Reply to "Comment on 'Pygmy dipole response of proton-rich argon nuclei in random-phase approximation and no-core shell model'"

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In Ref. [1] we studied the distribution of low-lying dipole strength in proton-rich nuclei. The focus of our work was on possible differences in the description of this dipole response between the random-phase approximation (RPA), adopted in previous studies, and the shell model. The ^{32}Ar and ^{34}Ar isotopes were studied in view of upcoming experimental data. The main results of our study were that the inclusion of configuration mixing, as described by the shell model, broadens the low-lying strength and reduces its strength.

In a comment to our work [2], Paar argues that our results for ^{32,34}Ar are inconsistent with a previous study [3] that used the same $V_{\rm UCOM}$ interaction but applied to medium and heavy nuclei near the valley of stability. Reference [3] has shown that RPA calculations using the $V_{\rm UCOM}$ interaction are in disagreement with data on the dipole strength distribution for *stable* nuclei. In particular, the Hartree-Fock (HF) gaps at the Fermi surface are too large [3,4], which translates into an overestimation of the centroid energy of giant dipole resonances (GDR) [5]. Our calculations for stable nuclei confirm these results. However, when applying $V_{\rm UCOM}$ to calculate the dipole strength for nuclei close to the dripline, where the relevant degrees of freedom are dominated by the proximity to the continuum, we find a quite different behavior. Valence nucleons near the driplines have significantly smaller separation energies that are correctly reproduced at the HF level (2.13 MeV in our calculation for ^{32}Ar, compared to the experimental value of 2.40 MeV). The next orbits are found in the continuum. Their position is dominated by kinetic energy and results in much smaller gaps between the two major shells, as compared to stable nuclei. This allows for the generation of enhanced dipole strength at low energies and improves the description of the GDR centroid at the RPA level.

Our calculations show that applying the $V_{\rm UCOM}$ interaction to proton-rich Ar isotopes leads to a RPA description of the dipole response that is (i) in qualitative agreement with the systematic of dripline nuclei (a low-energy peak and a giant resonance) and (ii) in good quantitative agreement with other theoretical predictions for the same nuclei [6] (no experimental data are yet available). The same interaction was then applied in our shell model calculations and a reduction of the low-energy dipole strength with respect to the RPA study was found. This is the main result of our work published in Ref. [1].

As noted in the conclusions of Ref. [1], second RPA (SRPA) calculations with $V_{\rm UCOM}$ tend to noticeably lower the GDR centroid energy, bringing them into better agreement with the data [7]. This is of course the experience with stable nuclei. SRPA calculations of dipole response for dripline nuclei have yet not been performed and hence the question of whether the proximity of the continuum might affect these calculations is still open. However, our shell model study has shown that the inclusion of 2-particle-2-hole configurations does not alter the energies of the enhanced low-lying strength or of the GDR centroid energy.

The term "pygmy" is often used in the literature to indicate the presence of enhanced dipole strength at low excitation energies. In this sense we have used this term. The Comment [2] criticized our use of the notion "pygmy resonance," suggesting that this term is reserved for states of a clear collective nature. As only the transition strength and transition densities could be accessed experimentally, any other quantity is model dependent. This situation has already been found in two studies of low-lying strength for ^{132}Sn that conclude that it is either collective [8] or noncollective [9].

In summary, the aim of Ref. [1] was to study the influence of correlations beyond the simple RPA approach on the low-lying dipole response for proton-rich nuclei. For the particular case of the isotopes ^{32,34}Ar, we found that the $V_{\rm UCOM}$ interaction gives a reasonable RPA dipole response. As this interaction is readily accessible for RPA and shell model calculations, we felt justified to adopt it for the first shell model calculation of low-energy dipole response in nuclei at the proton dripline investigating the importance of correlations beyond RPA on the dipole response.

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