverit, non autem praeposterum.	… gravium loca ea esse quae magis centro accedunt, levium vero quae magis distant, ***sensu*** **quidem quotidie intuemur**; quare talia determinata loca illis a natura praescripta esse, non est quod dubitemus: verum in dubium revocari potest, **cur** talem ordinem in distribuendis locis, non autem praeposterum, prudens natura servaverit.	In hunc, itaque, ordinem a natura distributa fuisse corpora, ut, scilicet, quae graviora essent, centro propinquiora manerent, **continua nobis declarat** ***experientia***: verum in dubium revocari potest **cur** talem ordinem in distribuendis locis, non autem praeposterum, prudens natura servaverit.

To the question 'why do heavy bodies rest near the center of the world?', Aristotle would have replied that it is because of their natural movement toward and their natural rest in the center of the world. In short, Aristotle assumes *by definition* that heavy

[58] The emphasis is always mine. *Dialogus*: "AL. - Let it, then, be presupposed, in the first place, that it has been established by nature that heavier things remain under lighter ones: that this in fact is the case is **very manifest** ***to the senses***. DO. - **We grasp** ***by our senses*** **that this thing which you presuppose is very true**; but I would like to understand the cause **why** nature would preserve such an order, and not the contrary instead." Treatise I: "Every day **we observe** ***with our senses*** that the places of heavy things are those that come near the center of the world, and that places of light things are those that are farther distant from it; consequently, that such determined places were prescribed for them by nature is not something that we may doubt; but it can be called into question, on the other hand, **why** prudent nature has observed such an arrangement, and not the opposite one." Treatise II: "… the places of heavy things are those that come nearer the center, while the places of light things are those that are more at a distance from it, **as we observe every day** ***with our senses***; consequently, that such determined places were prescribed for them by nature is not something that we may doubt: but it can be called into question **why** prudent nature has observed such an arrangement, and not the opposite one, in its distribution of places." Treatise III: "And so, that bodies were distributed in this arrangement by nature, that is, in such a way that those which were heavier remained nearer the center, **constant** ***experience*** **declares to us**: but it can be called into question **why** prudent nature has observed such an arrangement, and not the opposite one, in its distribution of places."

bodies rest near the center of the world.[59] As we have seen, it was this assumption that prevented natural philosophers from elaborating a cosmogony. They reasoned more or less as follows: provided that 'heavy' is the body that moves naturally toward the center of the world, there cannot be a body moving naturally (or the opposite of naturally) without there being already a center of the world. If motion involves the existence of a certain order of the world, there cannot be a passage or change (i.e., movement *lato sensu*) from disorder to order without there being already an order; hence, cosmogony is nonsensical.

Galileo certainly knew that this kind of argument was used by Aristotle and his followers, like Borro and Buonamici, to discredit the opinion of those, like the Atomists and Plato, who endorsed a monistic view of *gravitas*. In the *De motu antiquiora*, Galileo's aim is to defend such a monistic view. Perhaps, he seeks to defend it also by showing that thanks to it one can understand reason why (the *ratio*) in nature heavy bodies are placed near the center of the world. There is no need to assume it *by definition*. Also, once the *ratio* has been understood, one is also allowed to imagine how God and nature arranged the world according to that *ratio*. In light of this, cosmogony acquires a scientific status: its narrative can now rest on a rational understanding of the *ratio* underlying the order of nature.

Galileo says that usually "philosophers" takes the order of nature to be the result of the wish of Providence. For this reason, they believe it is useless to try to understand why heavy bodies have their natural place near the center of the world. Aristotle, continues Galileo, could only adduce a circular reasoning, as he did "in the *Physics*, book VIII, text 32 [255b15-17], when, asking why heavy and light things are moved toward their proper places, he supposes that the cause is because they are by nature suited to be carried somewhere, that is, the light upward, and the heavy downward." Galileo also reminds that Ptolemy, too, claimed that "it is futile to inquire about why heavy things are carried toward the center, after having demonstrated that the Earth, toward which they are carried, is in the center."[60] In sum, philosophers are content with a description of the world. Galileo, on the contrary, thinks that it is possible and crucial to understand *why* there is a certain order in nature.

[59] Galileo argues against these kinds of reasoning: "… Aristoteles, 8 Phys. 32, adferre videtur, dum, quaerens cur gravia et levia ad propria moveantur loca, subdit, causam esse quia habent a natura ut sint apta ferri aliquo, et hoc leve quidem sursum, grave autem deorsum. Ptolomaeus autem, in principio 7[i] capitis primi libri suae Magnae Constructionis, inquit frustra inquiri cur gravia ad medium ferantur; cum demonstrasset terram, ad quam feruntur, in medio esse. Verum haec difficultatem non tollunt: dato, enim, ferri ad medium quia ad terram ferantur, rursus, cur terra in medio non autem in loco ignis posita fuit, quaerimus" (OG, I, p. 342 [= second version of the treatise]; see also *ibid.*, p. 345 [= third version]). Aristotle's argument is repeated in every version, including the *dialogus* (cf. *ibid.*, pp. 374 nt. 2 [= *dialogus*], 252 [= first version of the treatise]).

[60] Cf. the previous note.

In the first version of the treatise, Galileo considers the "Ancient philosophers" as the only ones that, contrary to Aristotle's opinion, were able to understand what the *ratio* of nature is.[61] However, in the other two versions of the treatise Galileo drops the reference to the Atomists.[62] This may have happened for a reason. That reference does in fact clash with Galileo's own belief that the order of the world is not by chance, but by necessity.[63] According to Galileo, though it is difficult to understand why there is a certain order in the world, it is however possible to advance a plausible answer. The answer suggested by Galileo is certainly inspired by the Atomists, but his solution is not. Although Galileo's first cosmogony may recall some parts of Lucretius's narration of the *clinamen*, it departs from it in many respects, in fact.[64] As I shall show hereafter, the narrative elements included in the cosmogony of the *De motu antiquiora* are commonplaces, which makes it difficult for us to individuate their source – provided they have a source.

For now, I should like to shed some light on Galileo's original solution. In every version of the *De motu antiquiora*, he maintains three assumptions: (1) the world is spherical; (2) in a sphere whose space is divided concentrically, the more the space is near the center of the sphere, the narrower it is; (3) the same amount of matter is 'light' when placed in a wide space, 'heavy' when placed in a narrow space. From this, Galileo gathers *by association* that it is natural for heavy bodies to have their place near the center of the world, because spaces are narrower near the center of a sphere.[65] No wonder that Galileo did not consider the "cause" or *ratio* that he proposes to be "necessary," but only "appropriate and useful."[66] In the dialogue, he also says that, although that *ratio* is not of the highest sort (*ratio potissima*), it is however verisimilar (*habet veritatis speciem*).[67]

[61] "Cum enim, *ut antiquioribus philosophis placuit, una omnium corporum sit materia, et illa quidem graviora sint quae in angustiori spatio plures illius materiae particulas includerent*, ut iidem philosophi, immerito fortasse ab Aristotele 4 Caeli confutati, asserebant; *rationi profecto consentaneum fuit, ut quae in angustiori loco plus materiae concluderent, occuparent*" (OG, I, pp. 252, my emphasis).

[62] Wisan had already noticed it: "After the longer essay, revised versions of the two preliminary chapters drop the allusions to the ancient Atomists…" (Wisan (1986), p. 475). As for the *dialogus*, it must be noted that Galileo does never allude to the Atomists. At least, I could not find a clear and explicit stance in favor of the "ancient philosophers." Plato, too, is never mentioned by Galileo in the *dialogus*.

[63] "[S]i rem accuratius spectemus, non erit profecto existimandum, nullam tali distributione necessitatem aut utilitatem habuisse naturam, sed solum ad libitum et casu quodammodo operatam esse" (OG, I, p. 252 [= first version], repeated at pp. 342-343 [= second version], 344 [= third version]).

[64] Rendondi paired Galileo's cosmogony in the *De motu antiquiora* with Lucretius's (cf. Redondi (1998), pp. 176-177). However, Camerota has pointed out that the similarity between the two cosmogonies is extremely vague (cf. Camerota (2008), p. 148, nt. 21).

[65] Cf. OG, I, pp. 252-253 [= first version of the treatise], 343 [= second version], 345 [= third version], 374 [= *dialogus*].

[66] These expressions occur in every version of the treatise: cf. *ibid*., pp. 252, 343, 345.

[67] "Do. - Ratio ista, quamvis elementorum dispositionis existimanda non sit potissima, attamen nonnullam in se habet veritatis speciem, cui animus libenter adsentiur…" (*ibid*., p. 375).

At any rate, there is no doubt that in the *De motu antiquiora* Galileo feels himself allowed to account for the cosmological order of the world because his idea of *gravitas* is not *a priori* linked with a well-defined cosmological view. The linkage between *gravitas* and geocentric cosmology is provided by a certain kind of "experience," and this experience is accounted for through a sort of Archimedean *ratio* grounded in the three postulates listed above. So, Galileo does not assume that *gravitas* is by definition a tendency toward the center of the world. On the contrary, he attempts to explain why *gravitas* is that kind of tendency, and he does so by leveraging on a *ratio*, on a certain idea of order, that is *not* cosmologically oriented. That *ratio* is in fact based on considerations about space and matter which Galileo had initially ascribed to the Atomists. For this reason, Galileo can reintroduce cosmogony within the scientific discourse.

First of all, he can focus on the creation of the elements. As we have seen, Galileo claims that qualitative differences between elements can be narrowed down to a comparison between quantity of matter and volume. This means that there is a certain mathematical ratio behind natural differences. Starting from that ratio, Galileo can then deduce how nature created the elements. His stoichogony is interesting in that it contains a reconceptualization of the typically Aristotelian notion of *form*:

> [S]ince there is but one matter of all bodies, and those bodies are heavier that contain a greater number of particles of this matter in a narrower space, assuredly it was in accordance with reason that bodies that would maintain more matter in a narrower place, should also occupy narrower places, such as are those that come nearer the center. If, for example, we understand that nature, at the time of the original construction of the world, divided all the common matter of the elements into four parts, and then assigned to the *form* of earth its own matter, and in the same way to the *form* of air its own matter, and that the *form* of earth caused its matter to be concentrated in a very narrow place, and that the *form* of air caused its matter to be placed in a very wide place, was it not fitting that nature should assign to air a greater space, and to earth a lesser one? Now, in a sphere, places are narrower the nearer they are to the center, and they are more ample the more they are at a distance from it: hence, it is with both prudence and fairness that nature decreed that the place of earth was that which is narrower than the others, that is, near the center, and that for the remaining elements the places were more ample, the rarer was their matter.[68]

[68] OG, I, p. 345 [= third version], but repeated in every version of the treatise (cf. *ibid.*, pp. 343 [= second version], 253 [= first version]).

By "form," Galileo denotes the ratio between quantity of matter and volume.[69] This means that the term *forma* has been deprived of any kind of ontological connotation. Besides, the reconceptualization of *forma* provides another blatant instance – along with the reconceptualization of *gravitas* and *vis* or *virtus* – of Galileo's attempt to reform natural philosophy while keeping traditional terminology.

Galileo then clarifies that, although the entireties of elements are made of the same matter (*communis materia*), the quantity of matter ascribed to each of them is *not* necessarily the same. This is an important point for Galileo, because it allows him to criticize Aristotle's contrary opinion.[70] Accordingly, in the second and third version of the treatise Galileo does no longer speak of an original division of matter into four *equal* parts:

Version I OG, I, p. 253	*Version II* OG, I, p. 343	*Version III* OG, I, p. 345
Ut si, exempli gratia, intelligamus, naturam in prima mundi compagine totam elementorum communem materiam in quatuor *aequas* partes divisisse…	Ut si, exempli gratia, intelligamus, naturam in prima mundi compagine totam elementorum communem materiam in quatuor partes divisisse…	Ut si, exempli gratia, intelligamus, naturam in prima mundi compagine totam elementorum communem materiam in 4 partes divisisse…

This shows that Galileo's corrections of his stoichogony are not merely rhetorical, but respond to a precise standpoint in natural philosophy.

In my view, this also holds true for Galileo's first cosmogony, which appears in the last version of the *De motu antiquiora* treatise, when Galileo has all the conceptual tools he needs to think out a 'truthful history' of the origin of the world:

> After the marvelous assemblage of the most immense celestial sphere, the divine Creator, in order not to offend the eyes of the immortal and blessed spirits, forcefully drove away [*extrusit*] its excrements [*excrementa*] to the center of this very globe and hid them there: but, since its very dense and very heavy matter did not fill up by its size the ample and wide space left under the

[69] This was already noted by Maarten Van Dyck, who said that in Galileo's stoichogony 'form' has "taken on an entirely geometrical character" (cf. Van Dyck (2006a), p. 152, nt. 441).

[70] This criticism appears only in the third version of the treatise: "Ex his colligi potest, nullius esse momenti Aristotelis argumentum, quo probare contendit, elementorum materias inter se esse aequales…" (OG, I, p. 346)

> concave surface of the ultimate sphere, in order that this large space should not go unoccupied and be void, He tore apart that ponderous and confused mass [*onerosa indigestaque materia*], which, under the pressure of its *gravitas* [*pressa gravitate sui*], had confined itself within narrow limits; and from its innumerable particles, more or less rarefied, He formed those four bodies that we have later called the elements. Of these, what was heaviest and most dense remained as it had been before; He did not remove it from the place where it had previously taken refuge. Thus, earth was left in the center and, according to a similar disposition [*simili ratione*], the things that were denser were placed nearer to earth. And of the bodies which have been constituted from this matter, those were called denser which, being of the same size, contained a greater number of particles of this matter; and the denser were the heavier.[71]

Corrado Dollo wondered to what extent this narrative is rhetorical, and to what extent it is derived from a necessary deduction, instead.[72] Although I do not think that everything in this cosmogony results from a necessary deduction, it must be noted that even its most rhetorical parts are consistent with Galileo's view on 'heavy' and 'light,' on void, and on the *ratio* of nature.

It is not by chance that God creates the celestial sphere before anything else. Without the precise frame of reference provided by the sphere, *there would be no reason for heavy bodies to occupy certain regions of the world rather than others*. This is true because for Galileo, as I said, *gravitas* is not a tendency toward a certain place *by definition*. The cosmological state of affairs, in which *gravitas* inclines downward and 'downward' is defined as 'toward the center of the world,' is logically inferred by Galileo *after* having assumed by experience that the Earth is in the center of the world, and *after* having advanced an Archimedean, thus *decosmologized*, definition of 'heavier,' 'lighter,' and 'equally heavy.' As Maarten Van Dyck has neatly pointed out, this shows how Galileo

[71] "Vastissimae caelestis excrementa sphaerae, post illius mirabilem compaginem, divinus Opifex, ne forte immortalium beatorumque spirituum offenderent intuitum, in eiusdem globi centrum extrusit atque abscondidit: verum, cum satis amplum et capax sub ultimi concava superficie orbis relictum spacium densissima gravissimaque illa materia mole sua non expleret, ne magnum spacium otiosum atque vacuum esset, quae, pressa gravitate sui, onerosam illam indigestamque massam, in angustis se cancellis concluserat, distraxit; et ex illius innumeris particulis plus minusve rarefactis quatuor illa efformavit corpora, quae postea elementa diximus. Quorum quod gravissimum densissimumque, ut prius erat, remansit, e loco in quem antea confugerat non removit; et sic relicta est terra in centro: et, simili ratione, quae densiora fuerant, terrae viciniora constituta sunt. Eorum vero quae ex hac materia constituta sunt corpora, densiora illa dicta sunt quae, sub eadem mole, plures eiusdem materiae particulas coëgere; densiora, autem, graviora fuere" (*ibid.*, p. 344).

[72] "Non so quanto, in questo luogo, sia apparecchio oratorio e quanto risponda all'esigenza di una deduzione rigidamente necessaria" (Dollo (2003), p. 104).

> can *rethink* the Aristotelian cosmos from a fundamentally different perspective, rather than as doing justice to it. He retains some of its overall characteristics but fills it out completely anew from the inside by replacing qualitatively differentiated elements with homogeneously structured matter.[73]

When we put Galileo's first cosmogony within the context of the Pisan controversy on the motion of the elements, we can finally perceive its novelty. The natural philosopher is now authorized to speculate about the origin of the world, because the notion of *gravitas* has been freed from ontological as well as cosmological features. This means that a scientific cosmogony is not only possible, but even desirable. Through cosmogony the new science of motion receives a cosmological validation, and at the same time cosmology is scientifically validated, without this involving a circular reasoning. The latter can be avoided because the new science of motion is based on Archimedean assumptions which remain valid independently of the cosmological order.

Unlike Maurice Clavelin, I am convinced that in the *De motu antiquiora* Galileo does not (at least, he makes a lot of effort not to) provide an onto-cosmological definition of 'heavy' and 'light.'[74] In the *De motu antiquiora*, Galileo is not at all obliged by his definition of 'heavy' and 'light' to endorse geocentricism. On the other hand, Aristotle's physics is cosmologically oriented: heavy bodies move naturally toward the center of the world, light bodies move naturally away from it. Geocentric cosmological coordinates define what *gravitas* is, and thus they give rise to a certain doctrine of natural motion; at the same time, the doctrine of natural motion makes the geocentric cosmos (physically) real. In this view, mechanics and cosmology validate each other in a circular manner. Galileo breaks the circle, as it were. And he already breaks it in the *De motu antiquiora*. Sure, he assumes that the world is geocentric, but he does so on the basis of "senses" and "experience," and this experience is not justified through a tautological appeal to an aprioristic, ontological, and cosmologized, view of *gravitas*. Because of this, after having accepted the geocentric system, Galileo can try to

[73] Van Dyck (2006a), p. 110. An example may perhaps provide further evidence in this regard. Michele Camerota has found a passage in Buonamici's *De motu* that resembles Galileo's first cosmogony: "natura solertissima sedes angustissimas corporibus densis, nempe centro mundi apparavit; raris autem amplissimam circumferentiam nimirum concessit" (reported in Galluzzi (2011), p. 17, nt. 18). When this passage is put in its original context, it becomes evident that, contrary to Galileo, Buonamici *first* assumes that what makes a body denser (i.e., the *generans*) provides that body with a principle for motion toward the center of the world; *because of this*, he *then* says that in nature denser bodies stand near the center of the world: "Horum omnium caussa communis est generans, cuius consilium est transmutare substantiam, sed est alteratio, nisi mutatio substantiae perficiantur; secundum naturam vero generatio, ut cum ex aqua fit aër, quod ministratur auxilio caloris cuius officium est extendere, et quodammodo inflare, aut ubi ex adverso fit aqua ex aëre, id quod praestat frigus comprimens, *et cogens ad centrum*: *quapropter* natura solertissima sedes angustissimas corporibus densis, nempe centro mundi apparavit; raris autem amplissimam circumferentiam nimirum concessit" (Buonamici (1591), p. 720g-h, my emphasis).

[74] More on this later, §45.

understand *why* the world is geocentric, that is, why *gravitas* leads toward the center of the world. Galileo believes to have found the answer to a question that the Aristotelians did not even care to raise. For this reason, he can think of a cosmogony whose rationale represents the most evident *bridge* between an Archimedean science of motion and geocentric cosmology.

§44.
The Narrative Elements of Galileo's Geocentric Cosmogony

At least five important elements can be singled out from Galileo's first cosmogony: elements are made out the "excrements" (*excrementa*) of the celestial matter; the world has a spherical shape; God separates the excrements from the celestial sphere; there is no void in the world; the heaviest element remains "under the pressure of its own *gravitas*" (*pressa gravitate sui*) where it was initially driven by God, namely, in the center of the world. Since they are narrative elements, they are put within a narrative frame which gives them a temporal order:

1. God creates the spherical world;
2. God separates the celestial matter from elementary matter, i.e., the *excrementa*;
3. God uses the *excrementa* to create the elements;
4. in order not to be void, God makes the elements differ in density and occupy different regions of the world;
5. the matter of the heaviest (i.e., densest) element remains near the center of the world, where it was initially put after the separation from the celestial matter.

The Latin term *excrementum* indicates in general the matter that is left over after a process of separation, like the chaff, which is separated by winnowing or threshing. In this sense, Galileo's reference to the *excrementa* might remind us of Plato's famous winnowing-basket metaphor.[75] Yet, in the *Timaeus* the separation by winnowing is a metaphor for a mechanical process which is not overseen by the demiurge. Besides, in Timaeus's narrative, that separation, and the effective creation of the elements by the

[75] *Tim.*, 52d-53b: "And they, being thus moved, were perpetually being separated and carried in different directions; just as when things are shaken and winnowed by means of winnowing-baskets and other instruments for cleaning corn, the dense and heavy things go one way, while the rare and light are carried to another place and settle there" (English translation from Cornford (1937), p. 198).

demiurge, happen before the demiurge turns the world into a sphere.[76] This is an important difference with respect to Galileo's narrative. Contrary to Plato, Galileo believes that the matter of the celestial sphere differs from the one used by God to create the elements. Thus, the Latin word *excrementum*, though it does not denote an *ontological* difference, it does however point out an *axiological* difference between the matter of the celestial sphere and that of the elements.[77] Perhaps, it was customary to refer to this difference in the Renaissance – for instance, it was used by Giovanni Pico della Mirandola in his *Oratio de dignitate hominis*.[78]

Furthermore, Galileo tells us that the *excrementa* were thrown by God "under the concave surface of the *ultimate* sphere" (my emphasis). This means that the world is divided into different celestial spheres, and that by "the concave surface of the ultimate sphere" Galileo probably refers to the concave of the Moon's sphere. There is no doubt, then, that God had already created the planets and their planetary orbs before creating the elements. This shows that for Galileo – when he wrote the last version of the *De motu antiquiora* – the planets and their orbs are not made out of elements. This conclusion is not Platonic. And yet, it is not even fully Aristotelian. In fact, although orbs and planets are not made out of elements, they are however made out of a matter that, as such, is endowed with *gravitas*. Also, we must recall that for Galileo the elements are defined by a certain *form*, that is, a certain proportion between matter and volume. The fact that the celestial spheres are not made out of elements might just mean that their *form* is different. And, given that differences in *form* are nothing but different geometrical ratios between matter and volume, that conclusion does not amount to affirming the existence of an ontological difference between the celestial and the sublunary world.

Galileo's first cosmogony may resemble some aspects of Plato's cosmogony, but, as we have just seen, the two are substantially different. In this regard, I am convinced that the narrative elements used by Galileo were inspired by a commonplace account of God's creation related to *Genesis* 1:1-9, which was sometimes associated with Plato's cosmogony.

In Pererius's commentary to the *Genesis* – an important repertory of many different interpretations of the first book of the Bible – one can find exegeses bearing narrative elements similar to those used by Galileo in the *De motu antiquiora*. For

[76] Cf. *Tim.*, 32c-33b.

[77] This has also been noticed by Anna De Pace (cf. De Pace (2020), pp. XXX-XXXI), and by me (cf. Malara (2016), p. 91, nt. 124).

