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E pluribus unum: The first international scientific collaboration

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Summary. — In June 1761 and 1769, while European powers were fighting in the struggles for colonial hegemony, more than 250 astronomers and scholars from different nations gave life to the first international scientific enterprise: the observation of Venus transit, an extremely rare event that, if watched simultaneously from very distant locations, would have made it possible to calculate the Earth-Sun distance. A masterful example of how collaboration and sharing are two essential elements for science progress, but also of how knowledge and studying the history of a scientific concept allows us to fully grasp its current meaning.

1. – Introduction

Although in 2004 and 2012, thanks to the latest Venus transits, there was a renewed interest in the history of this astronomical event [1-3], a wide and complete discussion of such a theme in literature is still missing. This paper —taken from the author's thesis work— thus aims to be a first attempt to build a broad and rigorous review of the two 18th-century transits by reviewing more than 150 primary sources (printed works, letters, manuscripts and travel journals, in some case even unpublished) in their original language (English, French, German, Latin, Italian, Russian, and Swedish).

This historical tale begins in 1677, when Edmond Halley (1656–1742) observed the transit of Mercury from the island of Saint Helena. At the end of the 17th century, Mercury transit was in fact considered one of the means to determine the Earth-Sun distance (the so-called Astronomical Unit, AU): the phenomenon occurs about 13 or 14 times each century, thus providing multiple opportunities to make observations. Halley, however, realized that Mercury could not be suitable for this purpose, as it was too small and too close to the Sun. Nevertheless, there was another planet that could be much more useful: Venus. Unfortunately, the transit of Venus is an extremely rare event, taking place every 129.5 and 113.5 years, in pairs of transits separated by 8 years each. Therefore, in 1716, Halley published a short essay [4] in Latin (the official language of science at the time) in which he invited the scientific community to get prepared to observe Venus transit, expected in 1761 and again in 1769, which would have allowed calculating (at least in Halley's intent) the AU with an error of less than 1%.

In 1760, the French scholar Joseph-Nicolas Delisle (1688–1768) welcomed Halley astronomical "call to arms" and published his own *mappemonde* [5], that is a world map, indicating the best locations from which to make observations. Delisle sent his map to

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the main European Academy of Sciences and to the most famous astronomers of the time, inciting his colleagues to make a joint effort and encouraging the broadest participation. Halley and Delisle each proposed their own observation method: Halley's approach involved the determination of observatory latitude and the measurement of the entire duration of transit. Delisle's technique, on the other hand, only needed the exact measurement of one of the four contacts between the edge of Venus and the solar disk, but had the drawback of requiring not only the observatory latitude, but also its longitude. Two different methods, then, but with one aspect in common: they both required multiple and simultaneous observations, from different and as far away as possible locations. No observation alone, no matter how precise and accurate it was, would have been of any use: the scientific community had to collaborate, becoming, *out of many, one*.

2. – The black spot

How was it possible to exploit the transit of Venus to derive the AU? To understand it, we must take a step back and go to 1619, the year in which Johannes Kepler (1571–1630) published the *Harmonices Mundi*. In this work, Kepler presented what we now know as the Third Law of planetary motion, according to which the square of a planet orbital period is proportional to the cube of its average Sun distance. In this formula, the Sun distance was measured by means of the AU, but such a value was not known, except in a very approximate way. Subsequent attempts were conducted in 1659 by Christiaan Huygens (1629–1695), and in particular in 1672 by Giovanni Domenico Cassini (1625–1712) and John Flamsteed (1646–1719): the results obtained were a huge leap forward, providing a value with an error of less than 10%, but something better was still possible.

Venus transit would have finally made it possible to determine the AU with even greater precision, by measuring the solar parallax (that is, the angle subtended by the terrestrial radius R_{E} as seen from the Sun). In fact, using a simple trigonometric formula, parallax π is related to the AU according to the $\tan\pi = R_{\mathrm{E}}/\mathrm{AU}$ law. As the Earth radius had been known since the time of Eratosthenes of Cyrene (276–194 BC), once the solar parallax had been measured, calculation of the AU would have been immediate. Now, it could be argued that it is not possible to observe the Earth from the Sun; of course the point of view can be easily overturned, but there is nevertheless a problem: it is impossible to identify the centre of the Sun from the Earth and even the position of the Sun as a whole, because in daytime there are no fixed references (such as stars) to exploit as benchmarks. Here it is the importance of Venus transits: in fact, when it moves across the solar disk, Venus appears as a small black spot, and can therefore be used as a reference point.