[78] "Iam summus Pater architectus Deus hanc quam videmus mundanam domum, divinitatis templum augustissimum, archanae legibus spientiae fabrefecerat. Supercelestem regionem mentibus decorarat; ethereos globos aeternis animi vegetarat; *excrementarias* ac feculentas inferioris mundi partes omnigena animalium turba complerat" (my emphasis).

instance, it is possible to find the idea that by "God created the heaven and the earth" Moses meant to say that God created the celestial vault along with a chaotic, confused, and unformed, matter.[79] This kind of matter remains in the center of the world because of its crassitude (*crassitudo*) and density (*densitas*).[80] In Pererius's commentary, one can also read that some exegetes thought that that matter was the one used by God to create the planets and the elements so as not to leave a void space between the celestial vault and the rest of the world.[81] Pererius knows that this kind of exegeses can be aligned, and they were usually aligned, with Plato's account of cosmogony in the *Timaeus*, and with the cosmogony of Chaos held by other ancient thinkers. Yet he rejects this interpretative tradition.[82]

According to Pererius, Ovid's cosmogony in the first chapter of the *Metamorphoses* falls within the exegetical tradition just outlined.[83] Ovid's description of cosmogony is interesting for us, because some of its narrative elements are very close to those used by Galileo in his first cosmogony. In Ovid, too, we read that in the beginning there is a raw and confused matter (*rudis indigestaque moles*) all over the universe (*in orbe*). The elements are sorted out by God and nature from that chaotic matter, and earth, which is denser (*densior*) than the other elements, gathers heavy bodies (*grandia traxit*) and "*pressa est gravitate sui*."[84] This expression is very close to the "*pressa gravitate sui*" used by Galileo in the *De motu antiquiora* to describe the "ponderous and confused mass" (*onersa indigestaque materia*) thrown in the center of the world by God.

As is known also thanks to Viviani, Galileo was a fine connoisseur of Virgil, Ovid, Horace, Seneca, among the Latins, and Petrarch, Berni, Ariosto, among Italian

[79] "Etenim sive intelligimus per coelum et terram (ut placet multis) corpus ipsum coeleste et elementare, sive (ut visum est aliis) materiam informem, et naturam Angelicam" (Pererius (1607), p. 37).

[80] "Beda vero, et quicumque lucem illam putarunt, fuisse nubem quandam longe lateque lucentem, ad similitudinem eius columnae, quae Hebraeis in deserto per quadraginta annos, interdiu nubis, noctu autem ignis speciem gerens, index et dux itineris fuit, censent eam nubem primo illo triduo circumactam fuisse ab Angelo circum rudem illam et indigestam massam terrae et aquae, vel ut aliis placet, *circa materiam corpoream informem, quae sua crassitudine et densitate medium mundi locum obsidens*, idonea erat ad opacandum et obumbrandum, ex quo facta est illius tridui noctium et dierum distinctio" (*ibid.*, p. 82, my emphasis; see also p. 61).

[81] "Nomine autem terrae censent significari a Mose materiam primam, [1] vel informem omnino, ut videtur sensisse beatus Augustinus, sicut paulo supra diximus, et ex scholasticis in secunda sent. Marsilius et Gabriel; [2] vel non quidem omnino informem, sed habentem tantummodo generalem quamdam formam corporis, velut *corpulentam quamdam massam, quae totum illud vacuum, quod est intra Coeli empyrei ambitum, occupabat et implebat*: et ab initio erat corpulenta quaedam massa rudis et indigesta, ex qua deinceps corpora omnia, tam coelestia, quam sublunaria composita conformata sunt" (*ibid.*, p. 50, my emphasis).

[82] Cf. *ibid.*, pp. 67-68, where Pererius concludes as follows: "Sed haec a nobis nunc obiter dicta, et raptim collecta, aliena a proposito minime sectantibus satis esse debent."

[83] Cf. *ibid.*, p. 67.

[84] Ovidius (1516), p. 4r.

authors.[85] It is not unlikely, then, that Galileo's first cosmogonic narrative echoes Ovid's *Metamorphoses*, perhaps indirectly. Galileo knew the *Metamorphoses* also through their vernacular version issued by Lodovico Dolce in 1553, which is enlisted among the volumes of Galileo's library.[86]

Lodovico Dolce's *Trasformationi* is the result of a long process of vernacularization, whose beginning can be dated back to the XII century. In that period, Ovid's *Metamorphoses* come again to light in Europe, and they gradually begin to be read after the fashion of Christian moral teachings. This phenomenon is known as the 'moralization of the *Metamorphoses*.' It takes hold in France in the XIV century with the publication of the *Ovide moralisé*, probably written by a Franciscan author, and the *Ovidius moralizatus*, written by the Benedictine Pierre Bersuire. In these works, the Pagan myths included in the *Metamorphoses* are re-interpreted to fit within a Christian moral scheme.[87]

In Italy, between 1322 and 1323, Giovanni del Virgilio collects – at the request of his students – a series of lectures on Ovid's *Metamorphoses* held by himself in the Studio of Bologna. On the basis of these lectures, between 1375 and 1377, Giovanni dei Bonsignori writes the first Italian vernacular version of the *Metamorphoses*, which is published in Venice in 1497. This version is important, because it is not a simple translation: as the French authors did, dei Bonsignori, too, re-interprets the Ovidian allegories so much so that the *Metamorphoses* become a sort of apology of the Christian faith. In 1522, Niccolò degli Agostini issues a new vernacular translation of the *Metamorphoses* which is entirely based on dei Bonsignori's translation, such that it even neglects the original Latin version. Following the literary fashion of his time, degli Agostini transposes the *Metamorphoses* in the octave verse, that is, the Ariosto style. Furthermore, degli Agostini is convinced that Ovid's cosmogony is the description of the creation of the world by "the true God" (*del vero Iddio*), just like Hesiod's cosmogony.[88] It seems, then, that the god described by Ovid in the *Metamorphoses* undergoes

[85] Cf. OG, XIX, p. 627.

[86] It is possible to consult the entries in Galileo's library on the MuseoGalileo website at the following link:https://www.museogalileo.it/it/biblioteca-e-istituto-di-ricerca/progetti/banche-dati-e-bibligrafie/863-biblioteca-di-galileo.html (last accessed on October 2020). See also Hall (2013), p. 27, 180-181, nt. 75. For some general information on Lodovico Dolce, and his role in the vernacularization of some works of Aristotle, cf. Bianchi (2009b), pp. 375-385.

[87] Cf. Capriotti (2013), pp. 21-22. On the medieval reception of the *Metamorphoses*, see also Wright (1999). Wright shows how some medieval thinkers tried to reconcile Ovid's cosmogony with the creation narrated in the Bible.

[88] Cf. Capriotti (2013), pp. 22-24. On the importance of the Ariosto-like verse in vernacular translations of Ovid's *Metamorphoses*, see Guthmüller (2006). Bodo Guthmüller has shown that translators aimed at "avvicinare Ovidio alle preferenze stilistiche del pubblico, alle sue nozioni, al suo desiderio di ritrovare nella letteratura il proprio, il moderno." So they tried to "assimilare le Metamorfosi nella struttura, nella lingua e nello stile alla grande opera di successo del tempo, l'Orlando Furioso" (*ibid.*, p. 158).

a full metamorphosis by the time of the late-Renaissance.[89] This can be seen in the images that illustrate the published books of the *Metamorphoses*, where the *deus fabricator* described by Ovid is represented through the classical iconography of the Christian God. Both the Christianizing and the Ariosto-like tendency are present in Lodovico Dolce's *Trasformationi*.

John Heilbron has written a beautiful biography which lays much emphasis on Galileo's humanism, on his refined taste in literature as well as in fine arts.[90] Perhaps, as a great estimator of Ariosto, Galileo purchased the vernacular version of Dolce, although the latter was heavily criticized at the time of its publication.[91] It may as well be that Galileo enjoyed the beautiful illustrations included in Dolce's book and made by Giovanni Antonio Rusconi, a disciple of Tartaglia.[92]

G. A. Rusconi, *The Creation of the World*, in Dolce (1553), p. 1.

At any rate, in Dolce's *Trasformationi* there is a narrative element which is not taken from the original *Metamorphoses*, and that is also in Galileo's first cosmogony. Galileo says that God rearranged the chaotic mass under the last concave surface of the celestial sphere "in order that this large space should not go unoccupied and be void" (*ne magnum spatium otiosum atque vacuum esset*). In Dolce's version of Ovid's *Metamorphoses* we read that God created the planets "so as not to leave any empty part" (*perche vota non restasse parte*).[93]

[89] Maarten Van Dyck has drawn my attention to the *Liber chronicarum* (first published in 1493), where Ovid is mentioned in the beginning of the book, during the explanation of the first verses of the *Genesis*.

[90] Cf. Heilbron (2010).

[91] Girolamo Ruscelli raised harsh criticisms against Dolce's translation. He wrote a list of many errors made by Dolce: "Et cominciando pur da i piu agevoli à conoscersi et schivarsi, et piu gravi et fanciulleschi à commettersi, dirò primieramente quei delle rime, poi quelli della lingua, poi quei delle parole Latine, non intese et ridicolosamente spiegate, et per ultimo alcune poche cose del soggetto in quelle poche coselle, che fuor della tela dell'Autor Latino v'havete poste di vostra pentola" (cf. Ruscelli (1553), p. 89).

[92] Cf. Capriotti (2013), pp. 31-33. Capriotti also tells us that probably Rusconi started working on his illustrations before reading Dolce's translation (cf. *ibid.*, pp. 30-31).

[93] Dolce (1553), p. 3, col. 2.

However, these and other possible similarities do not allow us to point at Dolce or Ovid as direct sources of the *De motu antiquiora* cosmogony. As I tried to show, the narrative elements of Ovid's cosmogony went through a long process of vernacularization, which culminated in the Renaissance and made them part of a customary repertory to describe God's creation of the world. Similar cosmogonic accounts can also be spotted in other works of the time, e.g., Alessandro Piccolomini's *Sphere*.[94] Or, as I have shown in chapter VII, in Girolamo Borro's *De motu gravium et levium* (§28).

In conclusion, I believe that Galileo's first cosmogony gathers a series of traditional narrative elements which are rearranged to be consistent with the scientific view held in the *De motu antiquiora*. God is not yet conceived of as a 'geometer,' because Galileo has not yet found out the "necessary," thus the fully mathematical, *ratio* of the natural order of the world. This gives room to Galileo's own literary flair and to narrative embellishments that represents God as an 'artist' who does not want "to offend the eyes of the immortal and blessed spirits" or leave any empty space.

§45.
OTHER INTERPRETATIONS OF *GRAVITAS*

As we have seen, in the *De motu antiquiora* Galileo exploits traditional terminology but in a new, untraditional, way. To be clear, I do not think that Galileo's reconceptualization of certain terms, such as *gravitas*, *forma*, *vis*, *virtus*, etc., is original. I do not exclude that other contemporary thinkers were revisiting traditional Aristotelian notions.

It is therefore important to notice a crucial and well-known fact: scientific terminology in the late Renaissance is idiosyncratic. Every single term included in late-Renaissance scientific explanations is to a certain degree polysemic. That is, its meaning should be expounded after a careful analysis of the context in which it is used.

Galileo is no exception to this general rule. Especially because he emphasizes that names are but names, and that his science is not a science of names or definitions.[95] What counts is the *referent* that a certain name stands for. Given that names

[94] "Dico per hora che la Terra è gravissima come quella ne la qual discese et si adunò ogni purgamento et ogni feccia degli altri elementi, et conseguentemente de tutto 'l Mondo: per[ci]ò che per natura le cose gravi hebbero impeto di andarsene al basso, verso il Centro del Mondo, sì come per il contrario le leggieri di discostarsene più che possano" (Piccolomini (1561), p. 5). This passage has been spotted by Michele Camerota and reported by Paolo Galluzzi (cf. Galluzzi (2011), p. 17, nt. 18; Galluzzi's reference to Francesco Piccolomini, instead of Alessandro, is clearly a lapsus).

[95] On this, cf. Altieri Biagi (1965), especially pp. 43-81. See also what Carla Rita Palmerino has masterfully written in Palmerino (2006), esp. pp. 34-42. Galileo is obviously not the first one to held such a view

are human conventions, but natural phenomena are not, one can account for the same natural phenomenon using different terms after having agreed on the meaning of those terms.

This way of thinking destabilizes Aristotelian natural philosophers any time Galileo confronts with them. In the controversy on the bodies that float on water, for instance, Galileo asks his adversaries to agree on the definition of *gravità*, *gravità in specie* and *momento*.[96] Only after agreeing on the meaning of these terms, one can possibly understand Galileo's scientific discourse. But the Aristotelians are not keen to accept his definitions. The meaning they associates with *gravitas*, *gravitas in specie*, and *momentum*, is not the one suggested by Galileo. So, according to the Aristotelians, Galileo was led astray by his incorrect use of scientific terminology. Because of this, their fight is often seen by Galileo as a battle for words: since they are too focused on defending a certain meaning of words, they cannot understand what Galileo has to say about natural phenomena.[97]

We must be careful not to make the same mistake as the Aristotelians did. The fact that Galileo uses ambiguous (or, to say it better, flexible) terminology in the *De motu antiquiora* should not prevent us from understanding the actual meaning of his arguments. Those arguments should be studied bearing in mind that identical names can have different *referents*, which must be determined contextually.

If my reading is correct, it seems that in the *De motu antiquiora* the meaning of *gravitas* as a *vis* or *virtus* can be contextually narrowed down to two notions: (1) *gravitas* is weight, that is, an *internal* motive force which is proportional to the amount of matter in a body; (2) *gravitas* is the force determined by *external* conditions and needed to overcome an opposite force (*resistentia*) preventing natural motion. From a conceptual point of view, these two notions will be maintained by Galileo in his later works. While reasoning on the second one, in the *De motu antiquoria* Galileo reaches a conclusion which he will also maintain throughout his life: on a horizontal plane,

on names and things. Out of curiosity, I report here an interesting passage by Augustine: "An forte putabimus ita dictum esse: Omnia in mensura, et numero, et pondere disposuisti, ac si diceretur: Omnia sic disposuisti, ut haberent mensuram, et numerum, et pondus? Quia et si diceretur: Omnia corpora in coloribus disposuisti; non hinc esset consequens ut ipsa Dei Sapientia, per quam facta sunt omnia, colores in se prius habuisse intellegeretur, in quibus faceret corpora: sed ita acciperetur: Omnia corpora in coloribus disposuisti, ac si diceretur: Omnia corpora sic disposuisti, ut haberent colores. Quasi vero a creatore Deo disposita in coloribus corpora, id est ita disposita ut colorata essent, possit aliter intellegi, nisi aliqua ratio colorum singulis corporum generibus distribuendorum in ipsa disponentis sapientia non defuisse intellegatur, etsi color ibi non appellatur. Hoc est enim quod dixi: *dum res conceditur non esse de vocabulis laborandum*" (*De Gen. ad. lit.*, IV, 5.11, my emphasis).

[96] Cf. OG, IV, pp. 67-68. The definition of *momento* is added in the second edition of the *Discourse* n floating bodies.

[97] Commenting on Arturo d'Elci's definition of "gravità e leggerezza," Galileo writes: "nota, inoltre, qual leggiadra conclusione si raccolga da *tutta questa gran lunga diceria*" (*ibid.*, p. 158, my emphasis).

that is, along a trajectory that is equidistant from the place toward which natural motion is directed, a body can be moved by any given force.[98] The problem, though, is that in the *De motu antiquiora* Galileo is not sure about what should happen when a marble sphere, whose center of gravity coincides with the center toward which natural motion is directed, is set into motion around its own center of gravity. Does its motion continue eternally, or not?

According to some scholars, Galileo's answer to this question shows that in the *De motu antiquiora* Galileo's notion of *gravitas* is cosmologically as well as ontologically determined. For instance, in the *dialogus* Galileo says that a marble sphere would perhaps continue moving eternally around the center of the world; however, "that eternity of motion seems far removed from the nature of earth itself [*ab ipsius terrae natura*], to which rest seems to be more pleasant than motion."[99] In the treatise, Galileo does not answer the question, but it seems to be clear that he struggles because he is still convinced that *gravitas* is by definition a tendency toward the center of the world, and a body endowed with it must by necessity move toward the center of the world.[100] In short, Galileo's science of motion is still based on a traditional notion of *gravitas* grounded in qualitative and ontological differences between bodies. The result is that Galileo needs to get rid of that notion in order to develop a fully geometric science of motion, that is, a physics that neglects qualitative differences and that can therefore have a universal validity. Apparently, Galileo could accomplish that result *only* by endorsing the Copernican notion of *gravitas*, that is, a notion that has lost any ontological as well as cosmological connotation. Thus, the development of Galileo's physics would have never been possible without a prior adherence to the Copernican doctrine of *gravitas*.

This is in a nutshell the thesis advanced by Maurice Clavelin.[101] Obviously, my summary detracts much from Clavelin's arguments in support of his thesis. However, I hope it is sufficient to show some of its flaws.

Above all, it must be noted that in the *De motu antiquiora* Galileo does not think of *gravitas* as a tendency that must restore a preestablished order of the world.[102]

[98] On this, cf. Festa-Roux (2006).

[99] OG, I, p. 373.

[100] Cf. *ibid.*, pp. 304-307 [= first version].

[101] Cf. Clavelin (2016), pp. 88-94 and *passim*.

[102] This is how Clavelin interprets Galileo's views on cosmology, cosmogony, and *gravitas* in the *De motu antiquiora*. Clavelin thinks that, in the *De motu antiquiora*, there is a strong "lien que les mouvements naturels continuent d'entretenir avec la vision cosmologique traditionnelle. Un passage remarquable du *de motu* ne laisse aucun doute à cet égard. 'Ce fut donc à la fois avec prévoyance et justice, écrit Galilée, que la nature assigna à la terre l'emplacement qui était trop étroit pour les autres éléments, c'est-à-dire le plus proche du centre, et qu'à ces dernier elle donna des emplacements plus vastes en proportion de la subtilité de leur nature [note that the original Latin text has '*materia*' instead of 'nature': cf. OG, I, p. 253].' C'est

As I have tried to show, Galileo seeks to provide an Archimedean definition of heavy and light which is not cosmologically oriented. The reason why Galileo believes that *gravitas* leads toward the center of the world is provided by "experience," which Galileo attempts to account for without resorting to an arbitrary or tautological definition of *gravitas* as a tendency toward the center of the world. So, in order to endorse the idea that *gravitas* does not necessarily lead toward the center of the world, Galileo first has to learn how to *experience* the world differently. But this cannot happen by endorsing another decosmologized notion of *gravitas*. Just to make an example, a different experiencing of the world may rest on physical reasonings which Galileo had not yet developed in the *De motu antiquiora*, such as the so-called 'Galilean invariance.' It seems likely to me that the latter did not stem *solely* from a prior acceptance of Copernicus's natural philosophy. During the period in which the *De motu antiquiora* were written, Galileo was in fact already aware of Copernicus's philosophical arguments in favor of heliocentrism.[103] There is no good reason to downplay this fact, which suggests to us that by the time Galileo wrote the *De motu antiquiora* he did not find it possible for the Copernican system to be in accord with our daily experience.

I do not mean to deny the extremely important role of Copernicus in the development of Galileo's natural philosophy. I do not agree, for instance, with the opinion advanced by Stillman Drake, who believed that Copernicus did not exert any philosophical influence on Galileo's science.[104] To my mind, there is no need to develop an *aut-aut* point of view on Galileo and Copernicus. Sophie Roux and Egidio Festa have rightly claimed that Galileo's science benefited from Copernicanism, though its most groundbreaking features were not brought about by Copernicanism:

> [C]'est dans le cadre du copernicianisme que Galilée a réuni des éléments lentement conquis; la réussite de la synthèse qu'il a proposée dans le *Dialogue* ne

donc dans une cadre bien défini où les éléments sont disposés concentriquement au centre du monde – les plus denses au plus près du centre, les moins denses vers la périphérie – que prennent toujours place les mouvements naturels des corps. Bien que caractérisés désormais à partir des poids spécifiques, et non plus des poids individuels, ils restent inséparables d'un ordre cosmologique préétabli que leur fonction est de maintenir ou de restaurer. Or, à travers cette fonction, il est aisé de reconnaître la conception du mouvement-processus qui n'est ainsi nullement affaiblie par cette première tentative galiléenne. La perspective traditionnelle a été aménagée; son idée séminale n'a pas été modifiée: toujours déterminé par l'ordre du monde et la nature des corps, le mouvement continue d'apparaître comme un phénomène transitoire se déroulant entre un *terminus a quo* et un *terminus ad quem*, et nullement comme un phénomène physique autonome, susceptible d'une étude théorique directe et également autonome" (Clavelin (2016), pp. 90-91). Clavelin assumes that, since for Galileo the *order* of the world is geocentric, then his cosmo*logy* is traditional. Thus, the French scholar believes that, in the *De motu antiquiora*, Galileo is still "prisonnier du cadre cosmologique traditionnel" (*ibid.*, p. 90, nt. 8).

[103] Cf. OG, I, p. 326.

[104] Cf. Drake (1987), pp. 95-97.

> doit pas conduire à juger rétroactivement que ces éléments s'appelaient nécessairement les uns les autres. L'articulation effective du P[rincipe de la] F[orce] M[inime], de la conservation du mouvement acquis et d'un engagement cosmologique au sens fort est décisive, mais pas pour autant primitive, dans le corpus galiléen.[105]

Thus, it is not my aim to understand whether Galileo's physical reasoning led him to engage with Copernicanism, or the other way around. It is undeniable, however, that when scholars assume it as a fact that Galileo's new science of motion has to do with a prior commitment to the Copernican system, and thus to the Copernican doctrine of *gravitas*, they are inclined to force the reading of certain passages of the *De motu antiquiora*.

For instance, when Galileo in the *dialogus* claims, via his spokesman Alexander, that a marble sphere perhaps (*fortasse*) does not move eternally around its center of gravity, though the latter is also the center of the world, he is certainly making a statement about the *nature* (*natura*) of the element earth, which *seems* (*videtur*) to be unsuitable to eternal motion. However, it must be noted that Alexander's claim is part of a wider argument concerning the two traditional categories of motion, that is, natural and violent motion. His reply is aimed at showing that, even from an Aristotelian standpoint, it is not true what Dominicus believes, namely that every circular motion is natural because it has no contrary.[106] Alexander shows that, in the case of a marble sphere rotating around the center of the world, it seems likely to believe that that motion would not be natural, *not even for the Aristotelians*, because *they think that circular motion is not natural to earth*; hence, since they also think that only natural motion can be eternal, it *seems* that the circular motion of a marble sphere cannot continue eternally. That being so, any earthy sphere moving around its axes, whether or not its center of gravity coincides with the center of the world, must be regarded as having a violent motion. But how, asks Alexander – and this is the original problem he raised –, can the circular and violent motion of a marble sphere around its axes be caused by the medium, as held by the Aristotelians? That motion is in fact caused by an external mover who "twists both ends of the axes with his fingertips" and does not move the medium around.[107]

[105] Festa-Roux (2006), p. 147.

[106] Cf. OG, I, pp. 372-373.

[107] "Demum, et hoc sit potissimum argumentum, intelligatur sph[a]era marmorea seu ferrea, exacte rotunda et expolita, quae super axe, duobus cardinibus inhaerente, moveri possint; deinde accedat motor, qui utrasque axium extremitates extremis digitis controqueat: tunc certe sphaera per longum temporis spacium girabit; et tamen nec aër a motore fuit commotus, nec potest unquam medium succedere in partes a mobili relictas, cum nunquam sphaera locum mutet. Quid ergo de hoc violento motu dicendum? a quo

So, Alexander can conclude that the example of the marble sphere does "knock down to its foundations" the Aristotelian standpoint:[108]

> And so from all the reasons adduced it seems quite clear that the medium, far from helping motion, rather, on the contrary, opposes it. And thus it must be concluded that the mobile, when it is moved by a motion against nature, is moved by a force impressed by a motor: but what that force is, is hidden from us.[109]

When Alexander makes this argument, he has not yet defined what 'heavy' and 'light' mean according to him.[110] He is only trying to refute the theory that the medium is the carrier of projectiles – and he is doing it by assuming, for now, the Aristotelian view of *gravitas*. But, when Dominicus wants to know about Alexander's own view on motion via *gravitas* and *levitas*, Alexander asks his friend to take it as a fact *proved by the senses* that "heavier things remain under lighter ones."[111] Starting from this, he then tries to explain why the center of the world is occupied by what is denser. That is, Alexander does never claim that the Earth rests in the center of the world because *gravitas* is by definition a tendency toward the center of the world. It is therefore risky to decontextualize Alexander's words on earth's nature, and then to derive from them a view according to which Galileo, in the *De motu antiquiora*, conceives of *gravitas* as a property ontologically and cosmologically determined.

It is even riskier to read the *De motu antiquiora* treatise in light of this view. In order to show that Galileo's idea of *gravitas* is still entangled with ontological

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movebitur sphaera, cum extra manus moventis fuerit? quid dicendum, nisi a virtute impressa moveri?" (*ibid.*, p. 372). At this point, Dominicus raises the problem that, according to the Aristotelians, circular motion is not violent, but natural.

[108] The expression quoted is taken from the first version of the treatise. To my knowledge, no one has noticed that Galileo uses the marble-sphere example of the *dialogus* also in the treatise, and for the same purpose: "Verum, ut altera opinio verissima innotescat, hanc prius Aristotelis funditus evertere conabimur; alteram vero de virtute impressa quoad licuerit, declarabimus et exemplis illustrabimus." One of the arguments against Aristotle's opinion is the following: "intelligatur sphaera marmorea exacte rotunda et expolita, quae super axe, duobus cardinibus inhaerente, moveri possit; deinde accedat motor, qui utrasque axis extremitates extremis digitis controrqueat. Tunc certe sphaera per longum tempus girabit: et tamen nec aër a motore fuit commotus; nec potest aër in sphaeram agere, illam impellendo, cum nunquam locum utet et, cum sit expolita, nullas habeat cavitates in quas possit aër irruere: quin aër penitus immotus circa sphaeram manebit; ut patet si lumen sphaerae appropinquetur, qui nec extinguetur nec movebitur" (*ibid.*, pp. 308-309).

[109] *Ibid.*, pp. 373-374.

[110] Alexander's view is explained along several pages of the *dialogus*: cf. *ibid.*, pp. 374-386.

[111] Cf. *ibid.*, p. 374.

subtleties, Maurice Clavelin has unconsciously altered the translation of an important passage from the treatise:

> Si en effect, écrit Galilée, [la sphère] n'est pas mue **contre *sa* nature**, il semble qu'elle devrait se mouvir perpétuallement; en revanche, si elle n'est pas mue **selon *sa* nature**, il semble qu'elle doive finalement revenir au repos.[112]

> Si enim non ***praeter naturam*** movetur, videtur quod perpetuo moveri deberet; sed si non ***secundum naturam***, videtur quod tandem quiescere debeat.[113]

The passage just quoted is not a statement. The presence of the Latin *videtur* is again an important element which suggests to us that Galileo is dealing with a conundrum. He is wondering whether the circular motion of a marble sphere around its center of gravity, which is also the center of the world, can be eternal: it *seems* that it can be eternal only if it is *non preater naturam*. In this regard, it must be noted that Galileo distinguishes between circular motion *non praeter naturam* and *non secundum naturam*. By so doing, he is considering the possibility of a circular motion that is *non praeter naturam* without necessarily being *secundum naturam*, or that is *non secundum naturam* without necessarily being *praeter naturam*. Before making this distinction, Galileo had already associated the expressions *secundum* and *praeter naturam* to his definition of natural and violent motion, which is the following:

> [A] motion is natural as long as the mobiles, in moving forward, come near their proper place; but it is forced as long as the mobiles, which are moved, recede from their proper place. Since these things are so, it if manifest that the sphere rotating around the center of the world is moved with a motion that is neither natural nor forced [*neque naturali neque violento motu moveri*].[114]

The problem, then, is to understand whether this "neutral" kind of motion can be said to be eternal.[115] That this problem has nothing to do with the nature of bodies, is clear for four reasons: (1) in the *De motu antiquiora* Galileo claims that all bodies are heavy because they are all made of the same matter; (2) Galileo claims that there is only one natural place for all bodies, that is, the center of the world, but the reason *why* the natural place of heavy bodies is the center of the world is not derived from ontological

[112] Clavelin (2016), p. 77, my emphasis.
[113] OG, I, p. 305, my emphasis.
[114] *Ibid.*, p. 304.
[115] On the notion of '*motus neuter*,' which does not originate with Galileo, but that Galileo however reconceptualizes, cf Camerota (1991). See also Helbing (1989), pp. 229-232,

or metaphysical reasonings about the nature of bodies; (3) had Galileo claimed that different motions respond to different natures, he should have ascribed a "neutral" nature to those bodies in the universe which revolve around the center of the world – but he does never make this claim; (4) the real problem with circular motion is that, in order to understand whether it is eternal or not, "one must first see by what things that are not moved naturally are moved." [116] This is in fact the real problem. So, even if Galileo is vague about the possibility of circular eternal motion, what has come down to us does not allow us to assume (as Clavelin did in his translation) that Galileo's answer would have rested on ontological or qualitative differences.

The thesis according to which the main obstacle that initially prevented Galileo from endorsing the Copernican view (and, therefore, from developing a fully geometric science of motion) was a certain idea of *gravitas*, has also been supported in a recent book by Anna De Pace.[117] The book is important and desirable, because for the first time it yields extensive and thorough insights on Galileo's reading and understanding of Copernicus. For this reason, it surely represents an unavoidable point of reference for any further study on the subject. It must be noted, though, that it is not De Pace's main objective to understand how and why Galileo first approached Copernicus's *De revolutionibus*. However, in the Introduction to the book she suggests a very interesting hypothesis in this regard.

According to De Pace, Galileo in the *De motu antiquiora* welcomes an interpretation of Plato's view on *gravitas* which was also held by his Pisan teachers, namely, Girolamo Borro, Francesco Buonamici, and Jacopo Mazzoni.[118] The latter was teaching in the University of Pisa when Galileo was a professor there. In a well-known letter to his father, dated 1590, Galileo says that he is studying with and learning from Mazzoni.[119] Jacopo Mazzoni has therefore an important role in Galileo's philosophical education. Furthermore, as it has been emphasized by Camerota and Helbing, Mazzoni was involved in the controversy on the motion of the elements, which happens to be the main subject of Galileo's *De motu antiquiora*.[120] If we have achieved a better grasp of mazzoni and his relation to Galileo, this is especially thanks to Anna De Pace.[121] And I am convinced that she is right in pointing out again, in her new book,

[116] "Ad secundum [quaesitum], quod supra quaerebatur, non est hic responsionis locus; videndum enim prius est, a quo moveantur quae non naturaliter moventur" (OG, I, p. 306).

[117] The book was published at the end of October 2020, and I have not had the time to read it in its entirety.

[118] Cf. De Pace (2020), pp. XXVII-XXVIII, XXXIII, nt. 115.

[119] Cf. OG, X, *Galileo to Vincenzio Galilei*, 15 November 1590, pp. 44-45.

[120] Cf. Camerota-Helbing (2000a), p. 328.

[121] De Pace has published many papers and book pertaining to Mazzoni: for instance, cf. De Pace (1992), De Pace (1993), pp. 261-336, De Pace (2006b), and the introduction to Mazzoni (2010). Other important

that Mazzoni provided Galileo with crucial philological tools that influenced Galileo's reading of philosophical texts.

De Pace claims that, following a common understanding of Plato's doctrine of *gravitas*, held also by Mazzoni, Galileo in the *De motu antiquiora* believes that all bodies are heavy: heavier bodies get closer to the center of the world; lighter bodies are extruded upward by heavier ones. In short, Galileo associates Plato's view with that of the Atomists.[122] However, some issues he deals with in the *De motu antiquiora* lead him to a reappraisal of Plato's doctrine of *gravitas*.[123] Galileo asks Mazzoni for clarification in this regard, and Mazzoni directs him toward Simplicius's reading of Plato in his commentary on the fourth book of the *De caelo*, which is more literal and therefore more reliable as regards the different views of Plato and Aristotle on *gravitas*.[124] Galileo follows Mazzoni's advice, and starts a thorough study of Simplicius's commentary on the *De caelo*, which he already knew.[125] Thanks to Simplicius, Galileo finds out that Plato has never agreed with the Atomists. On the contrary, Plato rejected their view on *gravitas*. He held another one, according to which *gravitas* is a like-for-like tendency that does not depend on the quantity of matter, and that does not imply a concentric disposition of the elements in the world. It is very likely, De Pace reasons, that after realizing this, Galileo may have also realized how to solve "the doubt that much had troubled him about the 'nature' of earth as unable to perpetuate the circular motion 'neither natural nor violent' triggered by an external force." Furthermore, Galileo probably thought it necessary to deepen his direct knowledge of the *Timaeus*. By so doing, he might have found out other aspects of Plato's doctrine which were neglected by ancient scholars, including Simplicius, and which convinced him that it was no longer necessary to think of *gravitas* as a unidirectional tendency toward the center of the world.[126] Thanks to this new and original philosophical awareness

works on Mazzoni have been written by Frederick Purnell (cf. Purnell (1971), and Purnell (1972)). I would like to thank Eva Del Soldato for providing me with a copy of Purnell's dissertation.

[122] Cf. De Pace (2020), p. XXVII.

[123] It would be impossible to recapitulate here De Pace's brief but very detailed expositions of those issues. Cf. *ibid.*, pp. XXVIII-XXXIII.

[124] De Pace says that the initial pages of Simplicius's commentary on the *De caelo*, book IV, were "raccomandate da Mazzoni per la loro capacità di illustrare con chiarezza le irriducibili divergenze tra le esposizioni *ad literam* di Aristotele e del *Timeo* sulla concezione della gravità" (*ibid.*, p. XXXIII).

[125] Cf. *ibid.*, p. XXV.

[126] "È sensato ritenere che Galileo, intuendo in tale nozione della gravità, indipendente dalla quantità di materia, la possibilità di rimuovere il dubbio che tanto lo aveva arrovellato sulla 'natura' della terra inadatta a perpetuare il moto circolare 'non naturale né violento' innescato da una forza esterna, sia andato al *Timeo*, e si sia reso conto di altri aspetti della dottrina platonica negati o taciuti anche da Simplicio: cioè che dalla riflessione sulla sfera omogenea dell'universo 'ovunque eguale a se stessa' e dalla teoria del simile che insegnava essere valida indipendentemente dal fatto che il simile occupi il centro o la periferia del mondo (cfr. *Tim*. 63e3-7) Platone aveva contemplato l'unificazione ontologica di tutti i corpi componenti l'universo e l'applicazione a essi delle stesse leggi, accreditando così l'interpretazione del moto circolare

about Plato, Galileo was now finally open to a favorable reception of Copernicus's natural philosophy and cosmology, given that, according to De Pace, Copernicus's doctrine is also extensively grounded in Platonic foundations.[127]

De Pace's hypothesis presents a beautiful fresco. Galileo is represented standing near Mazzoni, who points at Simplicius on the other side, while at the same time directing Galileo's glance toward Plato and Copernicus in the background. As beautiful as it may be, though, this fresco is perhaps painted on a cracked wall.

In order to put forth her hypothesis, De Pace has to pit Plato's original view of *gravitas* against that of the Atomists. She claims it is possible to find such a clash in Simplicius's commentary on the *De caelo*, though no one of Galileo's contemporaries (not even Mazzoni!) has ever noticed it. Starting from this strong assumption, De Pace is perhaps led astray in her translation of some passages from the Latin version of Simplicius's commentary:

Occorre rilevare che non furono solo stratone ed Epicuro a pensare che tutti i corpi sono gravi e si muovono per natura verso il basso, ma contro natura (*praeter naturam*) verso l'alto; anche Platone sa che era sostenuta ***tale teoria***, e ***la*** **mette in discussione** ritenendo che basso e alto non sono propriamente applicati al mondo, e rifiutando di accettare che le cose fossero chiamate gravi [solo] in virtù del loro moto verso il basso.[128]	Sciendum autem quod non solus Straton neque Epicurus dicebant omnia corpora esse gravia et natura quidem ad deorsum mota, praeter naturam autem ad sursum, sed et Plato novit ***motam ipsam*** **et arguit**, deorsum et sursum in mundo non bene dictum esse putans et gravia dici sic ut ad deorsum mota non acceptans.[129]
E Platone dice che tutti i gli elementi hanno gravità, ma non nel senso che tutti si muovono verso il centro [del mondo] e i più gravi stanno sotto e i meno gravi, essendo stati espulsi dai più gravi e galleggiando sopra di essi, sono perciò chiamati leggeri [chiaro riferimento alla teoria di Stratone ed Epicuro], ma nel senso che tutti hanno un movimento verso il proprio	Gravitatem autem omnia quidem elementa, ait, habere, non sic autem tanquam omnibus ad centrum motis et gravioribus quidem subsidentibus, minus autem gravibus expulsi et supernatantibus illis, et propter hoc dictis levibus, sed tanquam omnibus eam quidem quae ad proprium locum lationem propter

perenne del globo terrestre al centro sostenuta da non pochi esegeti tra i quali lo stesso Aristotele, e aprendo anche alla sua dislocazione fuori del centro, come suggeriva lo stesso Simplicio appellandosi a ragioni divine e naturali, e come aveva dimostrato Copernico" (*ibid.*, p. XXXV).

127 Cf. *ibid.*, pp. XXXV-XXXVI.

128 *Ibid.*, p. XXXIV, nt. 116.

129 Simplicius (2004a), p. 372.54-58.

luogo a causa della gravità. **Dice infatti** che il desiderio (*appetitus*) porta ciascuna cosa verso il proprio affine ma tale portarsi è a causa della gravità ***e anche l'esserne estromessa è a causa della medesima [gravità].***[130]	gravitatem habentibus. **Ducit enim appetitus unumquodque ad cognatum, deductio autem per gravitatem.**[131]

It must be noted that the original Greek of the first passage is corrupt. For this reason, Robert J. Hankinson has added δόξα in order to make sense of a sentence which he translated into English as follows: "… but Plato too knows *this opinion* is held, and disputes *it*…"[132] Whether or not Hankinson is right, it is evident that William of Moerbeke did not intervene on the text as Hankinson did. It seems, though, that De Pace consulted Hankinson's translation from the original Greek in choosing her translation from the Latin ("… anche Platone sa che era sostenuta *tale teoria*, e *la* mette in discussione…").[133] In the Latin version, Galileo can only read that Plato argues against those who improperly use 'downward' and 'upward' to describe motion according or against nature (*praeter naturam*), because 'downward' and 'upward' are terms relative to our perspective. It must be noted that Galileo is already aware of this in the *De motu antiquiora*, as he says that "sursum et deorsum non re, sed ratione tantum, distinguantur."[134] But this does not prevent him from endorsing the Atomists' view while *experiencing* that the Earth stands still in the center of the universe.

Concerning the second passage – that I have already examined in the previous chapter (§33-34) – De Pace adds a sentence (…"e anche l'esserne estromessa è a causa della medesima [gravità]") which seems to be aimed at showing that Plato reformulated the extrusion theory put forth by the Atomists and held by Galileo in the *De motu antiquiora*. However, as I have already shown, in that context *deductio* was understood by the Latin readers as meaning 'transportation' or 'motion' – certainly not "being pulled away" (*esserne estromessa*). This is evident, especially because a little bit further, anyone, including Galileo, could read that for Plato parts can be pulled away from their entireties only insofar as they are endowed with *levitas* – not with *gravitas*, as understood by De Pace.

We must note that, although Simplicius attempts to clarify Plato's position by distinguishing it from that of the Atomists, he does never say that the two views are

[130] De Pace (2020), p. XXXV.

[131] Simplicius (1563), p. 236 [mistakenly written as 238], coll. 1-2. Cited also *supra*, §34.

[132] Simplicius (2004b), p. 91, my emphasis. For Hankinson's intervention on the original text, see note 455 at p. 147.

[133] There is another occasion where De Pace seems to consult the original Greek of Simplicius's commentary on the *De caelo* or the English provided translation by Mueller. Cf. De Pace (2020), p. XXXV, nt. 124, where De Pace translates "*conditor*" into "creazione," which corresponds to the original δημιουργία and to Mueller's translation as "creation" (cf. *supra*, §33, nt. 33, and Simplicius (2009), p. 90).

[134] OG, I, p. 413 [= memorandum]; see also *supra*, nt. 23.

incompatible. Galileo himself, when he was already fully Copernican (in 1612), was convinced that Plato and the Atomists held the same view on *gravitas*:

> So, let the weapons of Sig. Buonamici be directed against *Plato and other ancients, who, since they totally denied levity and assumed that all bodies are heavy, said that upward movement is not produced by a principle intrinsic to the mobile, but only by the pressing action* [*schiacciamento*] *of the medium*; accordingly, Archimedes and his doctrine are unharmed, as Archimedes gives no reason to be contested. But if someone thinks that this excuse adduced to defend Archimedes is too weak to free him from the objections and arguments made by Aristotle against Plato and other ancients – as though the very same objections and arguments also militated against Archimedes and his alleged doctrine, according to which the solid bodies which are less heavy than water return to the surface of water because of the pressing action of water – *I would not doubt that it is possible to hold that the opinion of Plato and the others is true. They absolutely deny lightness, and claim that in the elementary bodies there is but an intrinsic principle of movement toward the center of the Earth. They also claim that there is no cause for upward movement (I mean that movement which seems to be natural) other than the pressing action of the fluid whose gravity exceeds that of the mobile…*[135]

It is clear that the Atomists' view on *gravitas* held by Galileo since the time of the *De motu antiquiora* has never obliged him to assume that heavy bodies move toward the center of the world. In the passage just quoted, Galileo can therefore align that theory with the idea that heavy bodies move toward the center of the Earth. Even during the composition of the *Discourse on floating bodies* (1612), Galileo thinks that it is reasonable to assume that "the natural order requires that the heavier elements are under the

[135] "Sieno dunque indirizzate l'armi del Sig. Buonamici contra *Platone e altri antichi, li quali, negando totalmente la levità e ponendo tutti li corpi esser gravi, dicevano il movimento all'insù esser fatto non da principio intrinseco del mobile, ma solamente dallo scacciamento del mezo*; e resti Archimede con la sua dottrina illeso, poi che egli non dà cagion d'essere impugnato. Ma quando questa scusa addotta in difesa d'Archimede paresse ad alcuno scarsa per liberarlo dalle obbiezioni e argomenti fatti da Aristotele contro a Platone e agli altri antichi, come che i medesimi militassero ancora contro ad Archimede adducente lo scacciamento dell'acqua come cagione del tornare a galla i solidi men gravi di lei, *io non diffiderei di poter sostener per verissima la sentenza di Platone e di quegli altri, li quali negano assolutamente la leggerezza, e affermano ne' corpi elementari non essere altro principio intrinseco di movimento se non verso il centro della Terra, né essere altra cagione del movimento all'insù (intendo di quello che ha sembianza di moto naturale) fuori che lo schiacciamento del mezo fluido ed eccedente la gravità del mobile…*" (OG, IV, p. 85, my emphasis). Unfortunately, because of the lockdown due to Covid-19, I could not visit any library, and therefore I could not consult the English translation of this passage by Thomas Salusbury. I apologize for my poor English translation. Hopefully, I will soon be able to replace it. I would like to notice here, out of curiosity, Galileo's consistency in using a warfare metaphor (*armi*, *impugnato*, *militassero…*), which I have tried (with very scarce results) to maintain in my translation.

less heavy, under which the heavier bodies would go if they are not hindered."[136] This "axiom," which comes directly from the *De motu antiquiora*, is not in principle at odds with the Copernican system, for it holds true regardless of cosmology. One thing is certain: when Galileo wrote these passages, he had already overcome the obstacles given by the "experience" that in the *De motu antiquiora* prevented him from endorsing the Copernican system.

To conclude, I think it is a pity that De Pace lays much emphasis only on the Platonic reasons that may have induced Galileo to endorse the Copernican system. Maybe because of that, she has neglected the following interesting passage from Galileo's reaction (published in 1615, and co-written by Benedetto Castelli) to Lodovico delle Colombe's writings on floating bodies:

> Now, if you want to receive good advice, given that you wish to understand Copernicus in order to be able to contradict him, I would suggest you to begin, first of all, by studying Euclid's *Elements*, starting from the definition of point; then, make sure you understand the *Sphere* and the *Teoriche* [i.e., the geometric model for the motions of each planet]. Once you have understood these things, then move on to Ptolemy's *Almagest*, and make as much effort you can to understand it well. Once you have understood it, apply yourself to the study of Copernicus's *De revolutionibus*. By succeeding in grasping this science, you would first clarify to yourself that the understanding of mathematics is not child's play, as you say in that writings of yours where you judge mathematics in light of the [poor] knowledge of it that you have now. But if you judge mathematics in light of the knowledge that Ptolemy and Copernicus had of it, and that you too would have after studying them, you would find out that mathematics deserves the study of a hundred-year old men. And the most marvelous thing would be that you would change opinion about Copernicus, and you would ascertain that, *once you have understood him, you cannot but agree with his opinion*.[137]

[136] "[L]'ordine naturale richiede che i corpi più gravi stiano sotto i men gravi, sotto i quali anderanno, non sendo impediti" (*ibid.*, p. 36).