3. – Land and sea adventures

Hence, on June 6, 1761 [6-11], and June 3–4, 1769 [12-15], more than 250 astronomers from different countries, joined forces to observe Venus transits, achieving what is considered the first international scientific enterprise. This fact, already extraordinary in itself, is even more incredible if we consider that, at that time, the majority of European powers were at war with each other: in fact, the 1761 transit took place in the middle of the Seven Years War, a conflict that ravaged across Europe from 1756 to 1763, and whose aftermath dragged on for decades, due to subsequent struggles for colonial hegemony.

Despite dangers and difficulties, the main Academies of Sciences (in some cases financed by sovereigns, in others by patrons) organised several expeditions, sometimes even by enrolling or bringing together scholars from enemy countries and sharing astronomical equipment. In this enlightened climate of trust in the neutrality and supremacy of science, courageous scientists, for science sake (but also in search of fame and glory), left for the most remote and inaccessible locations of the then-known world, as the icy Siberia, the faraway island of Newfoundland, the exotic India and the mysterious and still unexplored Australia. In their perilous travels, which in many cases lasted several months, if not years —as for the Frenchman Guillaume Le Gentil (1725–1792), who was away from home for 11 years, 6 months and 13 days [16, 17]— among incredible adventures, unexpected enemy attacks and numerous setbacks, those astronomers devoted themselves to exhausting and repeated observations, in order to obtain extremely accurate data, which still today surprise and fascinate for their precision. At the crucial moment, after long waiting and grueling efforts, only a few of them were lucky enough to accomplish their mission: many observed a desolately cloudy sky; one —the American David Rittenhouse (1732–1769)— even fainted for emotion [18]; some did not even reach their destination and others —such as Jean-Baptiste Chappe d'Auteroche (1728–1769) together with his Spanish colleague-rival (being their countries at war) Salvador de Medina (d.1769) in their joint expedition to California [19], and Charles Green (1734–1771)— unfortunately never returned home.

4. – "Pieces of Eight"

After each transit, despite hostilities between their countries, astronomers shared pages and pages of data and information and sent them to different Academies; there, expert scholars spent months in combining all values and made the necessary calculation to derive the AU [20, 21]. Regardless of the huge effort, the 1761 transit proved to be a complete failure, as the AU was estimated between 124.1 and 158.8 million km, an interval clearly too wide to be of any use. Things went much better in 1769, when observations led to a value of 153 million km (with an uncertainty of 1 million km), according to Joseph Jérôme Lalande (1732–1807), and later, in 1771 (after two years of calculations), of 151.7 million km, according to Jesuit father Maximilian Hell (1720–1792). However, if we compare these values with the one currently in use (149.597 million km), we realize that the precision obtained was not entirely satisfactory, as the uncertainty found was greater than 1%, in contrast to Halley request. In fact, it was necessary to wait for the two transits of 1874 and 1882 (which constituted the second pair of "Pieces of Eight" and the last adventurous enterprise related to Venus transits) to obtain a parallax value in accordance with the precision desired by the English astronomer.

As Shakespeare would say: *much ado about nothing*? Surprisingly, not. In fact, the importance of this enterprise lies not only in the astronomical results achieved: the expeditions also led to fundamental geographical explorations and to the discovery of new lands, such as New Zealand, which was circumnavigated during James Cook (1728–1779) voyage in the Pacific Ocean [22]; moreover, several astronomical and measuring instruments were significantly improved; in addition, new remedies for some diseases were studied (such as a cure to prevent scurvy, essential for long voyages at sea); and, last but not least, on the occasion of the 1769 transit, thanks to the work of Hell [23] and his assistant János Sajnovics (1733–1785), the first linguistic comparison study was carried out, leading to the discovery of a common root between Hungarian and Sami languages (both belonging to the linguistic family called, because of that, Finno-Ugric).

5. – And last

In addition to the issues discussed above, one last aspect remains to be clarified and justified: why dealing with history in the case of events like this, which were not entirely satisfactory from the point of view of the astronomical and scientific results obtained? The answer is very simple. History allows us to highlight how the scientific challenge is always limited by the boundaries of knowledge and technology of its time. But, at the same time, we realize how science is the driving force that contributes to widen these boundaries, both from a theoretical and a practical point of view. The story of the historical context thus becomes crucial to understand both the significance of a scientific enterprise and its effects, not only the scientific ones. Moreover, studying the history of a scientific concept, with its birth and its evolution over time, also through its failures and all the difficulties encountered along the way, allows us to fully grasp its current meaning and to have a greater awareness of it. Hence, knowing the past to better understand the present. A story within a story. How to narrate it, is only up to us.

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