[137] "Or se volete ricevere un buon consiglio, desiderando voi d'intendere 'l Copernico per potergli contradire, mettetevi a studiar prima gli Elementi d'Euclide, cominciando dalla definizion del punto; proccurate poi d'intendere la Sfera e le Teoriche; e intese queste, passate all'Almagesto di Tolommeo, e usate ogni studio per impossessarvene bene; e guadagnata questa cognizione, applicatevi al libro delle Revoluzioni del Copernico: e succedendovi il far acquisto di questa scienza, verrete prima a chiarirvi che la cognizion delle matematiche non è da fanciulli, come dite in quella scrittura, mentre l'andate misurdando con quella parte che ne possedete voi adesso; ma misurandola con quello che ne seppe Tolommeo e 'l Copernico, e che allora ne intenderete voi ancora, la troverete essere studio da uomini di cent'anni; e, quello che vi sarà più maraviglioso, cangerete opinione intorno al Copernico, e vi accerterete come *è impossibile l'intenderlo e non concorrer con la sua opinione*" (*ibid.*, p. 589, my emphasis). Again, I am really sorry for my poor English translation. Another interesting letter, writtne by Evangelista Torricelli, can shed light on the studies that made

It is worth noting that when Galileo wrote the *De motu antiquiora*, he had already studied Euclid, he had a good knowledge of the *Sphere*, and he was also working on a commentary on Ptolemy's *Almagest* (now lost) while probably reading Copernicus in parallel, the latter being also quoted in the *De motu antiquiora*.[138]

To conclude, I believe that there is a lack of evidence for claiming that Galileo's physics in the *De motu antiquiora* is held back by a notion of *gravitas* which is trapped in ontological and cosmological difficulties. As I tried to show, Galileo welcomes the geocentric view for reasons other than his definition of *gravitas*. It is because of "experience" that he believes that the Earth stands still in the center of the world. Relying on this experience, and given that *gravitas* is no longer by definition a tendency toward the center of the world, Galileo can attempt to understand *why* the world has a certain order and not another. Once he has understood the *ratio* underlying the natural disposition of the world, he can advance a cosmogony that responds to the same *ratio*.

Galileo's disciples (and probably Galileo himself) embrace the Copernican system: "Sono di professione matematico, ben che giovane, scolaro del Padre R.mo [Benedetto Castelli] di 6 anni, e duoi altri havevo prima studiato da me solo sotto la disciplina delli Padri Gesuiti. Son stato il primo che in casa del Padre Abbate, et anco in Roma, ho studiato minutissimamente e continuamente sino al presente giorno il libro di V. S. [the *Dialogue*], con quel gusto che ella si puoi imaginare che habbia havuto uno che, già havendo assai bene praticata tutta la geometria, Apollonio, Archimede, Teodosio, et che havendo studiato Tolomeo et visto quasi ogni cosa del Ticone, del Keplero e del Longomontano, *finalmente adheriva, sforzato dalle molte congruenze*, al Copernico, et era di professione e di setta galileista" (OG, XIV, p. 387, my emphasis).

[138] In the *De motu antiquiora* Galileo says that his commentaries "super Magnam Ptolomaei Constructionem [...] (Deo favente) brevi eduntur" (OG, I, p. 314 [= first version of the treatise]; see also Favaro's remark at p. 249). As for the reference to Copernicus, cf. *ibid*., p. 326.

X.
GALILEO'S HELIOCENTRIC COSMOGONY

§46.
GRAVITY, FREE FALL, AND COSMOGONY

By the end of the first decade of the seventeenth century, Galileo had perfectioned his science of motion. After the publication of the *Sidereus Nuncius* (1610), he also became publicly known for being a supporter of Copernicus. His new science of motion, the astounding telescopic discoveries, and the earned tutelage of the Grand Duke of Tuscany, made Galileo confident that favorable times were about to come for the Copernican system.[1]

Throughout all these changes in Galileo's life and work, cosmogony remained among the issues to which Galileo devoted his attention as a natural philosopher. As I shall attempt to show, this insistence on cosmogony shows that Galileo regarded cosmogony as a valuable means to universalize his science of motion and integrate it with heliocentric cosmology. The following passage from Galileo's annotations to Antonio Rocco's *Philosophical Exercises* (1633) is an often-neglected instance of Galileo's attempt to unify physics and cosmology:

> The parts of the Earth have a propension toward the center of the Earth, such that if the Earth changed place, its parts (although they were far from the [Earth's] globe while the latter had moved) would follow it everywhere. An example in this regard is provided by the perpetual following of the *Medicee* [*viz.* Jupiter's satellites], although they are continually separated from Jupiter. The same must be said of the Moon, which is obliged to follow the Earth. And this is enough for the simple-minded persons, who have a hard time understanding how these two globes – although they are not tied together with a chain or skewered in a pole – follow each other, so that when one accelerates or decelerates, the other one, too, accelerates and decelerates.[2]

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[1] On the development of Galileo's science of motion during the Paduan period, see the studies devoted to Ms. Gal. 72, e.g., Wisan (1974), Hooper (1992), Damerow et al. (2004), and Büttner (2019). For two different approaches to the study of Galileo's telescope and celestial discoveries, see Biagioli (2006), and Bucciantini-Camerota-Giudice (2012). Another essential study in this regard is Reeves (2008).

[2] "Le parti della Terra hanno tal propensione al centro di essa, che quando ella cangiasse luogo, le dette parti (benché lontane dal globo nel tempo della mutazione di esso) la seguirebbero per tutto: esempio di ciò sia il séguito perpetuo delle Medicee, ancor che separate continuamente da Giove. L'istesso si deve dir della

The "propension toward the center of the Earth" is an implicit reference to the Copernican notion of gravity, namely, an inclination of the parts toward their totality. Galileo's acceptance of Copernicus's idea of gravity is made explicit in some of the writings following the *Sidereus Nuncius*, such as, for example, the *Letter to Francesco Ingoli* (1624) and the *Dialogue*.[3] Although there is no explicit mention of gravity in the passage just quoted, we can nonetheless notice that, for Galileo, satellites *gravitate* around the planets thanks to the same natural inclination that makes heavy bodies fall. For this reason, satellites "follow" the planets although they are not connected to them through chains and poles.

When he wrote the passage above, Galileo had already developed the so-called theory of 'proto-inertia.' According to this theory, once a body is set into motion around the place toward which it would naturally move, its motion is everlasting unless it is forcedly stopped. Galileo has therefore finally solved the problem raised in the *De motu antiquiora*. Now, he feels free to claim that circular motion can be natural as well as perpetual. This view has important repercussions in astronomy. When proto-inertia is applied to the motion of satellites, for example, it allows Galileo to account for their circular motion without involving miracles, solid spheres, or animistic principles. Galileo need not resort to *ad hoc* forces to explain celestial physics. The circular motion of satellites does indeed mirror a situation inferred from studying the behavior of heavy bodies on Earth.

Proto-inertia is also used by Galileo to account for the planets' circular motion around the Sun, as it will become evident when I will consider Galileo's heliocentric cosmogony. But now, I should like to stress the originality of Galileo's use of Copernican gravity to solve a problem raised by Tycho Brahe in astronomy. To the Tychonian question concerning the planetary motion in the absence of solid orbs, Galileo can in fact now reply without giving credit to extravagant hypotheses. [4] This is an important point of departure from Copernicus's understanding of gravity. A departure

Luna, obbligata a seguir la Terra: il che serva per i semplici, che hanno retinenza di capire come questi 2 globi, non essendo legati insieme con una catena o infilzati 'n un'asta, si conseguitino l'un l'altro, sì che all'incitarsi o ritardarsi dell'uno, si acceleri o ritardi l'altro" (OG, VII, p. 544). Libero Sosio has used this passage to argue that Galileo had a "barlume del concetto di gravitazione" (cf. Galileo (1970), pp. LXV-LXVI).

[3] Cf. OG, VI, *Letter to Ingoli*, pp. 556-557, and OG, VII, *Dialogue*, pp. 57-58, 123, 270.

[4] Bucciantini has rightly emphasized the importance of Brahe's question in Galileo's attempt to integrate mechanics and heliocentric cosmology: "… per chi come Galileo si professava già allora copernicano, il tentativo di fondare una nuova concezione della gravità che spiegasse il moto dei pianeti dopo gli sconvolgimenti apportati dall'astronomo danese – a meno di fare ricorso a un principio interno di movimento (anima motrice) o ad altre soluzioni extrafisiche come l'infinita potenza di Dio – diventa una necessità impellente" (Bucciantini (2003), pp. XVII-XVIII; see also p. 299).

that can be also noticed with respect to terminology: unlike Copernicus, Galileo does never call gravity a "desire." It is likely that Galileo thinks that 'desire' is a far too animistic term. After all, he probably knew Simplicius' interpretation of Plato's reference to desire (*appetitus*): the elements have a desire for their totality because all things in the world are led by desire, although not all of them can choose what to desire.[5] As far as I know, Galileo's only reference to gravity as a desire is in the *Two New Sciences*, when Sagredo describes Plato's cosmogony as a "poetical" account of the true origin of the world.[6]

In the first book of the *De revolutionibus*, gravity is teleologically understood as to maintain and restore a situation of order represented by the spherical shape of celestial bodies. Thus, in line with a certain tradition, gravity is *exclusively* ascribed to the parts of different 'entireties.' Certainly, Galileo maintains that gravity restores a situation of order in the world, and he, too, ascribes gravity to the parts of each planet conceived as a "worldly" or "wholly body" (*corpo mondano*, or *corpo integrale*).[7] But there is more, Galileo does also use gravity to account for the same acceleration of falling bodies.

By 1604, Galileo had discovered that all bodies fall with the same acceleration. The first historical instance of Galileo's law of fall – although Galileo never calls it a 'law' – is traceable in a letter that the Pisan mathematician sent to Paolo Sarpi in 1604. In this letter, Galileo grounds his law in an erroneous assumption: velocities at a given time are proportional to the distances travelled until that time. But between 1604 and 1607, Galileo realizes that this assumption is wrong, and replaces it with the right one: the velocity of fall is proportional to time.[8] Galileo's law of fall was however correct from the beginning; it states that the distance traversed by a falling body is proportional to the square of time. This discovery makes now evident to Galileo that there is no proportion between velocity of fall and weight. He must therefore acknowledge to be fully in the dark about the cause of acceleration. Eventually, Galileo holds that acceleration has to do with gravity, that is, with an "intrinsic principle of moving

[5] "Divinissimus igitur Plato viventia omnia que in mundo considerans et habentia appetitum propriorum bonorum et propter hoc etiam inclinationem ad suas totalitates ac ad opportuna propinquantium ipsis naturaliter corporum et non secundum electionem factam, similiter novit et terram et ignem ad propria appetibilia nota et pripter hoc gravari unumquodque ad proprioum ait; gravare enim ubi inclinari dicibus" (Simplicius (2004a), pp. 90-91).

[6] "[God] turned their straight motion into circulation, the only kind [of motion] that is suitable to be conserved equably, turning always without retreat from or approach toward any pre-established goal *desired* by them [*senza allontanarsi o avvicinarsi a qualche prefisso termine da essi desiderato*]. The conception is truly worthy of Plato…" (Galilei (1974), p. 233, my emphasis [= OG, VIII, *Two New Sciences*, pp. 283-284]).

[7] On the retaining of some Copernican elements in Galileo's notion of gravity, see Bucciantini (1995), pp. 167-168.

[8] On Galileo's letter to Sarpi and the correction of his initial mistake, cf. *supra*, §1.

toward the common center of heavy objects," but he admits to ignore how gravity causes all bodies to fall with the same acceleration.[9]

Galileo's incapacity to provide a causal explanation of free fall acceleration posed a serious problem for the acceptance of the law of fall. As is known, Descartes criticized Galileo's law of fall on the basis of a certain understanding of gravity. Other thinkers such as Hobbes and Huygens, sought to develop mechanical explanations of how gravity makes all bodies fall at the rate described by Galileo's law of free fall. However, the problem could not be solved before the Newtonian reformation of mechanics, which would lead to a distinction between inertial and gravitational mass.[10]

Considering the purposes of the present work, it is more interesting to note another consequence of Galileo's 'agnosticism' about the cause of free fall. As I have pointed out in chapter VI, it has been argued that Galileo was forced to involve God in order to integrate the Copernican system with his mechanics. Indeed, Galileo assumes that the Sun is the planets' 'gravitational' center appointed by nature and God (and this, of course, is another important departure from the Copernican doctrine of gravity in that gravity does no longer apply only to the parts of planets). He then imagines that the planets were created by God in a certain place, and from there they were let fall toward the Sun. Once they had acquired a certain velocity, their straight trajectory was deviated by God in a circular path around the Sun. The velocity acquired through free fall was from that moment maintained eternally thanks to proto-inertia. In sum, Galileo's integration of mechanics and cosmology requires extra-scientific, and in this sense metaphysical, postulates. From this, one may conclude that Galileo's cosmogony stems from the defeat of Galileo's mechanics, which could not provide a causal explanation of acceleration.

Although I agree that Galileo's heliocentric cosmogony requires God, I do not think that God must necessarily play a metaphysical role in Galileo's cosmogony, nor do I think that Galileo's reliance on cosmogony to integrate mechanics and cosmology must be seen as a defeat of Galileo's science of motion (especially because this kind of defeat can be seen only from an anachronistic perspective). In my view, since Galileo's cosmogony aimed at demonstrating the universal validity of one of the most important scientific discoveries of Galileo, that is the law of fall, one should first of all try to

[9] The quotation is from the *Two New Sciences*: Galilei (1974), p. 77 [= OG, VIII, *Two New Sciences*, p. 118]. On this passage and Galileo's neglect of the causes of acceleration (the classic locus in this case is OG, VIII, *Two New Sciences*, p. 202), see the acute observations by Clavelin in Clavelin (2016), pp. 102-105. Clavelin does also notice that Galileo can use gravity to explain acceleration because he draws a distinction between two functions of gravity: "gravifique et motrice" (Clavelin (2016), p. 118).

[10] On Descartes's reaction, see Palmerino (1999). On Hobbes, cf. Leijenhorst (2004), and Baldin (2017), pp. 150–163. On Huygens, see Overmann (1974), pp. 152–175. Also, on Mersenne's growing skepticism concerning the law of free fall, see Palmerino (2010).

understand whether Galileo's *strategy* to accomplish such a demonstration involves metaphysics.

Above all, it must be noted that thanks to Copernicus Galileo can reframe cosmogony as a problem that can be mathematically solved. Copernicus did in fact provide what Ptolemy's system fell short of, that is a mathematical determination of the relative distances between planets (using the Earth-Sun distance, i.e., the radius of the Earth's orbit, as a yardstick). As a Copernican, Galileo is therefore able to develop a *fully mathematical account of cosmogony* by relying on specific astronomical data.[11]

In light of this, if the chief problem is that Galileo could not provide a causal explanation of the law of free fall without involving God, I would argue that Newton had to face a similar problem concerning his law of universal gravitation. What is the cause of the universal gravitational attraction of all bodies? In this regard, Richard S. Westfall has pointed out that

> Newton did not believe that the universal gravitational attraction of all bodies, the force by which his *Principia* explained the functioning of the heavenly system, is a power inherent in matter. The meaning of his concept of the world as God's sensorium was that the Creator was the "agent acting constantly according to certain laws" (as he put it to Richard Bentley) that makes body moves as though they attract each other.[12]

Notwithstanding Newton's appeal to God and his own skepticism about gravity as a force acting at a distance, his law of universal gravitation was accepted because it could "explain the functioning of the heavenly system." Galileo's intuition was not much different. He felt that, if the law of fall can be used to explain why the planets revolve around the Sun with such-and-such velocity, the same law can then be accepted as a scientific universal principle notwithstanding Galileo's appeal to God. Galileo's cosmogony is thus revealing of a peculiar *epistemological strategy* that bypasses questions of metaphysical foundations as long as a problem can be translated into mathematical

[11] On the advantage provided by the Copernican system in the determination of the relative distances of planets, see Copernicus (2015), I, pp. 356-361.

[12] Westfall (1986), p. 233. See also the rhetorical questions raised by Koyré: "Let us not forget, however, that for the minds of the seventeenth century the frontier between the believable and the unbelievable did not lie exactly where it does for us. […] Did not Newton himself believe that God had placed the heavenly bodies at their 'proper' distances from the sun and that he had conferred upon them, later or at the same time, the 'proper' speeds which would be necessary for them to accomplish their revolutions? Why could Galileo not have believed that God had - or, at least, that he could have - used the mechanism of falling?" (Koyré (1965), p. 220).

terms and then solved with the tools of a science of motion grounded in mathematical demonstrations and experiments.

In sum, Galileo sees cosmogony through the lenses of a particular kind of problem-solving strategy, as I shall argue later (see §48). If we think of Galileo's cosmogony in these terms, we can notice that Galileo could have never arranged such a cosmogony had he not found out that free fall acceleration is the same for all bodies on Earth. Starting from this fact, Galileo can assume that the law of fall applies to all bodies, including the celestial ones. However, for Galileo this assumption has no *a priori* guarantee. The universal validity of Galileo's law of fall is *not* grounded in the idea of God as a perfect geometer. Galileo does indeed try to demonstrate its universal validity through cosmogonic calculations, which have fortunately come down to us in Ms. Gal. 72 (see §49).

In this respect, too, Galileo's cosmogony is far from being a metaphysical solution to astronomical problems. On the contrary, the strategy behind Galileo's cosmogony highlights that his idea of God as a perfect geometer is subordinated to a prior but not aprioristic understanding of *how* God arranged the world. As we have seen, in the *De motu antiquiora* Galileo conceives of God as an artist-like Creator that arranged the world without leaving empty spaces and in order to please the sight of the immortal spirits. This view of God does perhaps stem from the fact that, in the *De motu antiquiora*, Galileo has not found the necessary reason (i.e., the fully mathematical reason) as to why the world has a certain order and not another. But in both the *Dialogue* and the *Two New Sciences*, Galileo claims that the cosmogony problem can be solved mathematically. No wonder, then, that in Galileo's heliocentric cosmogony God is a perfect geometer. What I am trying to say is that it is never a prior metaphysical understanding of God and nature that underlies Galileo's cosmogonies. Or, at least, such a metaphysical understanding is flexible and can change in accord with Galileo's scientific findings. Because of this, I suggest that Galileo's cosmogonies should not be seen as scientific failures. Not all references to God and the divine do necessarily originate from 'metaphysical' and 'extra-scientific' reflections. It seems to me that, although Galileo's cosmogonies require God, it would be a mistake to regard them as metaphysical solutions to astronomical issues.

Divine cosmogony is strategically used by Galileo to bridge the gap between mechanics and cosmology. The strategy behind Galileo's cosmogony shows that Galileo is not trying to ground this bridge upon metaphysical pillars. Armed with the mathematical tools of his new science of motion and with detailed astronomical data, Galileo begins to conceive of cosmogony as a new kind of scientific problem subject to mathematical solution. Provided that such a solution can be found, then the result is astonishing: Galileo's science of motion, a science grounded in mathematical demonstrations and sensible observations of 'earthly' natural phenomena, is proved to have a universal range that fits perfectly into the Copernican picture of the world. Galileo begins to see cosmogony as an astrophysical problem that can be solved mathematically. Notwithstanding the flaws of his attempt (which I shall point out later), it must be noted that no one before Galileo has ever thought of demonstrating a certain order of the world through physical laws which holds true independently of cosmology, as they are based on mathematical demonstrations and systematic observations.

§47. COSMOGONY AS A BRIDGE BETWEEN MECHANICS AND COSMOLOGY

Bridges are meant to close gaps. In this sense, the bridge represents a good metaphor to describe Galileo's use of cosmogony. The gap that Galileo seeks to close divides mechanics, or more generally physics, from cosmology.

Such a gap, as we have seen, was not extant in the Aristotelian tradition, where geocentric cosmology received its physical validation on the basis of a cosmologically-oriented definition of gravity. This kind of tautological reasoning, whereby physics and cosmology validate each other circularly, prevented Aristotelian thinkers from conceiving cosmogony as a *natural* event that actually occurred in the past. Also, for the Aristotelians natural motion is not by chance, but it responds to a certain order characterized by cosmological as well as ontological features. As a consequence, natural motion entails cosmological and ontological features, too. While naturally moving toward the center of the world, a body fulfils its own nature. The tight link between physics and cosmology is thus strengthened by being placed within a coherent ontological frame, where natural motion is regarded as a *process* aiming at a natural place of rest in the cosmos.[13] This view, and the principle that God and nature do nothing in vain, lies behind Pererius's conviction that God created each thing in its natural place. Cosmogony, understood as a progressive and temporal genesis of the order of the world, is seen by Pererius as an unnecessary *miraculous* event. As I have shown in chapter VI, Pererius believes that the *Genesis* must not be read as the biblical account of a miracle, for God would not resort to a miracle without a good reason.

When, however, gravity is conceived of as a tendency toward any natural place, it becomes reasonable to consider the possibility of a cosmogonic arrangement of the world. The demiurge, by some understood as God, who must appoint the natural places of each thing in the world. We have seen that Simplicius – who reinterprets

[13] On the understanding of motion as a process in the Aristotelian physics, cf. the classic overview in Koyré (1966), pp. 20 and ff.

Plato's view on heavy and light – and Augustine – probably influenced by different traditions – ascribe a crucial role to the demiurge and God in determining the natural place, and therefore the natural motion, of simple bodies. Copernicus developed a decosmologized doctrine of gravity, which he could have found in many sources of his time (including Simplicius and Augustine), and used it to justify his astronomical system from a physical standpoint.

In the *De motu antiquiora*, Galileo does neither endorse the Aristotelian doctrine of gravity nor the Copernican one. His view integrates Archimedean hydrostatics with an atomist take on matter. Galileo defines 'heavy' and 'light' in comparison with each other, that is, their meaning is determined outside a cosmological frame. True, Galileo is still convinced by "experience" that gravity leads toward the center of the world. But he does not conclude from this 'fact' that gravity is by definition a tendency toward the center of the world – the gap between physics and cosmology is thus put in place. Galileo is however convinced that it is possible to explain *why* there is a certain order in nature and not another one. After he finds a plausible *ratio* behind the geocentric order of the world, he can use it to guess *how* God arranged the world. God's arrangement of the world is *a priori* assumed to respond to a certain *ratio*, but the latter, according to Galileo, can be grasped *a posteriori*, by analogy with what happens to matter when placed in more or less narrow spaces. Although Galileo's initial assumption may be regarded as metaphysical, his first cosmogony is nonetheless based on a non-metaphysical attempt to bridg the gap between his Archimedean physics and geocentric cosmology. A similar explanatory scheme is maintained by Galileo after he has accepted and revised the Copernican doctrine of gravity: provided that there are some physical laws which have been demonstrated independently of cosmology, one can try to test their validity against the backdrop of astronomical data.

In order to understand Galileo's scientific approach to cosmogony, it may be beneficial to compare it with Kepler's metaphysico-theological approach to God's creative action. In the *Mysterium cosmographicum*, Kepler's objective is to find the *a priori* reason as to why there are certain distances between the planets. After several attempts, Kepler finds out that each planetary circle can be inscribed within one of the five regular solids. This, according to Kepler, provides the *a priori* reason he was looking for (it also explains why the planets are six) and that allows him to place the Copernican system within a metaphysical frame.[14] In this case, it is true that a metaphysical idea of God as a Creator, platonically understood as a perfect geometer, has played an important role in directing Kepler's quest for a foundation of the Copernican system, and in supporting his confidence during the exhausting research process.

[14] Cf. Kepler (1981), pp. 62-73.

Galileo picks a different strategy. First of all, he attempts to reframe the Copernican system in terms of a problem that can be solved with the conceptual tools provided by his mechanics. This is an important and hitherto unnoticed twist in tackling what Édouard Mehl has conveniently called "le problèm cosmologique." Mehl has highlighted that, for some post-Copernican thinkers (e.g., Kepler and Descartes), the Copernican system posed issues, and became in its own right an issue, calling for metaphysical answers. Seen from this perspective, Galileo's approach to the "cosmological problem" seems to be an exception: Galileo does in fact consider the problem to be one whose solution can rely on the cunning application of the principles of his mechanics, principles which are derived from a study of motion that neglects metaphysics and is conducted via methodical experiments and mathematical demonstrations.[15]

From the standpoint of natural philosophy, Kepler's approach to the Copernican system does also differ from that of Galileo. Kepler *qua* natural philosopher thinks it reasonable to put forth *ad hoc* theories whose chief objective is to account for the celestial physics of the planetary movements. To this end, Kepler is willing to change opinion about gravity, which he conceives of under the influence of many different sources.[16] In sum, Kepler does not try to bridge mechanics and cosmology, because he does not see the two separately. Instead, he tries to develop a celestial mechanics suited to the Copernican system.

This approach, although prominently qualitative, nonetheless puts Kepler in a much better position than that of Galileo when it comes to reconsidering and eventually rejecting the circular planetary orbit. Unlike Galileo, Kepler does not have a strong commitment to the circular trajectory of the planets' movement. He can therefore appeal to *ad hoc* theories on the specific *vis* or *virtus* that, in accord with his laws, moves the planets along their elliptical orbits. Perhaps, the major constraints to Kepler's physical theories are posed by theology. The spherical shape of the universe, for example, is an indispensable tenet of Kepler's cosmological view, and it is derived by analogy with his archetypical take on the Trinity.[17] Such a theological constraint cannot be found in Galileo's writings. Since Galileo changed his mind more than once with respect to the finitude, immensity, or infinity of the universe, he certainly did

[15] Cf. Mehl (2019) and my review, Malara (2020b).

[16] Cf. Koyré (1965), pp. 173–175, and Overmann (1974), pp. 31–53. See also Regier (2014), where Jonathan Regier sheds light on how (non-Aristotelian) medical ideas influenced Kepler's conception of force at a distance, e.g., the force of the Sun as a planetary mover.

[17] On the theological foundations of Kepler's astronomy, see Barker-Goldstein (2001). The two authors argue (rightly, in my view) that the theology behind Kepler's arguments must not be confounded with mysticism. See also Westfall (1986), pp. 219-224.

not think that the sphericity of the universe was an indispensable feature of the Copernican system.[18]

Concerning the elliptical orbits, we must notice that – as we shall soon see – when Galileo develops for the first time his heliocentric cosmogony, Kepler has not yet discovered the three laws of planetary motion. However, when Galileo writes the *Dialogue* and the *Two New Sciences* – both of which include his cosmogonic account of the Copernican system –, Kepler has already argued for the existence of elliptical orbits on the basis of astronomical data collected with Tycho Brahe. Kepler's laws were based, in short, on extremely reliable astronomical data. The latter had also been used by Kepler to compile the *Tabulae Rudolphinae* (1627), which Galileo most likely knew as being more reliable than the *Tabulae Prutenicae* (1551) based on Copernicus's *De revolutionibus*. Since the astronomical data allowed to predict the future position of celestial objects, Kepler's laws were 'falsifiable.' From our point of view, then, it is surprising that Galileo never accepted Kepler's laws.

Galileo's refusal has received two kinds of explanations: (1) it was due to an aesthetic preference for the circle, symbol of perfection in the Renaissance culture; (2) it resulted from a notion of order that Galileo regarded as an indispensable premise to Copernican cosmology.

None of them makes a good point in my view. The first thesis was developed by Erwin Panofsky in reply to Albert Einstein, who could not understand what prevented Galileo from welcoming Kepler's laws. Massimo Bucciantini has delivered a compelling criticism of Panofsky's thesis and alike. Thus, Panofsky's opinion is no longer a viable option today.[19]

The second thesis has been advanced by Maurice Clavelin, who drew a distinction between Galileo's works on cosmology (e.g., the *Dialogue*) and those concerning mechanics (e.g. the *Two New Sciences*), but at the same time he showed that Galileo's mechanics was influenced by cosmological premises. First of all, Galileo was conditioned by the aprioristic idea that the world must be orderly. Secondly, he believed that the uniform circular movement is the only one able to maintain the order of the world, that is, to maintain the spatial or temporal relations between the parts of the world. The consequences of these important premises are mainly three: (1) the order of the world is no longer understood as a notion that has to do with the ontology of the bodies that make up the world;[20] (2) the uniform circular movement is no longer

[18] On this and other differences between Galileo and Kepler in this regard, see Bucciantini (2003), pp. 288-355.

[19] Cf. Panofsky (1956). On the dialogue between Panofsky and Einstein, see Bredekamp (2001), pp. 184-187. For Bucciantini's criticism, see Bucciantini (2003), pp. VIII-XVIII. Clavelin had already noticed, *en passant*, that it is "inutile d'invoquer des motifs esthétiques ou une prétendue perfection intrinsèque du mouvement circulaire" (Clavelin (1996), p. 218).

[20] On this idea of order, see Galluzzi (1979b).

understood as a *process* toward the fulfillment of a certain nature, but it is now associated with rest, that is, both circular motion and rest can be regarded as *states* in which things maintain the order of the world; (3) last but not least, both the new idea of order and that of circular motion put decisive constraints on Galileo's mechanics, such that they prevent Galileo from welcoming Kepler's laws. As Clavelin puts it:

> Nécessité d'un ordre du Monde, primauté du mouvement circulaire, telles sont donc les deux prémisses générales que la raison invite à placer en tête de la cosmologie. Or si favorables qu'elles fussent au copernicianisme, ces prémisses n'en représentaient pas moins une anticipation sur le comportement réel des corps, et de ce fait imposaient à la pensée de Galilée une contrainte certaine. [...] [L]e véritable obstacle est ailleurs, et, comme on pouvait s'en douter, réside tout simplement dans la suprématie accordée au mouvement circulaire. En faisant de celui-ci le seul mouvement capable de conserver un monde ordonné, Galilée ne rendait pas seulement très difficile une interprétation mécanique des mouvements planétaires: il énonçai encore un préalable de nature à perturber gravement la science astronomique elle-même.[21]

According to Clavelin, it is especially in the polemic with Orazio Grassi that the "caractère dogmatique de la position galiléene" becomes evident. In *The Assayer* (1623), Galileo excludes that celestial objects, including comets, move along elliptical trajectories, although he recognizes that the ellipse, contrary to the oval, is a "regular" figure. That is, the ellipse could maintain an orderly proportion among the parts of the world. Thus, the elliptical movement of a comet is in principle compatible with the first cosmological premise outlined above. However, "[q]ue Galilée n'en examine même pas l'éventualité confirme bien que si les comètes n'ont pas de place dans le Ciel, c'est en raison de leur incompatibilité avec le mouvement circulaire, et de leur désaccord avec l'ordre du Monde, sinon avec sa simplicité."[22]

Clavelin's view might suggest that Galileo's proto-inertial principle was blindly or even dogmatically based on cosmological assumptions that originated with Galileo's adherence to Copernicanism. It is against this kind of conclusions, however, that Festa and Roux have rightly claimed – as I have already reported in the previous chapter – that, although the Copernican system enabled Galileo to unify different elements of his mechanics, nonetheless this does not allow us to assume that those elements did originally stem from cosmological premises.[23] After all, Galileo was not a Copernican

[21] Clavelin (1996), pp. 218-219.
[22] Cf. *ibid.*, pp. 218-222.
[23] Cf. Festa-Roux (2006), especially p. 147, nt. 64.

when in the *De motu antiquiora* he began to consider the possibility of eternal circular motion.

In my view, the situation is in fact the reverse of that described by Clavelin. The second cosmological premise (circular motion) adopted by Galileo does neither have positive nor negative effects on his mechanics. It is not a cosmological dogma that prevents Galileo from accepting the elliptical trajectory of comets, or that held him back from giving due consideration to Kepler's laws. It is Galileo's mechanics – a mechanics still based on the qualitative distinction between natural and violent motion – that needed to be reformed before one could accept Kepler's laws. Behind the proto-inertial principle, for example, lies the conviction that gravity is inherent in matter. Gravity is an innate natural inclination toward a certain place. Accordingly, natural motion exists insofar as there is a terminus toward which motion is naturally directed. So, a proto-inertial kind of motion requires the constant presence of a force (gravity) as well as the condition in which that force can be regarded as null; that is, it requires a *condition of equilibrium*.[24] It seems to me that Galileo visualizes the problem more or less as follows: a body is placed within a mechanical system where the conditions for equilibrium are fulfilled, so that the body is in a state of rest. The only movement that can keep the conditions of equilibrium unchanged is the circular one around the place toward which gravity naturally leads the body. Indeed, circular motion is the only motion thanks to which all the different Galilean declinations of *momentum* (e.g., the *momentum* of weight, and that of velocity) do not change.[25] From this perspective, circular motion appears to be a sort of *dynamic repetition*, at each point of the circle, of the same condition of *static equilibrium*. For this reason, which has nothing to do with cosmology, Galileo can assimilate the state of rest with motion along a circular trajectory. As we have seen, the 'hybrid' nature of circular motion had troubled Galileo since the time of the *De motu antiquiora*. It is likely that Galileo's engagement with the Copernican system played an important role in convincing him that circular motion is natural and perpetual (although Galileo could have inferred this from studying the parabolic shape of projectiles' motion). But this, however, does not detract from

[24] This has been explained in clear terms by Maarten Van Dyck: "A body lying on a horizontal plane is indifferent to motion according to Galileo, not because there are no forces, but precisely because there is equilibrium of forces. It is important, but in a sense only accidental, that these equilibrium situations primarily show in circular motion around the center of the earth. The most important thing is that strictly speaking *'inertial states' are only thinkable for Galileo in the presence of forces* – in complete opposition to the classical viewpoint. This is of course due to Galileo's conviction that gravity is something internal to matter, responsible for its essential tendency toward motion" (Van Dyck (2006a), pp. 169-170). De Pace has recently argued that Galileo's mechanical view on circular motion, as a kind of "equilibrio dinamico," departs from that of Copernicus (cf. De Pace (2020), pp. 349-351).

[25] On Galileo's attempt to unify statics and dynamics by leveraging on the notion of *momentum*, see Galluzzi (1979a).

the fact that the major reason for Galileo's neglect of Kepler's laws can be found in the non-cosmological premises of Galileo's mechanics.[26]

I would go so far as to argue that for Galileo circular motion can be given a metaphysical dress, one that serves the purpose of maintaining the cosmological order, only because circular motion can be adequately framed within Galileo's mechanics. In this sense, mechanics poses serious limits to Galileo's cosmological and metaphysical view, not the other way around. In sum, Galileo's mechanics cannot fit all kinds of revision of the heliocentric system. According to Galileo, Kepler's laws and elliptical orbits are devoid of physical reality because they cannot be given a mechanical explanation. Historians have no problem thinking that Descartes had troubles accepting the law of fall because Galileo did not provide a proper causal explanation of it. So, I believe that there should be no problem in thinking that Galileo neglected Kepler's laws for a similar reason.

After all, Kepler's laws are the apotheosis of the notion of order (Kepler would perhaps call it "harmony") described above as the first cosmological premise adopted by Galileo. It is evident, then, that Galileo's refusal of Kepler's laws has very little to do with abstract reasoning about the order of the world. Had Galileo accepted Kepler's laws, he would have been obliged to rebuild his mechanics upon them. But the reasons that prevented Galileo from being a Newton *ante litteram* cannot be narrowed down to the negative effects played by the alleged cosmological premises of his mechanics. Starting from Galileo's take on gravity, many were the issues inherent in Galileo's mechanics that needed to be solved before one could be able to reach a proper physical explanation of Kepler's laws. And yet, this should not prevent us from appreciating the novelty of Galileo's attempt *to show through cosmogony*, not only the reality of the Copernican system, but *especially the success of his mechanics at a universal scale*. Had Galileo given credit to Kepler's laws, he should have renounced to bridge the gap between his mechanics and heliocentric cosmology.

§48.
Reinterpreting Cosmogony within a Problem-Solving Frame

The orbital period of Saturn is T_S; its distance from the Sun, i.e., the radius of Saturn's

[26] On this point, see the stimulating observations in Westfall (1966). In my view, Westfall is right in arguing that Galileo's understanding of gravity as a 'natural tendency' "is a major obstacle preventing his advance toward a concept of force" (*ibid.*, p. 93). However, I am not convinced by the argument that "[the] organized cosmos to which [Galileo] clings refuses to dissolve itself into the mechanical universe from which the concept of force ultimately emerges" (*ibid.*, p. 94).

orbit, is r_s. Provided T_s and r_s, determine the height (h_s) from which Saturn began to fall naturally toward the Sun. Repeat the same exercise using the data relative to the other planets. The problem is considered solved if the value of h relative to each planet is such that all planets result to fall from the same distance from the Sun.

This is more or less how Galileo reinterprets the cosmogony problem in the *Dialogue* and in the *Two New Sciences*.[27] Cosmogony is transformed into a problem that has to do with the measuring of distances; as such, it requires to be solved geometrically. In its new form, the cosmogony problem does not differ much from the kind of issues that a surveyor or a military engineer of Galileo's time was supposed to deal with. Matteo Valleriani and other important scholars before him, like Leo S. Olschki and Ludovico Geymonat, have rightly emphasized that Galileo himself was a gifted engineer.[28] Unlike Koyré, Geymonat was convinced that, more than Platonic metaphysics, it was Galileo's ability as a practitioner that had a crucial role in the emergence of the new science of motion. Thomas B. Settle, who has much contributed to the reappraisal of Galileo's experimental practices, has also pointed out that Ostilio Ricci, Galileo's first and probably only teacher of geometry, used Leon Battista Alberti's *Ludi rerum mathematicarum* as an essential pedagogical tool for the teaching of geometry.[29] Apparently, Galileo was trained as a humanist in geometry, too. This training consisted in eliciting the student's interest in geometry through problems, puzzles, games, all rooted in concrete and practical activities of measuring. In short, the pedagogical model used by Alberti is that of a sort of 'active learning,' where theory and practice are hardly separable from each other.[30]

The problems described by Alberti concern, for example, the measuring of the height of a tower, the depth of a well, the width of a river, the extension of a field, and so forth. Interestingly, Alberti also includes the problem of Hiero's crown solved by Archimedes. All these problems have in common that they require to be solved through a particular kind of 'ingenuity' driven and at the same time constrained by Euclidean geometry. In this sense, applying geometry to the solution of well-defined problems amounts to *engineering* the practical means thanks to which those problems

[27] See the passages cited *infra*, §49.

[28] See Valleriani (2010) and Geymonat (1969).

[29] On Galileo's experiment, see Settle (1961). On the role of Ricci as a "bridge between Alberti and Galileo," see Settle (1971). See also Vinci (1929), for an overview on Ricci, and the transcription of Ricci's manuscript concerning *L'uso dell'archimetro, ovvero del modo di misurare con la vista*. Alexander Marr has welcomed Sven Dupré's suggestion, according to which it is likely that Ricci taught optics and catoptrics to Galileo (cf. Marr (2011), p. 90 and nt. 17).

[30] On the importance of the practical use of geometry for its transmission in the Renaissance, see Camerota F. (2006). On practical geometry and Alberti, see Souffrin (1998).

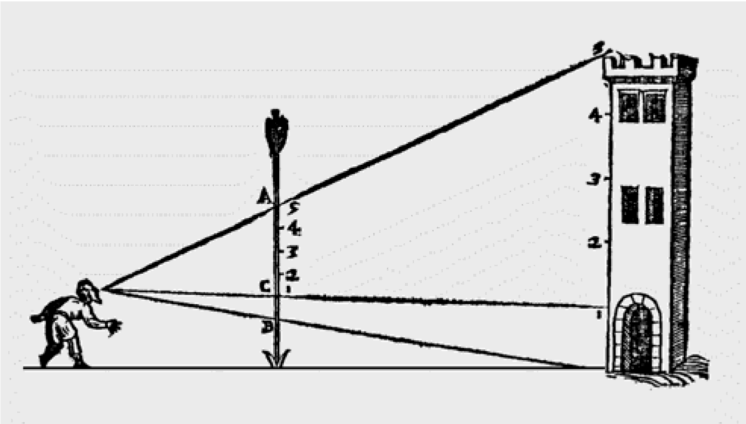

Figure 1. How to compute the height of tower by sight, knowing only the elevation of one of its points.

can be solved.[31] This can be done, for example, by ingeniously using a common object, such as a dart, to measure by sight the height of a tower (see figure 1). The need to solve practical problems of measuring could also stimulate the construction of more versatile instruments, which could be used to perform a wide range of 'measuring actions.' A famous example in this regard is Galileo's geometric compass, thanks to which it was possible to perform a greater number of measuring actions than that allowed by other military compasses of his time. Since it was an extremely complicated piece of technology, Galileo's geometric compass needed to be preceded by a technical training to be properly used.

In my view, Alberti's *Ludi* showcases several instances of a common strategy for the application of mathematics (more specifically, geometry) to practical issues – a strategy that Maarten Van Dyck has conveniently called "problem-solving through construction."[32] Van Dyck interestingly argues that the practical success of such a strategy may have induced some thinkers to make mathematical problem-solving a criterion of truth in natural philosophy. This way of mathematizing natural philosophy brings with it two important consequences: (1) the Aristotelian explanatory scheme used in natural philosophy can be replaced by mathematical construction;[33] (2) this replacement does not necessarily stem "from prior metaphysical beliefs about the ultimate nature of reality, as Koyré famously contended," as it can be "rather

[31] On the origins of the term "engineer" from the Latin *ingenium*, see Vérin (1993), pp. 19-42. In the introduction to her book, Vérin notices that the "problème à résoudre" represents a crucial "modèle" we must consider if we want to understand the work of the engineers practicing between the sixteenth and the eighteenth century. "C'est à cette mise en forme-problème que reviendrait, en effet, l'essentiel de la technologisation des arts. Le travail des ingénieurs consisterait précisément à réduire toutes sortes de situations dans les termes de problèmes qui peuvent être exposés et compris par les différents acteurs dont le projet définit les rôles et les tâches…" (*ibid.*, pp. 11-12). On the importance of the knowledge of artisans and engineers for the emergence of the new science, see also Rossi (2017), pp. 112-144, and Rossi (2000), pp. 35-54.

[32] Van Dyck (in press-a). I profited a great deal from reading this paper; I therefore wish to thank Maarten Van Dyck for allowing me to read it before its publication.

[33] On this, see Van Dyck (in press-b). Again, I am thankful to Maarten Van Dyck for sharing with me his not yet published paper.

naturally suggested by the successes and broader appeal of mathematical practice."[34] From this, and in line with an opinion already held by Hatfield, Van Dyck shows that Galileo's "mathematization of physics" did not start out from metaphysical convictions about the mathematical nature of reality. Hatfield has indeed pointed out that early modern science is not grounded in only one kind of metaphysical belief about nature, often labelled as 'mathematicism' or 'mathematical ontology,' but in many different ones, and sometimes in none.[35] With respect to Galileo, Hatfield has convincingly shown that those passages that have been often interpreted as Galileo's most patent statements in favor of mathematicism – like the overquoted passage of *The Assayer* where nature is described as a book "written in the language of mathematics" – do in fact fit into an "alternative picture of Galileo, one that denies that he subscribed to a mathematical ontology and, indeed, denies that he subscribed to any ontology (theory of being) in the metaphysical sense at all." According to Hatfield, those passages show how Galileo attempted to "extend the paradigm of scientific knowledge provided in actual mathematical sciences (and practices) to new sciences, or to new approaches and conclusions within established sciences."[36]

It is my conviction that Galileo's heliocentric cosmogony fits well into the "alternative picture of Galileo" suggested by Hatfield and Van Dyck, although I do not concur with Hatfield when he says that Galileo did not subscribe to any theory of being. I do not think that Galileo's scientific discourse does never appeal to a certain ontology or metaphysics. From my point of view, the real matter is to single out the 'foundations' of Galileo's metaphysics. It may be that Galileo's science has metaphysical foundations, but the pillars of these metaphysical foundations (the foundations of the foundations) are probably not metaphysical. Just like a set of Chinese boxes, the metaphysical foundations of Galileo's science may be built upon practices which rest on mathematical expectations, expectations which concerns the solutions of particular problems, solutions which stand thanks to several reality checks. Thus, Galileo's metaphysical view, his supposed mathematical ontology, may have actually stemmed from certain practices which involved mathematics and experimentation. (In this case, to what extent such a mathematical ontology can be regarded as 'Platonic'?)

By extending the paradigm of practical mathematical problem-solving to cosmogony, Galileo is attempting to place the cosmogony problem within the purview of scientific knowledge – or, to say it differently, to make cosmogony a science. Galileo's attempt is directed at closing the gap between mechanics and cosmology. The fact that he chooses to close this gap through a problem where the law of fall can play

[34] Van Dyck (in press-a).
[35] Cf. Hatfield (1990).
[36] *Ibid.*, pp. 129 and ff. On Galileo's metaphor of nature as a book, see Biagioli (2003), Palmerino (2006), and Palmerino (2016).

a role similar to that of the dart in the example mentioned above, shows that Galileo does not have the metaphysical guarantee that the gap can be actually closed, as he does not have the *a priori* guarantee that the law of fall can be extended to the whole of nature.

When looked from this perspective, Galileo's heliocentric cosmogony represents a precious 'archeological relic' for historians of science, one that bears evidence of Galileo's epistemological thinking. It shows that Galileo is to some extent aware that his science of motion is not ultimately grounded in metaphysical underpinnings which would *ipso facto* make the law of fall universal. For this reason, he sets out a computable cosmogonic problem suited to his new science of motion. Galileo feels authorized – philosophically intended – to extend to the universe the validity of his science of motion, as long as the latter can be successfully used to solve the cosmogonic problem. To this end, he also feels authorized to use ontologically obscure notions, such as that of gravity, as long as they make it possible to implement successful mathematical problem-solving strategies.

§49.
Galileo's Cosmogonic Calculations

Does Galileo's cosmogony allow for a successful application of mathematical problem-solving strategies? In the *Dialogue*, Galileo is convinced that it does:

> [A]t what altitude and distance from the Sun would have been the place where the said globes were first created, and could they all have been created in the same place?
>
> To make this investigation, we must take from the most skillful astronomers the sizes of the orbits in which the planets revolve, and likewise the times of their revolutions. From these data we deduce how much faster Jupiter (for example) moves than Saturn; and it being found (as in fact it is) that Jupiter does move more swiftly, it is necessary that Jupiter, departing from the same height, descended more than Saturn – as we know is actually the case, its orbit being inferior to that of Saturn. And going still further one may determine, from the proportions of the two velocities of Jupiter and Saturn and from the distance between their orbits, and from the natural ratio of acceleration of natural motion, at what altitude and distance from the center of their revolutions must have been the place from which they originally departed. This place determined and agreed upon, it is asked whether Mars, descending from there to its orbit, is found to agree in size of orbit and velocity of motion with what is found by calculation; and the same is done for the Earth, Venus,

> and Mercury, the size of whose orbits and the velocities of whose motions agree so closely with those given by the computations that the matter is truly wonderful.[37]

The final result is that "sizes of orbits and speeds of planetary motions accord in ratio with descent from the same place."[38] Galileo is thus convinced that the conceptual tools provided by his mechanics can be successfully applied to solve the cosmogonic problem. Six years later, Galileo confirms this result in the *Two New Sciences*. It is the fourth day, and Salviati is reading Theorem III, Proposition III, when Sagredo interrupts him. He thinks it is "proper" to "adorn" Salviati's explanation "with its conformity to a conception of Plato's regarding the determination of the various speeds of equable motion in the celestial motions of revolution." According to Sagredo, Plato

> said that God, after having created the movable celestial bodies, in order to assign to them those speeds with which they must be moved perpetually in equable circular motion, made them depart from rest and move through determinate spaces in that natural straight motion in which we sensibly see our moveables to be moved from the state of rest, successively accelerating. And he added that these having been made to gain that degree [of speed] which it pleased God that they should maintain forever. He turned their straight motion into circulation, the only kind [of motion] that is suitable to be conserved equably, turning always without retreat from or approach toward any pre-established goal desired by them. The conception is truly worthy of Plato, and is to be the more esteemed to the extent that its foundations, of which Plato remained silent, but which were discovered by our Author in removing their poetical mask or semblance, show it in the guise of a true story. And since, through very competent astronomical doctrines, we have data about the sizes of the planetary orbs and the distances from the center about which they turn, as well as about their speeds, it seems very credible to me that our Author, from whom the Platonic concept did not remain hidden, may at some time have had the curiosity to try whether he could assign a determinate sublimity from which the bodies of the planets left from a state of rest, and were moved through certain distances in straight and naturally accelerated motion, and were then turned at the acquired speeds into equable motions. This might be found to correspond with the sizes of their orbits and the times of their revolutions.

Salviati agrees with Sagredo. He also remembers that Galileo told him

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[37] Galilei (1967), p. 29 [= OG, VII, *Dialogue*, pp. 53-54].
[38] *Ibid.*, marginal note.

> he had once made the computation, and also that he found it to answer very closely to the observations. But he did not want to talk about it, judging that he had discovered too many novelties that have provoked the anger of many, and others might kindle still more sparks. But if anyone should have a similar wish, he may satisfy his taste for himself through the teachings of the present treatise.[39]

Galileo is convinced that all those who study his *Two New Sciences* acquire the mathematical tools required to solve the cosmogony problem. As a result, *anyone can attest by themselves the universal validity of Galileo's science of motion*. Yet, Galileo's reference to Plato and the absence of cosmogonic calculations made some scholar suppose that Galileo never made the computations, and that his cosmogony is only meant to have an illustrative role, like Platonic myths.[40]

This opinion seems to be corroborated by the fact that Plato is also mentioned in the *Dialogue*, where Galileo's spokesman Salviati postpones the calculations "for another time" – perhaps an allusion to the *Two New Sciences*.[41] In the *Dialogue*, Galileo first shows that different degrees of velocity can be naturally acquired only through free fall motion. He then explains why the same degree of velocity can be naturally maintained only along a circular path around the terminus toward which free fall motion is directed.[42] Having assumed all this, Galileo says through Salviati that one can suppose

> God to have created the planet Jupiter, for example, upon which He had determined to confer such-and-such a velocity, to be kept perpetually uniform forever after. We may say with Plato that at the beginning He gave it a straight and accelerated motion; and later, when it had arrived at that degree of velocity, converted its straight motion into circular motion whose speed thereafter was naturally uniform.[43]

As is known, Galileo's reference to Plato has raised a difficult issue about the precise passage of the *Timaeus* to which Galileo refers. I shall leave this issue for later (§50). Now it is interesting to note that, from the passages just quoted, according to

[39] Galilei (1974), pp. 232-234 [= OG, VIII, *Two New Sciences*, pp. 283-284].
[40] Cf. Barcaro (1983). See Dollo (2003), p. 46, nt. 60, for a criticism of Barcaro's opinion.
[41] "The procedure is indeed long and difficult, and besides I am not sure I could reconstruct it offhand. Therefore we shall keep it for another time" (Galilei (1967), p. 30 [= OG, VII, *Dialogue*, p. 54]).
[42] Cf. Galilei (1967), pp. 20-21 [= OG, VII, *Dialogue*, pp. 44-45].
[43] *Ibid.*, p. 21 [= OG, VII, *Dialogue*, p. 45].

Alexandre Koyré one can only conclude that, either he was inspired by Plato or not, "Galileo had no doubt neglected to make" the cosmogonic calculations. In support of this conclusion, Koyré marshalled Frénicle, Mersenne, Newton, and Mansion, who made the calculations and showed that "the conception expounded by Galileo was impossible."[44]

Stillman Drake challenged Koyré's opinion, after he had found Galileo's cosmogonic calculations in manuscript Gal. 72. Drake noticed that in ff. 134, 135, and 146, Galileo performs calculations based on some of the astronomical data provided by Kepler in the *Mysterium cosmographicum*. Eric Meyer, Jochen Büttner, and more recently Lucia Bucciarelli, have integrated and improved Drake's preliminary study.[45]

Meyer has been able to detect an important detail which escaped Drake's attention. He understood that Galileo began to work on his cosmogonic calculations as soon as he discovered the law of fall. This conclusion is inferred from the fact that in ff. 134 and 135 Galileo grounds the cosmogonic calculations on his early erroneous assumption that the velocity of fall is proportional to the distance fallen. In f. 146, on the other hand, Galileo uses cosmogonic proportions which do no longer assume the wrong proportionality between velocity and distance. It is evident that Galileo's cosmogonic calculations were made in two different times: (1) between 1597 and 1607, that is, after Galileo had received Kepler's *Mysterium*, and while Galileo was still convinced that velocity of fall is proportional to the distance fallen;[46] (2) after 1607, i.e., after Galileo had understood and corrected his initial mistake.

Meyer's important conclusion is today generally accepted by Galileo scholars. Assuming Meyer's conclusion, but improving the latter's analysis of ff. 134 and 135, Büttner has intriguingly suggested that Galileo emended his initial assumption on free fall while working on cosmogony:

> Galileo's elaboration of his theory of motion to include cosmogony may have had far-reaching repercussions on its very foundations. The insight into the contradiction between the law of fall and the early erroneous principle led to a conceptual revision of the foundations of his theory of motion, requiring in

[44] Koyré (1965), p. 218. At pp. 209-210, Koyré cites Newton's reply to a letter from Bentley, where Newton argues that "there is no common Place from whence all the Planets being let fall, and descending with uniform and equal Gravities (as Galileo supposes) would at their Arrival to their several Orbs acquire their several Velocities, with which they now revolve in them."

[45] Cf. Drake (1973), Meyer (1989), Büttner (2001), Bucciarelli (2016), pp. 156-184.

[46] More precisely, Drake suggested that the first attempts were performed around 1602 (cf. Drake (1973), pp. 184-187). Bucciantini's study on the relations between Galileo and Kepler, through the mediation of Edmund Bruce, is line with Drake's suggestion (cf. Bucciantini (2003), pp. 109-110). Also, Renn has shown that Galileo might have inferred the law of fall in 1592 while performing experiments with Guidobaldo del Monte (cf. Renn (1992), pp. 153, 138-164, and Renn et al. (2001), pp. 79-89).

particular a shift to a new principle of fall, according to which the degrees of speed increase with the times fallen.[47]

This is a very interesting suggestion, which gives cosmogony an eminent role in the development of Galileo's mechanics. However, it must be noted that Büttner's hypothesis is based on the analysis of a diagram that Galileo drew on f. 134*r*, a diagram whose meaning seems to be open to different interpretations.

Drake, for example, thought that the diagram was unrelated to Galileo's cosmogonic calculations in f. 134. Meyer, instead, pointed out that Drake was wrong to ignore a diagram "of the sort used early on by Galileo to represent the increase of speed in free fall, welcome assurance that this is indeed the issue here." But Meyer was perhaps too harsh against Drake, as the latter also supposed that the diagram was added to f. 134 in a second moment.[48] Like Meyer – but before him –, Drake understood that the diagram on f. 134*r* is similar to "other lines" used in f. 91*v* of the same manuscript. Unlike Meyer, though, Drake assumed on the basis of watermarks that f. 134*r* belongs to 1604, whereas f. 91*v* belongs to 1609. Also, Drake linked the diagram in f. 134*r* to the 'double-distance-rule' diagram included in Theorem III, Proposition III of the fourth day of the *Two New Sciences*.[49] As we have seen, Sagredo interrupts Salviati's exposition of Proposition III in order to introduce Galileo's cosmogony. Thus, Drake concluded that the "additional diagram on f. 134*r* was drawn after 1604-6, and almost certainly after f. 91*v*, relating a conclusion about free fall to some astronomical speculations."[50]

Drake, however, failed to notice what Meyer documented in his study, that is, the cosmogonic proportions included in ff. 134 and 135 are based on the double-distance rule. Thus, the agreement between the content of f. 134*r* and the diagram therein included suggests that the latter was not added in a second moment, as supposed by Drake. Büttner's further analysis of ff. 134 and 135 have confirmed this conclusion. According to Büttner, the "diagram represents, in a nutshell, the essential mechanism of Galileo's calculations based on three fundamental ingredients, the law of fall, the

[47] Büttner (2001), p. 400.

[48] Cf. Meyer (1989), p. 463, nt. 25, where Meyer refers to Drake (1973). However, Drake had already returned to the topic in his *Galileo at Work*, adding new interesting considerations on the diagram on f. 134*r*: see Drake (1978), pp. 154-156.

[49] The double-distance rule "states that a body whose motion is diverted into a uniform motion after fall through a certain distance will, in the time it took to fall, traverse in uniform motion twice the distance fallen" (Büttner (2001), p. 393). The diagram of the double-distance rule included in the *Two New Sciences* is reported and explained by Domenico Bertoloni Meli in Bertoloni Meli (2006), p. 77, figure 3.5. The double-distance rule is also mentioned by Galileo in the *Dialogue*, right before Salviati says that it is possible to calculate the distance from which all planets fell (cf. OG, VII, *Dialogue*, p. 52).

[50] *Ibid.*, p. 155.

double distance rule, and the erroneous proportionality between degrees of speed and the distances of fall."[51]

Like Drake and Meyer, Büttner too has recognized that the diagram on f. 134*r* is similar to those included in other folio pages of Ms. 72. But he did not link the diagram to f. 91*v*, as Drake did. Instead, Büttner linked it to f. 152*r*, where Galileo seems to realize "the internal contradiction between his erroneous principle and the law of fall on the basis of considering exactly the same diagram."[52] These are the considerations upon which Büttner has based the hypothesis reported above, namely that the cosmogonic calculations "probably had a profound impact on Galileo's science of motion."[53]

Nothing, however, prevents us from noticing with Drake that in the fourth day of the *Two New Sciences* Galileo seems to suggest that there is a correlation between the double-distance rule expounded in Proposition III, and the cosmogony tale narrated by Sagredo. Needless to say, by the time he wrote the *Two New Sciences*, Galileo had already emended his erroneous assumption about free fall. Perhaps Büttner, who focused only on ff. 134 and 135, assumed that in the successive calculations on f. 146 the double-distance rule is no longer a "fundamental ingredient" of Galileo's cosmogonic proportions. And perhaps this assumption was indirectly suggested to him by Meyer, who argued that "the double-distance rule is not a very appropriate tool for the task of relating speeds to different distances of fall. Its application makes sense only if the work on folios 134-135 was done before his [Galileo's] discovery of the correct rule for speeds of fall late in 1607."[54] If this is true, it becomes difficult to square Meyer's considerations with the *Two New Sciences*, and with Bucciarelli's analysis of f. 146. Bucciarelli has indeed noticed that on f. 146 Galileo drew another diagram that she has associated with the double-distance-rule diagram included in the *Two New Sciences*.[55]

In sum, if a similar kind of diagram bears evidence of Galileo's rethinking of the principle behind the law of fall, as Büttner has suggested, why would Galileo draw it again on f. 146? All things considered, I believe that further studies are necessary in order to confirm Büttner's very tempting hypothesis.

Büttner gathers another interesting conclusion from his detailed study of Galileo's cosmogonic calculations:

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[51] Büttner (2001), p. 399.

[52] *Ibid.*, pp. 399-400. Büttner refers here to the study of Ms. Gal. 72 conducted in Damerow et al. (1992), pp. 185-194.

[53] Büttner (2001), p. 399.

[54] Meyer (1989), p. 463.

[55] Cf. Bucciarelli (2016), pp. 156-184. Bucciarelli maintains this reading in a recent English draft (cf. Bucciarelli (draft)), which she kindly sent to me. I wish to thank her for allowing me to read it.

> The interpretation given shows that Galileo tried to integrate his new science of motion with Copernican concepts already at an early stage, that is at a time when neither his science of motion nor his Copernican position were fully developed. As a matter of fact, in Galileo's time, the omnipresence of Aristotelian natural philosophy and the astronomical issues related to it created boundary conditions that no attempt at a new science of motion could ignore. Galileo's early attempt of an integration of his new science of motion with cosmological issues hence does not bear the characteristics of a strategically planned step, but has rather to be interpreted as an unavoidable encounter that affected both, Galileo's understanding of cosmology and his theory of motion.[56]

As I tried to show, when Galileo attempts for the first time "to integrate his new science of motion with Copernican concepts," he is not new to cosmogony. In the *De motu antiquiora*, Galileo had already tried to close the gap between mechanics and cosmology through a cosmogonic tale. If my interpretation is correct, this was precisely due to "boundary conditions" created by Aristotelian natural philosophers. The latter regarded the agreement between a doctrine of motion (mechanics) and the order of the world (cosmology) as a norm thanks to which it is possible to understand whether a doctrine of motion is physically plausible. Galileo was therefore required to show that his Archimedean science of motion, which was not grounded in cosmology, was consistent with the real cosmological view, which he assumed to be geocentric. It is especially because Galileo accepted an Aristotelian norm in physics – a norm stating that a doctrine of motion must agree with cosmology to be physically valid – that he resorts to cosmogony in the *De motu antiquiora*. Galileo probably accepted this norm in order to fight the Aristotelians on their same battle field.

Thus, I believe that Büttner's conclusion can be applied to Galileo's geocentric cosmogony, which was not a "strategically planned step," but rather an "unavoidable encounter" between the 'Archimedean' science of motion and the geocentric system. But if my reconstruction is plausible, then Galileo's early attempt to heliocentric cosmogony shows that Galileo is deliberately, if not "strategically," returning to an old problem as soon as he believes to have what he needs to solve it.

In any case, Büttner is certainly right in pointing out that the need of encounter between mechanics and astronomy was originally forced onto Galileo by the philosophical context around him. And I also agree with Büttner when he leverages on this fact to debunk an important question in Galileo historiography: "the question – Büttner says – of whether it was a fully developed Copernican program that shaped

[56] Büttner (2001), pp. 400-401.

Galileo's science of motion or whether it was only his theory of motion that led to the development of such a program [...] is posed too narrowly."[57] As I have already said, there is no need, indeed, to raise a dichotomic question as to whether Galileo's science of motion stemmed from his adherence to Copernicanism, or the other way around. Such a question may mislead our historical inquiries, especially when they concern Galileo's approach to cosmogony.

Drake's discovery of Galileo's attempts to perform a series of cosmogonic calculations has given rise to new considerations about the role of mechanics and cosmology in Galileo. It has also allowed historians to ascertain, once more, that Galileo's cosmogonic calculations were doomed to failure. None of the proportions used by Galileo could have helped him find the supposed proportionality between the "sublimity" or height from which the planets began to fall, and the velocity of planets derived from the astronomical data provided by Kepler. Sure, scholars have noticed that Galileo considered Kepler's data to be approximative, since he tried to adjust the value of some of them. While Meyer and Büttner assumed that Galileo's adjustments are obtained through a rather empirical trial-and-error strategy, Bucciarelli has pointed out that "Galileo employs the mathematical rule of the 'double false position' (also known as method of Elchataym), which provides an iterative method to approximate the desired result by adjusting the variables."[58] Notwithstanding the attempts to adjust the values of Kepler's data, the scholars just mentioned all agree that Galileo could have never reached the desired result. Knowing this, it becomes difficult to understand why Galileo presents his cosmogony as a mathematical success. Why did Galileo give the readers of his two masterpieces the chance to reject, on a mathematical basis, the universal validity of the law of free fall?

§50.
GALILEO'S 'PLATONIC' COSMOGONY

There are two possible answers to the question just posed. The first one is that Galileo was led astray by Plato. Galileo's philosophical faith in Plato was such that he was eager to show the agreement between his science and Plato's cosmogony in the *Timaeus*. In this regard, some scholars have argued that Galileo's interpretation of Plato's cosmogony can be more or less legitimately regarded as faithful to the original

[57] Büttner (2001), p. 400.
[58] Bucciarelli (draft).

Greek.[59] However, this does not provide evidence that Galileo derived his cosmogonic hypothesis from Plato. Although in the *Dialogue* and the *Two New Sciences* the heliocentric cosmogony is preceded by a reference to Plato's cosmogony, this narrative sequence may not reflect the chronological and logical sequence actually followed by Galileo while developing his cosmogony. Such a transition from the narrative level to the historical one cannot be immediate. It may be that Galileo first developed his cosmogony and then ascribed it to Plato through a more or less legitimate interpretation of certain passages of the *Timaeus*. In this case, the most significant problem would be to understand why Galileo felt the need to ascribe his cosmogony to Plato. To this end, perhaps it would be useful to ascertain to what extent Galileo's reference to Plato responds to a rhetorical strategy.[60] And this can be done, for example, by studying the intertextual relationship between the cosmogonic narratives of the *Dialogue* and the *Two New Sciences*.

In the *Dialogue*, Salviati seems to refer to the *Two New Sciences* when he says that the cosmogonic calculations should be kept "for another time."[61] But in the *Two New Sciences* the calculations are again shrewdly evaded, and Salviati now only vaguely remember that Galileo once told him that he "made the computation, and also that he found it to answer very closely to the observations" (*mi par sovvenire che egli già mi dicesse, haver una volta fatto il computo, ed anco trovatolo assai acconciamente rispondere alle osservazioni*). Sagredo, too, seems to have forgotten that Salviati told him in the *Dialogue* that Galileo knew and discussed Plato's "sublime concept." He now just assumes that it is most likely to believe ("*mi pare assai credibile*") that Galileo, who certainly knew about Plato's concept, had performed the cosmogonic calculations out of curiosity.[62] Furthermore, the narrative perspective in the *Dialogue* perfectly mirrors

[59] Cf. Sambursky (1962), Acerbi (2000), Hankins (2000), De Pace (2005), De Pace (2020), pp. 355-395. Sambursky argued that Galileo combined *Tim*. 38c-39a with 30a and 43b, and that he interpreted them with the same "liberties of exegesis" he took years before when interpreting some passages of the Bible (cf. Sambursky (1962), p. 464). Acerbi suggests that Galileo's cosmogony might have been inspired by the same passages of the *Timaeus* already noticed by Sambursky (although Acerbi clearly does not know about Sambursky's paper), and he shows that those passages had already received diverse interpretations in the antiquity. De Pace argues that Galileo read Plato's *Timaeus* in the original Greek, coming up with a plausible interpretation of 38c6-39a3. On the other hand, Adriano Carugo has attempted to show that Galileo's cosmogony can in no way be reconciled with the original passages from Plato's *Timaeus* (cf. Carugo (2017)). For De Pace's arguments against Carugo's view, see De Pace (2020), pp. 380-381, nt. 95. James Hankins argued that Galileo borrowed some elements of his Platonic cosmogony from Ficino (cf. Haskins (2006), esp. p. 221). De Pace has strongly criticized Haskins's opinion (cf. De Pace (2006a), esp. pp. 506-507).

[60] Maurice Finocchiaro has delivered a crucial study highlighting the importance of rhetoric for Galileo's scientific explanations in the *Dialogue*. With respect to cosmogony, Finocchiaro shows the pitfalls of reading Galileo's cosmogony through 'Newtonian' lenses (cf. Finocchiaro (1980), p. 99, nt. 30).

[61] Cf. *supra*, nt. 41.

[62] Cf. the passage of the *Two New Sciences* cited *supra*, namely, Galilei (1974), pp. 232-234 [= OG, VIII, pp. 283-284].

that of the *Two New Sciences*. In the *Dialogue*, Salviati attempts "to adorn a Platonic concept" (*adornare un concetto Platonico*) through Galileo's science of motion; whereas in the *Two New Sciences*, Sagredo wants to "adorn" (*adornar*) Galileo's science of motion "through its agreement with the concept of Plato" (…*adornar questo pensiero dell'Autore con la conformità del concetto di Platone*…).[63] Also, in the *Two News Sciences* the Platonic concept is not *explicitly* associated with the heliocentric system.

These differences in the two narratives deserve to be studied carefully. They might provide evidence that Plato's cosmogony is strategically exploited by Galileo every time he wants to demonstrate that God arranged the world heliocentrically – as though to mitigate the scope of this demonstration. And this is in line with Salviati's claim that Galileo "did not want to talk about it [*viz*. the success of his cosmogonic computations], judging that he had discovered too many novelties that have provoked the anger of many, and others might kindle still more sparks."[64] Although this statement may just be fictional, we must notice that, at that time, Galileo's demonstration of the heliocentric cosmogony would have certainly added fuel to the fire had he not restricted it to an "illustration" of Plato's concept.

All this makes me believe that Galileo uses Plato to downplay a Copernican claim on the origin of the world – a claim supposedly based on mathematical computations. After all, thanks to Paolo Beni, Galileo knew that Plato's cosmogony was open to different interpretations.[65] Galileo must have realized that it was possible to dissimulate his strong Copernican beliefs behind Plato's myth. In this sense, the intent of Galileo's dissimulation does not differ much from that of Descartes in *Le Monde* (published posthumously in 1664), where the French philosopher "asks us 'in our imagination' to move out of sight of the world actually created five or six thousand years ago and to consider a new world where the laws of nature, acting on chaotic matter, produced a world very much like our own."[66] Galileo's strategy is even more effective

[63] This was already noticed by Fabio Acerbi while rebuking an opinion expressed by Koyré (cf. Acerbi (2000), pp. 360-361.

[64] Galilei (1974), pp. 233-234 [= OG, VIII, *Two New Sciences*, p. 284].

[65] On the connection between Galileo's heliocentric cosmogony and Paolo Beni's commentary on the *Timaeus*, see De Pace (2005), and De Pace (2020), pp. 368-395. On Beni's work and his more general relations with Galileo, see Bartocci (2013), and Bartocci (2016). Although I lean on the essential work of De Pace, my point of view on Galileo's cosmogonic calculations is the opposite of that held by De Pace. According to De Pace, "è lecito presumere che le conversazioni con Beni sui passi del *Timeo* in questione *precedettero* quei calcoli" (De Pace (2020), p. 374, my emphasis). In my view, it is equally "lecito" to assume that Galileo's heliocentric cosmogony was developed independently of Plato, and then it influenced Galileo's reading of Plato. This option in my view has the merit that invites us to reflect on why and how Galileo uses Plato. As Dollo had already noticed, Galileo is a *selective* Platonist (cf. Dollo (2003), pp. 23-62). Also, in one of his essential essays Galluzzi has highlighted that it is important to historicize Platonism (cf. Galluzzi (1973)). In this regard, I am convinced that, just like Charles B. Schmitt suggested that we should talk of Aristotelianism*s*, we should also talk of Platonism*s* in the Renaissance. We should then try to understand what kind of Platonist was Galileo, and why.

[66] Ashworth (1986), p. 140.

than that of Descartes. Galileo does not leverage on our imagination. Instead, he asks us to regard his cosmogony as a scientific interpretation of Plato's myth, thereby charging Plato (not our imagination) with Galileo's own opinion. By so doing, Galileo disclaims responsibility for the heliocentric cosmogony; at the same time, he shifts responsibility for it onto an important philosophical *auctoritas*. Similarly, he lowers the heliocentric cosmogony to the rank of a myth, while also advancing an interpretation of it that makes it a "likely history" (*verace istoria*). These features make Galileo's Copernican beliefs a less easy target for censorship than those of Descartes. Galileo's dissimulation is so effective that he can again resort to Plato's cosmogony in the *Two New Sciences*, five years after the abjuration (22 June 1633). Although no explicit reference is made to the heliocentric system, I agree with Lucia Bucciarelli that "Galileo's [cosmogonic] narration in the *Two New Sciences* – introduced as a mere digression – represented the '*eppur si muove*' (and yet it moves) that Galileo did not pronounce after the 1633 condemnation."[67]

If not led astray by Plato, then why did Galileo refer twice to his impossible cosmogonic calculations? There may be another answer to the question. While underlining the fact that the results of Galileo's calculations could not square with Kepler's astronomical data, Eric Meyer made the following observation:

> In order to find a reasonable explanation for Galileo's willingness to overlook this disagreement rather than concede failure, one must first recall that the planetary data available to Galileo were themselves open to question. Copernicus had, after all, been the first astronomer to determine the absolute sizes of the planetary orbits; it would hardly be surprising if his figures were somewhat in error. Significantly, Kepler had devoted an entire chapter (Ch. 18) of the *Mysterium* to this issue, by way of excusing the discrepancies between the sizes of his own five geometric solids and the Copernican orbits. He had even gone so far as to suggest that his scheme of solids might serve to correct any errors in the Copernican data! Now Galileo's theory was straying further from these figures than Kepler's did; had his knowledge of astronomy been deeper, he might have placed smaller limits on the possible errors in the Copernican ratios. *Yet his physics also gave him deeper reasons for attributing the deficiency to the data. This cosmogony was the only possible one, for if the planetary motions had a natural origin – and Galilean physics would have little relevance for astronomy if they did not – it must have been in falling toward the Sun.* Moreover, the common point of origin did nicely account for the observed fact that the inner

[67] Bucciarelli (draft). On Galileo's use of dissimulation, see Bucciarelli (2019).

> planets move at progressively greater speeds, a convincing argument for the essential correctness of the idea.[68]

Galileo knows that his geometric science of motion is not *ipso facto* a universal science of motion. A new conception of gravity allows him to speculate about the universal applicability of the laws of his new science of motion. But in order for such a speculation to be scientifically corroborated, Galileo must abide by his own scientific method, which in this case obliges him to provide necessary (i.e. mathematical) demonstrations in accord with astronomical data. Galileo is confident that the law of free fall can be extended to the universe. Too confident, perhaps.

§51.
COSMOGONY DENIED?

In Galileo's cosmogony, the planets acquire their orbital velocity by falling from a certain height. Galileo believes that this is the only possible narrative if we are to hold that God abided by the laws of nature when He arranged the world. Besides, Galileo claims that this cosmogonic narrative is confirmed by mathematical calculations. However, on certain occasions Galileo seems to give up his cosmogony, especially when he claims that the planets are carried around by the Sun. This implies that they did not acquire their velocity through free fall. In what follows, I shall attempt to show that: (1) Galileo's appeal to the motive power of the Sun falls within rhetorical strategies in support of Galileo's reading of the Bible; (2) the idea of the Sun as a planetary mover has been wrongly ascribed to Galileo on the basis of a biased interpretation of some passages of the *Dialogue*.

1. *Cosmogony denied? The* Copernican Letters.

In the so-called *Copernican Letters*, Galileo strives to make a convincing case for the independence of natural philosophy from theology. Galileo appeals to religious and political authorities, asking them to tolerate the disinterested pursuit of truth in

[68] Meyer (1989), pp. 467-468, my emphasis.

matters which fall outside the ultimate scope of the Bible, which according to Galileo is spiritual salvation.[69]

Although in the Bible there are passages which might suggest that the world is geocentric, Galileo thinks that those passages can be interpreted differently. The core of Galileo's argument is that God is both the *author* of the Bible and the *maker* of the universe. As the author of the Bible, God operated through the intermediation of men who needed to be understood by other men; thus, the Bible is written in a simple language open to ambiguity and subject to interpretation. As the maker of the universe, God provided the world with immutable and inviolable laws, which are used by nature regardless of human wishes and prayers. So, while the Bible is written *for* human beings, nature can be regarded as a book written *regardless of* human beings. However, Galileo thinks that there is at least a reading strategy which men can use to understand nature. Lest ascribing mutability to the laws of nature, the book of nature must be read in a way that is not open to interpretation; since Euclidean geometry *cannot* yield contradictory results, geometry is the only language that allows for *definitive* readings of nature. Once the natural philosopher has been able to read nature through geometry, he *cannot* withdraw or re-interpret what he has read.

Galileo is convinced that this mathematical constraint cannot be breached by theologians. He argues that the objective of theologians should be distinguished from that of natural philosophers. On the one hand, natural philosophers trained in mathematics seek to understand some truths about nature; on the other hand, theologians protect the true Revelation of the Bible from being misunderstood. In Galileo's perspective, the work of theologians is twice as difficult as that of natural philosophers. For theologians must understand and be aware of the discoveries of natural philosophers in order to align them with the Bible. Since the truth of the Bible and that of nature cannot clash with each other – as they both stem from God –, the arduous task of reconciling science and faith falls entirely on theologians' shoulders.

Now, in the *Copernican Letters* Galileo tries to show to theologians that some passages of the Bible might only appear to be geocentric. One of these passages is *Joshua* 10: 12-13, where we it is written that Joshua prayed God to stop the Sun and the Moon, in order to give the Israelites more time to win the Amorites: "So the Sun stood still, and the Moon stopped [...]. The Sun stopped in the middle of the sky and delayed going down about a full day" (NIV).

[69] The secondary literature on Galileo's *Copernican letters* is immense. The brief overview that I shall propose here is based on my personal reading of the *Copernican letters* mediated by the following studies: Martini (1972), Fabris (1986), Rossi (1989), pp. 67-89, Shea (1989), pp. 107-129, Blackwell (1991), Stabile (1994), Carroll (1997), McMullin (1998), Carroll (1999), Pesce (2000), Howell (2002), Pantin (2002), Pesce (2005), Hamou (2008), Bucciantini's and Camerota's *Introduciton* to Galilei (2009), Damanti (2009), Guerrini (2009), Camerota (2010), Camerota (2011), De Pace (2016).

It is easy for us to think that Joshua employs a common way of speaking: after all, we still say today that the Sun and the Moon *rise* and *set*. But at Galileo's time, such a reading was not allowed by theologians, who supported a literal reading of the Bible.[70] How can the literal reading of *Joshua* 10: 12-13 agree with a non-geocentric cosmology? Galileo embarks in the difficult task of showing that the literal reading of *Joshua* 10: 12-13 would backfire against those who support a geocentric reading of it.

First of all, Galileo argues that it is always necessary to "gloss and interpret" the words of Joshua in order to make sense of them.[71] But whatever it is the interpretation one gives to *Joshua* 10: 12-13, it is impossible to provide a geocentric literal reading of it. On the contrary, the Copernican system fits well into a literal reading of the same passage, when the latter is given a certain interpretation. Thus, lest saying that the Copernican system is in accord with the literal meaning of *Joshua* 10: 12-13, theologians must agree that the Bible cannot always be read in a literal sense. Finally, Galileo concludes that the literal reading of the Bible cannot be used as a norm to determine what the real cosmic order of the world is.[72]

Before focusing on Galileo's solution, which leverages on the Sun as a planetary mover, three important things must be noted. First, Galileo does not aim at convincing theologians that the Bible must be read in a Copernican sense. He does not claim that the Copernican reading of *Joshua* 10: 12-13 is the true one. The Copernican reading can only be determined by theologians. Galileo is in fact asking theologians to endorse an exegetical approach in which *they* take account of science in order to determine how the Bible must be read. So, Galileo is just suggesting a possible reading of *Joshua* 10: 12-13, in order to persuade theologians that another exegetical approach is viable. In this regard, it must be noted that in the *Copernican Letters*, the Copernican system is presented by Galileo as a scientifically valid alternative to the geocentric view. But Galileo does never claim that the Copernican system has been scientifically proven. He claims that it *might* be proven one day, given that some of its features do already make it a better alternative to geocentricism in natural philosophy. Galileo's strategy is to leverage on these features in order to (*a*) convince religious and political authorities to be open-minded about the Copernican system, and (*b*) show that a Copernican reading of some critical passages of the Bible is *possible*. Both (*a*) and (*b*) have a common objective: to prevent a theological interference, which was also a

[70] After the Council of Trent (1545-1563), this exegetical approach was binding for Catholic thinkers.

[71] Cf. Galilei (2008), *Letter to the Grand Duchess Christina*, p. 128 [= OG, V, p. 330].

[72] On this point, I fully agree with Giorgio Stabile, Michele Camerota, and Carla Rita Palmerino, *pace* Mauro Pesce (cf. Stabile (1994), p. 63, nt. 51, Camerota (2004), pp. 271-272, Palmerino (2006), pp. 32-33, Pesce (2005), p. 101). However, I believe that Paolo Rossi was right when he highlighted that Galileo *risks* to compromise ("rischia di compromettere") his own exegetical principles (cf. Rossi (1989), p. 83).

threatening institutional interference, on matters that fall within the purview of natural philosophy.

The second important thing to be noted is that Galileo is forced by historic-political circumstances to address exegetical problems. For this reason, the *Copernican Letters* cannot be regarded as a unitary and coherent scientific treatise: they are rooted in a certain political context and their objective is oriented toward the achievement of a precise political goal. While dealing with politics and strong institutional powers, Galileo has to be extremely careful with what he writes. The recent finding of the original Copernican letter to Castelli has shown that Galileo was indeed so worried as to modify those words and statements that might have generated conflictual reactions. A conflict would have certainly jeopardized the success of his political goal.[73]

The third important point is that Galileo is not a theologian. When, in 1613, he writes the first *Letter* to his pupil Benedetto Castelli, he relies on his own exegetical wit. But when he writes the *Letter to the Grand Duchess Christina*, Galileo is most likely assisted by Castelli and perhaps another theologian, who help him trace his view back to positions well attested in the exegetical tradition.[74] Galileo, then, is no longer alone in his battle, and he is also well-documented. In this regard, Bernard R. Goldstein has attempted to understand Galileo's use of the sources of the *Letter to the Grand Duchess*. Goldstein pointed out that Cosme de Magalhães's *In sacram Iosue historiam* (1612) is the main source from which Galileo draws important information on different readings concerning, for instance, the miracle described in *Joshua* 10: 12-13. Goldstein also noticed that Galileo adds information that cannot be found in Magalhães's text. Consider the following passage from Galileo's *Letter to the Grand Duchess*:

> For example, Dionysius the Areopagite says that it was not the Sun but the Prime Mobile which stopped; St. Augustine thinks the same thing, namely, that all heavenly bodies stopped; and the bishop of Avila [*viz.* Alfonso Tostado (1400-1455)] is of the same opinion. Moreover, *among the Jewish authors whom Josephus endorses, some thought that the Sun did not really stop, but that it appeared so for the short time during which the Israelites defeated their enemies*.[75]

Goldstein could not find a passage in Magalhães's text where it is said that Titus Flavius Josephus argues what Galileo claims in the passage above. Because of this, Goldstein suggested that we

[73] Cf. Camerota-Giudice-Ricciardo (2019a) and (2019b).
[74] On this point, see the important observations in De Pace (2016).
[75] Galilei (2008), *Letter to the Grand Duchess Christina*, p. 135, my emphasis [= OG, V, p. 337].

> might emend Galileo's text slightly, substituting the Bishop of Avila (mentioned at the end of the preceding sentence) for Josephus, in which case the text would read: according to the Jewish authors endorsed by the Bishop of Avila, the Sun did not really stand still but merely appeared to do so by reason of the shortness of the time during which the Israelites defeated their enemies. But that does not work because the Bishop of Avila opposed this view and, in any event, he does not ascribe it to Jewish authors.[76]

Thus, Goldstein concluded that "Galileo read Magahaens's text and then cited it from memory leading to various divergences from his source," and that "Galileo has confounded his sources."[77] However, as I tried to show elsewhere, it is methodologically unsound to derive such important conclusions – so important as to have a great impact on our historical narratives – from our inevitably biased knowledge of the sources of that time.[78] In this case, Goldstein was led astray by a perfectly understandable oversight. Otherwise, he would have realized that Galileo is not confounding his sources, or citing from memory, as testified by the following verbatim correspondence:

Magalhães	Galileo
Sunt inter Hebraeos, quibus videtur favere Iosephus, qui existimant Solem *et Lunam* revera non stetisse, sed visos fuisse stetisse ob brevitatem temporis, quo Israelitae hostes suos debellarunt.[79]	… tra gli autori Ebrei, a i quali applaude Ioseffo, alcuni hanno stimato che veramente il Sole non si fermasse, ma che così apparve mediante la brevità del tempo nel quale gl'Isdraeliti dettero la sconfitta a' nemici.[80]

Magalhães's text is even more similar to Galileo's original words than Elia Diodati's Latin translation of the *Letter to the Grand Duchess* is.[81] Notwithstanding the missing

[76] Goldstein (1990), p. 14.

[77] *Ibid.*, p. 15.

[78] As for my doubts about a *Quellenforschung* applied to the *Juvenilia*, see Malara (2019), and *supra*, §6, 21.

[79] Magalhães (1612), p. 338, my emphasis.

[80] OG, V, *Letter to the Grand Duchess Christina*, p. 337.

[81] "Sed multo magis inter auctores Hebraeos nonnulli (quibus adstipulatur Iosephus) existimarunt, Solem re vera substitisse immotum, sed pro brevi tempore, intra quod Israelite hostes suos fuderunt, id ita visum esse" (Galilei (2012), p. 96). As far as I know, Bucciantini has been the only one who has been able to recognize the striking similarity between the two passages collated above (cf. Galilei (2009), p. 70, nt. 90). However, he regarded it as a further piece of evidence in support of Goldstein's thesis.

reference to the Moon, Galileo's passage can be successfully paired with Magalhães's text. It seems likely to me that Galileo has received some excerpts of Magalhães's text from Castelli, or another peritus. Also, it is possible that the excerpts were already translated into vernacular when Galileo read them. At any rate, the passage above bears evidence that Galileo was very careful not to include inaccurate information in the *Letter to the Grand Duchess*. Given the political circumstances, he could not afford to cite from memory.

The three points just outlined, namely, (1) the exegetical challenge, (2) the political mission, and (3) the effort toward theological accuracy, must all be taken into account in order to correctly frame Galileo's reference to the motive power of the Sun. Now, in the *Letter to Castelli* and in the *Letter to the Grand Duchess*, Galileo leverages on two (interpretative) premises to show that there might be literal agreement between *Joshua* 10: 12-13 and the Copernican system:

1. it must be conceded that God does not alter the order of nature;
2. it is reasonable to suppose that the Sun is the motive power of planets.

As for the first point, Galileo claims that the maintenance of order involves that God stopped all planets from moving, "so that the stopping of only one would not introduce unnecessarily universal confusion and great turmoil in the whole order of nature."[82] But, while in the *Letter to Castelli* this conclusion is only logically inferred by Galileo, in the *Letter to the Grand Duchess* it is solidly grounded in an authoritative exegetical tradition, including *auctoritates* such as "Dionysius the Areopagite," "St. Augustine himself, and the Bishop of Avila."[83]

As for the second point, in the *Letter to Castelli* Galileo recalls that he has "necessarily demonstrated" (*necessariamente dimostrato*) that the Sun turns around its own axis. Then he claims that this scientific truth makes it "very reasonable" to believe that the Sun, "as if it were the heart of the world, gives not only light, as it clearly does, but also motion to all the planets which revolve around it."[84] In the *Letter to the Grand Duchess*, Galileo adds other two considerations in support of this opinion: (1) he specifies that he has conclusively ascertained that the Sun is the only source of light; (2) he says that many "serious authors" have argued for "the admirable power and strength of the Sun," but he restricts himself "to just one passage from the book *The Divine Names* by the Blessed Dionysius the Areopagite."[85]

Having established both points, Galileo can explain his exegetical solution:

[82] Galilei (2008), *Letter to the Grand Duchess Christina*, p. 142 [= OG, V, p. 345].
[83] *Ibid*, p. 141 [= OG, V, p. 344].
[84] Backwell (1991), Appendix IV (*Letter to Castelli*), p. 201 [= OG, V, p. 287].
[85] Cf. Galilei (2008), *Letter to the Grand Duchess Christina*, p. 142 [= OG, V, p. 345].

> Therefore, given that the sun is both the source of light and the origin of motion, and given that God wanted the whole world system to remain motionless for several hours as a result of Joshua's order, it was sufficient to stop the sun, and then its immobility stopped all the other turnings, so that the earth as well as the moon and the sun (and all the other planets) remained in the same arrangement; and during that whole time the night did not approach, and the day miraculously got longer. In this manner, by stopping the sun, and without changing or upsetting at all the way the other stars appear or their mutual arrangement, the day on the earth could have been lengthened in perfect accord with the literal meaning of the sacred text.[86]

As Massimo Bucciantini has neatly pointed out, it is evident that Galileo is intertwining two rhetorical levels: one strictly scientific and supported by necessary demonstrations; the other one less ascertained, a little ambiguous, and at most probable. It is within the latter that the Sun is regarded as the source of planetary motion. And although this opinion, as Bucciantini writes,

> does not lack its own kind of "natural" plausibility – which derives from the idea of the Sun as "the instrument and highest minister of nature," source of light for the whole universe (as it is also gathered from the discovery of its rotating motion) – who cannot see that its value as the "most probable and reasonable" proposition depends from the confrontation with Scripture?[87]

I would go further and say that in the *Letter to the Grand Duchess* Galileo is willing to give up his epistemological standpoint in order to succeed in the "confrontation with Scripture." This can be noted when, for instance, Galileo assumes that the world is spherical, as though this were a fact that need not be ascertained via geometrical demonstration:

> Furthermore, what deserves special appreciation, if I am not mistaken, is that with the Copernican system one can very clearly and very easily give a literal meaning to another detail which one reads about the same miracle; that is, that the Sun stopped in the middle of heaven [*viz. Joshua* 10: 13]. Serious theologians have raised a difficulty about this passage […]. We can remove

[86] *Ibid.*, pp. 142-143 [= OG, V, p. 345].

[87] Bucciantini (2003), p. 240, my translation. Similar observations in this regard were made by Paolo Rossi: "La distinzione fra le 'probabili opinioni' e le 'verisimil conietture' e la 'sicura e dimostrata scienza' è dunque fortemente presente anche in queste 'singolari' pagine galileiane" (Rossi (1989), p. 85).

> this and every other implausibility, if I am not mistaken, by placing the Sun, as the Copernican system does and as it is most necessary to do, *in the middle, namely, at the center of the heavenly orbs and of the planetary revolutions*; for at any hour of the day, whether at noon or in the afternoon, the day would have been lengthened and all heavenly turnings stopped by the Sun stopping in the middle of the heavens, namely, at the center of the heavens, where it is located.[88]

Galileo is strategically exploiting the sphericity of the world to meet his exegetical purpose. This, again, invites us to consider that the *Copernican Letters* cannot be regarded as a scientific treatise. In the *Copernican Letters*, Galileo puts forth opinions and supports ideas that are not given a scientific status by Galileo himself when he writes as a natural philosopher. Among these opinions and ideas there is certainly the conception of the Sun as a planetary mover.

2. *Cosmogony denied? The fourth day of the* Dialogue.

Some scholars have pointed out that in the fourth day of the *Dialogue* Galileo appeals to the idea of the Sun as a planetary mover.[89] In what follows, I shall attempt to understand whether this claim finds adequate support in Galileo's text. To this end, I will also cite long passages from Galileo's fourth day of the *Dialogue*.

According to Galileo, tides are caused by two genres of causes: (1) the "primary cause," that is, the Earth's double rotation around its axis and around the Sun; and (2) a set of "concomitant causes" which produce effects that cannot be brought about by the primary cause alone. For instance, the primary cause can account for a twenty-four-hour tidal period, but Galileo knows that it takes twelve hours to complete a tidal period in the Mediterranean Sea. The latter can be explained by pointing out the concomitant causes that, along with the primary cause, are responsible for it.

The distinction between primary and concomitant causes can be easily misunderstood. Galileo does not claim that the concomitant causes are independent of the primary cause. On the contrary, he believes that the concomitant causes are removed upon removal of the primary cause. So, even the "accidental effects" brought about by concomitant causes – e.g., the six-hour tidal period – require a necessary, though not sufficient, condition to exist, namely, the Earth's double rotation:

[88] Galilei (2008), *Letter to the Grand Duchess Christina*, pp. 143-144, my emphasis [= OG, V, p. 347].
[89] In particular, see Applebaum-Baldasso (2001), and Bucciantini (2003), pp. 306-308.

> Now this [the Earth's double rotation] is the most fundamental and effective cause of the tides – says Salviati –, without which they would not take place. But the particular events observed at different times and places are many and varied; these must depend upon diverse *concomitant causes, though all must have some connection with the primary cause*. So our next business is to bring up and examine the different phenomena which may be the causes of such diverse effects.[90]

For instance, to the question 'why do we see that the Moon exerts a certain effect on tides?', Galileo replies that the supposed attraction of the Moon can be explained as the effect of a concomitant cause in which the Moon's rotation plays a role along with the Earth's double rotation. Galileo is indeed convinced that the explanation of tidal phenomena must not rely on notions (e.g., attraction) whose status is epistemologically unclear and uncertain:

> There are two events [*accidenti*] whose causes we must investigate; the first concerns the variation which occurs in the tides over a monthly period, and the other belongs to the annual period. We shall speak first of the monthly, and then deal with the annual; and we must first resolve the whole *according to the axioms and hypotheses already established, without introducing any innovations either from astronomy or from the universe to help out the tides*. We shall demonstrate that the causes for all the various events perceived in the tides reside in *things already recognized and accepted as unquestionably true*.[91]

Here, we are already looking at a passage which is in principle preventing Galileo from using the supposed motive force of the Sun to account for tides. As we have seen, in the *Copernican Letters* Galileo supposed that the idea of the Sun as a planetary mover is only "probable and reasonable." So, it would be strange that now, in the *Dialogue*, Galileo is willing to place that very same idea among the "things already recognized and accepted as unquestionably true." This would be also at odds with the fact that the Sun as a planetary mover is not among the "axioms and hypotheses" that in the passage above are said to have been "already established."[92] However, it may well be

[90] Galilei (1967), p. 428, my emphasis [= OG, VII, *Dialogue*, p. 454]

[91] *Ibid.*, p. 449, my emphasis [= OG, VII, *Dialogue*, p. 474].

[92] According to Applebaum and Baldasso, Galileo does also refer to the Sun as a planetary mover in the third day of the *Dialogue* (cf. Applebaum-Baldasso (2001), p. 388, nt. 38). However, in the passage they refer to Galileo is only showing that the rotating movement of sunspots can be more easily explained by assuming that the Earth moves around the Sun (for important considerations on how to read this passage, see Finocchiaro (1980), pp. 248-249).

that in what follows Galileo contravenes his own epistemological standpoint. Let us see, then, whether Galileo is led to such a patent contradiction.

Salviati continues by pointing out what he considers to be an unquestionable truth:

> Thus I say that one true, natural, and even necessary thing is that a single movable body made to rotate by a single motive force will take a longer time to complete its circuit along a greater circle than along a lesser circle. This is a truth accepted by all, and in agreement with experiences, of which we may adduce a few.[93]

In this passage, Galileo holds that a body which is moved by a certain "motive force" (*virtù motrice*) does "take longer time to complete its circuit along a greater circle than along a lesser circle." This "truth accepted by all" can be illustrated through two "experiences."

The first example is taken from the functioning of "wheel clocks." These mechanical watches worked thanks to a device called escapement. The escapement performs an important job: it links a certain "motive force" to the timekeeping device. Before reaching the timekeeping device, the motive force is channelled into a train of gears that, along with the escapement, convert the motive force into a slow motion that keeps an equal pace. Through Salviati, Galileo points out that the wheel clocks are sometimes also endowed with a particular mechanical device thanks to which one can "regulate the time in wheel clocks." This mechanical device is taken by Galileo as a fitting example to illustrate how a body moved by the same motive force takes longer time to complete its circuit along a greater circle than along a lesser one:

> In order to regulate the time in wheel clocks, especially large ones, the builders fit them with a certain stick which is free to swing horizontally. At its ends they hang leaden weights, and when the clock goes too slowly, they can render its vibrations more frequent merely by moving these weights somewhat toward the center of the stick. On the other hand, in order to retard the vibrations, it suffices to draw these same weights out toward the ends, since the oscillations are thus made more slowly and in consequence the hour intervals are prolonged. *Here* the *motive force* is the same, that is, the *counterweight*, and the moving bodies are the same weights; but their vibrations are more frequent

[93] Galilei (1967), p. 449 [= OG, VII, *Dialogue*, p. 474].

> when they are closer to the center; that is, when they are moving along smaller circles.[94]

"Here," that is, 'in this example,' the motive force is the suspended weight, that is, the "counterweight," whose power is linked to the timekeeping device through an escapement device. The two leaden weights represent "moving bodies," namely, bodies moved by the same motive force. The leaden weights are indeed placed on the extremities of a stick whose horizonal swinging is powered by the counterweight's motive force. By displacing the leaden weights closer to the center of the stick, the stick decreases its swinging period, while the motive force is kept the same.

Galileo has illustrated an "unquestionably true" principle through an example taken from ordinary "experience." Is it ordinary, though? Perhaps it was not so common to see those big "wheel clocks" described by Galileo. Maybe because of this, Galileo also refers to another experience within everyone's reach: the swinging of a weight attached at the extremity of a thread. 'What? – Galileo seems to ask to his reader – can you not picture a swinging pendulum in your mind? Well, do not bother about it. Follow my instructions and check out yourself what I am trying to explain to you.' And Salviati does indeed instruct the reader as follows:

> Attach such a weight to a cord passed through a staple fastened to the ceiling, and hold the other end of the cord in your hand. Having started the hanging weight moving, pull the end of the cord which you have in your hand so that the weight rises while it is making its oscillations. You will see the frequency of its vibrations increase as it rises, since it is going continually along smaller circles.[95]

It is this kind of informative effort that makes Galileo a real master of science communication. Even I today can perfectly understand what Galileo is saying. Even I today can replicate the experience described by Galileo. And when I do replicate it – as I am doing right now – I realize that, using my left hand, I am imparting a motive force to the hanging weight. The same motive force is then maintained while, with my right hand, I pull the other end of the thread, thereby bringing the hanging weight

[94] *Ibid.*, my emphasis [= OG, VII, *Dialogue*, pp. 474-475].

[95] *Ibid.*, pp. 449-450 [= OG, VII, *Dialogue*, p. 475]. From the English translation, one may even think that the weight can impart its own motive force after it has been released. But the original Italian passage seems to exclude this sense: "Ma più: attacchisi un tal peso a una corda la quale cavalchi un chiodo fermato nel palco, e voi tenete l'altro capo della corda in mano, ed *avendo data l'andata al pendente peso*, mentre ei va facendo sue vibrazioni, tirate il capo della corda che avete in mano, sì che il peso si vadia alzando…" (my emphasis).

up closer to the suspension point. Galileo is perhaps trying to tell me that I have imparted a tangential velocity to the hanging weight. The same tangential velocity makes the weight move with a different angular velocity along different concentric circles. But how does this relate to the Moon's effect on tides?

> Now – continues Salviati – if it is true that *the force which moves the Earth and the Moon around the Sun* always retains the same strength, and if it is true that the same moving body *moved by the same force* but in unequal circles passes over similar arcs of smaller circles in shorter times, then it must necessarily be said that the Moon when at its least distance from the Sun (that is, at conjunction) passes through greater arcs of the Earth's orbit than when it is at its greatest distance (that is, at opposition and full moon). And it is necessary also that the Earth should share in this irregularity of the Moon.[96]

Having assumed all this, Galileo can then conclude his explanation:

> From this it may be clear that the annual movement of the earth in its orbit along the ecliptic is not uniform, and that its irregularity derives from the Moon and has its periods and restorations monthly. Now it has already been decided that the monthly and annual periodic alterations of the tides could derive *from no other cause than from varying ratios between the annual motion and the additions to it and subtractions from it of the diurnal rotation*; and that such alterations might be made in two ways; that is, by altering the annual motion and keeping fixed the magnitudes of the additions, or by changing the size of these and keeping the annual motion uniform. We have now detected the first of these two ways, based upon the unevenness of the annual motion; it depends upon the Moon, and has its period monthly. Thus it is necessary that for this reason the tides should have a monthly period within which they become greater and smaller.
>
> Now you see how the cause of the monthly period resides in the annual motion, and at the same time you see what the Moon has to do with this affair, and how it plays a role without having anything to do with oceans or with waters.[97]

As we can see, in this explanation Galileo does not appeal to the idea of the Sun as a planetary mover. When he refers to the "force which moves the Earth and the Moon around the Sun," he does not say what that force is, or from where it comes. He only

[96] *Ibid.*, p. 453, my emphasis [= OG, VII, *Dialogue*, p. 478].
[97] *Ibid.*, pp. 453-454, my emphasis [= OG, VII, *Dialogue*, pp. 478-479].

asks the reader to suppose that the "motive force" moving the Earth and the Moon is the same. This is how Galileo have Salviati resume the analogy with the clock:

> So that what happens in this matter is just what happened to the rate of the clock, *the Moon representing to us that leaden weight which is attached now farther from the center, in order to make the vibrations of the stick less frequent, and now closer, in order to speed them up*.[98]

What does the Sun represent, though? Is it the *counterweight*? Galileo does not say it, and there is no reason to ascribe to him such a claim. In my view, there is a lack of evidence in support of the reading according to which Galileo appeals to the Sun as a planetary mover in the fourth day of the *Dialogue*.

There is however a passage that might be regarded as an implicit denial of cosmogony:

> Getting back to our original purpose, we were explaining that for things moved circularly by some motive force which is kept continually the same, the times of circulation are preestablished and determined, and impossible to lengthen or shorten. Having given examples of this and brought forth sensible experiments which we can perform, we may affirm the same to be true of our experience of the planetary movements in the heavens, for which the same rule is seen to hold: Those which move in the larger circles consume the longer times in passing through them.[99]

If by "motive force" Galileo means tangential velocity, as I have suggested earlier, Galileo does clearly say that all planets move along their orbit with the same 'degree' of velocity. This would be in contrast with Galileo's cosmogony, where planets acquire a different degree or *momentum* of velocity by means of naturally accelerated fall. As a consequence, Galileo's opinion about the planets' motive force would be also in contrast with the Copernican (and traditional) 'rule' stating that the inner planets have a greater velocity than the outer ones. This rule was confirmed by the astronomical data compiled by Kepler in the *Mysterium* – the same data used by Galileo in his cosmogonic calculations.[100]

But is it right to replace "motive force" for 'tangential velocity,' as I did earlier? It is not. Not only is Galileo silent about the origin of the motive force, but he also

[98] *Ibid.*, p. 453, my emphasis [= OG, VII, *Dialogue*, pp. 478].
[99] *Ibid.*, p. 452 [= OG, VII, *Dialogue*, pp. 477].
[100] Cf. Drake (1973), pp. 175-190, Meyer (1989), pp. 458-460, Bucciantini (2003), pp. 106-107.

refrains from saying in clear terms *what* the motive force is. It is not by chance, I believe, that Galileo uses a generic expression instead of making a clear reference to velocity. The expression "motive force" is ambiguous by choice. Galileo scholars should not seek to sort out the ambiguity. Ambiguity is already *as such* an important evidence to be taken into account when attempting to understand the passages of the *Dialogue* cited above.

§52.
Cosmogony and Theology

Alexandre Koyré was convinced that Galileo had never attempted to calculate the height from which God let the planets fall. This however did not prevent Koyré from claiming that Galileo's heliocentric cosmogony was more than a mere rhetorical exercise:

> It seems to me – Koyré writes – therefore that only one conclusion is possible. For Galileo the "Platonic" cosmology is not a simple μῦθος, like that of the *Timaeus*, but a possible if not a "true" story.[101]

The fact that Galileo did actually perform the calculations corroborates Koyré's opinion. But my question now is: did Galileo hope to demonstrate something through those calculations? If yes, what did he want to demonstrate?

In my account of Galileo's cosmogony, I have often used the verb "to demonstrate." I did it in a rather loose sense, to show that Galileo adopts a specific epistemological strategy, which leads him to reframe cosmogony into a mathematical problem-solving situation. Only if this situation can be solved by applying the mathematics behind the new science of motion, Galileo feels allowed to claim that the law of fall extends to the universe, and that all planets gravitate around the Sun. In this broader sense, Galileo's cosmogonic calculations were meant to *demonstrate* that the cosmogonic problem can be solved. And this was probably enough for Galileo to claim that the Copernican system was given an adequate physical explanation.

Can this loose meaning of 'demonstration' be used to say that Galileo attempted to demonstrate that God let the planets fall from a certain height? To put it more radically, does Galileo's cosmogony demonstrate God's existence? Obviously, it does not. Although Galileo's cosmogony requires God, Galileo was certainly aware that a successful mathematical solution to the cosmogonic problem would have not

[101] Koyré (1965), p. 220.

amounted to a demonstration of God's existence. Geometrical demonstrations can be also based on false assumptions. Some of Archimedes' demonstrations, for example, are based on the false assumption that geometrical figures have a center of gravity.[102] So, Galileo perhaps knew that his attempt to demonstrate that all planets fell from the same height had neither positive nor negative bearings on theology.

In the *Two New Sciences*, there is however a beautiful passage where issues about God and creation are taken up by Simplicio. It is the third day. Salviati is reading a series of theorems and propositions on rectilinear and circular motion, when Sagredo interrupts him, out of the blue, with the usual politeness formula: "Please, Your Lordship, allow me to interrupt your lecture for a moment in order that I may clear up an idea which just occurs to me." Sagredo is now allowed to begin a relatively short digression, where he points out a "freakish and interesting circumstance" (*uno scherzo grazioso*) that happens in nature. Let a pebble drop into quiet water, says Sagredo, you will see a series of concentric waves departing from the pebble. Now imagine a point crossed by an infinite number of lines, and imagine that on each line there is a body. All bodies depart at the same time from the crossing point and move with uniform velocity along their line. While each of them moves on a straight line, if you visualize them conjointly, you will see a circle departing from its center and gradually enlarging, just like concentric waves in quiet water. Now, imagine a horizontal plane, continues Sagredo, and pick a point on it. Under that plane, and from that point, let depart an infinite series of lines inclined at every possible angle. Then imagine that on each line there is a body, and that each body starts moving simultaneously with naturally accelerated velocity from the inclination point. Also, imagine that after a certain time, another infinite series of bodies do the same. Although each of them moves on a straight path with uniformly accelerated velocity, taken all together, they make up gradually enlarging circles. And although these circles are not concentric, but eccentric, Sagredo finds it remarkable that nature can use both uniform and naturally accelerated motion on a straight trajectory to produce circles. Salviati agrees that this is truly remarkable, indeed.[103]

Simplicio, too, cannot hold his wonder. For though he is not fully able to understand why accelerated motion would produce circles, nonetheless he believes that Sagredo's observations find natural outlet in the explanation of a "great mystery":

> For my part – says Simplicio – I can at least grasp this idea of the manner of production of circles and spheres by the two different natural motions, although I [still] do not completely understand some of the results that depend

[102] Cf. OG, I, p. 300 [= first version of the *De motu antiquiora*].
[103] Cf. OG, VIII, *Two New Sciences*, p. 225.

> on accelerated motion, and some of its demonstrations. Yet since we can assign as the site of such emanations the lowest center, as well as the highest spherical surface, I believe that some *great mystery* may perhaps be contained in these true and admirable conclusions – I mean a *mystery* that relates to the *creation of the universe*, which is supposed to be spherical in shape, and perhaps [relates] to the *residence of the first cause* [*alla residenza della prima causa*].[104]

Simplicio is Galileo's most beautiful narrative creation. His character embodies a wide spectrum of personalities, ideas, and philosophical attitudes. And yet, this does not make his opinions inconsistent. The consistency of such a multifaceted character comes out by contrast with Salviati and Sagredo. These two characters share a common epistemological point of view; Simplicio does not have a single epistemological point of view: he has many points of view, just as he is many characters in one. Outside the dialogical dimension, Simplicio ceases to exist as a single character. In the absence of a common scapegoat, as it were, his conflicting forces are free to err hither and thither, each its own way. But with Salviati and Sagredo, within the dialogue, he can restore his intricate simplicity. In the passage above, for instance, Simplicio is not just an Aristotelian. The reference to the "great mystery" related to creation and to the "residence of the first cause" cannot go unnoticed. It may be that Simplicio is also the representation of the author of the *Mysterium cosmographicum*. And even if he is not the representation of Kepler, in that passage he certainly is the incarnation of all those who do not understand science but nonetheless use it to answer questions beyond its reach.

Galileo does not blame Simplicio for wanting to draw hidden things from his science of motion. Through Saliviati, though, he reminds Simplicio about the boundaries of his philosophical enterprise:

> I feel no repugnance to that same belief. But such profound contemplations belong to doctrines much higher than ours, and we must be content to remain the less worthy artificers who discover and extract from quarries that marble in which industrious sculptors later cause marvelous figures to appear that were lying hidden under those rough and formless exteriors. Now, with your permission, we shall proceed.[105]

[104] Galilei (1974), p. 182 [= OG, VIII, *Two New Sciences*, p. 225].

[105] *Ibid.*, pp. 182-183 [= OG, VIII, *Two New Sciences*, p. 225]. This passage has received different interpretations. Burtt found in it evidence for a "positivistic trend" (cf. Burtt (1932), pp. 94-95). Dollo interpreted it as an instance of Galileo's Platonism (cf. Dollo (2003), pp. 51-52).

Concluding Remarks

There is a crack in everything
That's how the light gets in

LEONARD COHEN, *Anthem* (1992)

I have argued for a twofold thesis: (1) on the hand, I have tried to show that Galileo had no theological or metaphysical interest in the problem of creation; (2) on the other hand, I have sought to shed light on Galileo's 'scientific' approach to cosmogony. I have claimed that Galileo's cosmogonies should not be interpreted as his most patent failure to account for a certain cosmological view. They are *not* metaphysical attempts at bridging a gap between mechanics and cosmology; on the contrary, they show to us that Galileo strived to transform cosmogony into a problem that can be given a mathematical solution based on the new conceptual tools of his science of motion.

In the first part of the dissertation, I have also tried to show that some of Galileo's contemporaries saw in his science a doctrine useful to solve theological problems. Castelli's 1607 letter is an important piece of evidence in this regard. For it tells us that some unidentified 'enthusiasts' of Galileo's "doctrine of motion" did not wait a second to apply the tenets of his new natural philosophy to old issues about God's existence and the beginning of the world. I believe that here lies an important challenge for historians of science, that is, to understand why Galileo did not leverage on the *positive* theological bearing of his new science, although he was probably urged to do so. Why did he not engage with theological quarrels side by side with his enthusiast supporters? Why was he not interested in intertwining theology and natural philosophy?

In my view, there is no simple answer to these questions. Without making any claim for exhaustiveness, in my study I have however tried to point out some possible reasons that convinced Galileo to avoid theological questions on creation. In the first place, Galileo was not a lonely thinker. One should not underestimate the important role of Castelli, who suggested his master to delimit the scope of the new science. In the second place, Galileo himself was wont to select philosophical questions to the extent that they would fall within the range of problems solvable through experience and necessary demonstrations. In this case, I am convinced that there is no need to raise dichotomic questions about Galileo being a philosopher or a mere engineer. Galileo was both a philosopher and an engineer. Sometimes, Galileo addressed important philosophical questions from the angle of the engineer. It may be that his own trust in mathematics was not ultimately grounded in metaphysical elucubrations upon the essence of God and nature. Perhaps, his alleged 'mathematicism' was not blindly derived from (whatever kind of) Platonism, but it was the standpoint of a man who gradually became (a certain kind of) Platonist after having experienced that mathematics can solve real and concrete problems.[1] This kind of experiences might have convinced Galileo that simple machines respond to necessary and unescapable rules. He understood that nature cannot be deceived, it is not the realm of opinions. Because of this, he may have felt authorized to make a crucial transition from (hydro)statics to natural philosophy (or dynamics). If machines work in accord with the rules of nature, this means that nature can be studied through simple machines; the latter can be used to constrain experiences within a mathematical frame which can in turn help to perform a more rigorous kind of experiments. However, this transition from the *artificial* to the *natural* – as Paolo Rossi would perhaps define it – was not self-evident and immediate. First of all, it needed to be triggered by external and local circumstances, such as the philosophical controversy on the motion of the elements, which gave Galileo the occasion to express himself on matters related to natural philosophy. Secondly, it presupposed the neglect of onto-cosmological subtleties – a neglect that for Galileo was already at play in the *De motu antiquiora*, where he welcomes Atomism and disregards the act-potency explanatory scheme.

However, this does not mean that Galileo was not at all interested in questions about God and creation.[2] It only means that he was chiefly interested in issues and questions that could undergo mathematical problem-solving: *these* questions fell indeed within the purview of his science. In this sense, cosmogony was a problem that Galileo gradually 'mathematized' and that he believed to have solved as a 'man of science.'

My conclusions cannot be definitive. As far as I know, my dissertation represents the first extensive study on the interplay between Galileo's science of motion and the creation theme. For this reason, my work does certainly need to be improved in light of the suggestions, comments, and criticisms, of many competent scholars. My hope, however, is that I have at least contributed to pave the way for a more

[1] I am sure that Galileo's philosophy was somehow influenced by Plato's philosophy. However, his heliocentric cosmogony is more than a Platonic account of the origin of the world. Also, I am not at all convinced by William R. Shea when he claims that Galileo "adhered *dogmatically* to the notion that the world was written in mathematical symbols" (Shea (1986), p. 123, my emphasis). In my view, the real matter is to understand *why* Galileo was Platonic, and *to what extent* his reflections on the mathematical status of reality can be said to be Platonic. As far as I know by now, I can only presume that Galileo's justification to mathematicism is neither dogmatic nor totally metaphysical.

[2] I would like to thank Carla Rita Palmerino, who reminded me, inter alia, that Galileo reflected upon the creation of mathematical truths in a letter to Gallanzone Gallanzoni (cf. OG, XI, *Galileo to Gallanzoni*, 16 July 1611, pp. 141-155; see also Palmerino (2006), pp. 37 and ff., and Palmerino (2016), p. 43). In this dissertation I have not dealt with this letter, which does actually deserve a lot of attention.

thorough and detailed assessment of the subject. I also hope that my way of historicizing Galileo's approach to cosmogony stands as a good reply against those who might think that, after all, I have just revived an old positivist image of Galileo.[3]

[3] Having followed Hatfield's suggestions in this regard, my reply would be the same as his: "… I shall argue that by paying attention to the historically actual activity and content of metaphysics, we reopen the possibility that at least some of the adherents of the new science proceeded independently of metaphysics. If this sounds like the old positivist line that Burtt was seeking to undercut, it is not. I am claiming that because Burtt's strategy for undercutting the positivist ideal of a purely 'factual,' nonmetaphysical science relied upon treating assumptions as a metaphysics, he gave short shrift to explicitly nonmetaphysical attitudes toward the justification of a mathematical approach to nature, thereby overlooking their place in the development of both modern science and modern philosophy" (Hatfield (1990), p. 95).

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Abbreviations

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BNM	Biblioteca Nazionale Marciana
BUP	Biblioteca dell'Università di Padova
NIV	The New International Version of the Bible
NRSV	The New Revised Standard Version of the Bible
OG	Galileo Galilei, *Opere*. National Edition ed. by Antonio Favaro. Florence: Barbèra 1890-1909, 20 vols.

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