Systematic large scale Quasiparticle Random Phase Approximation calculations with Relativistic and Chiral interactions

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Abstract: The atomic nucleus is a quantum many-body system. This implies that nontrivial collective behaviors may arise. One of them are giant resonances, which consist of harmonic oscillations of all the nucleons as a whole [1]. These excitations are present on all nuclei along the nuclear chart, and as a fundamental excitation modes of the nucleus, they are involved in a plethora of nuclear phenomena.

To study giant resonances, some of the most used models are Random Phase Approximation (RPA) for nuclei without pairing and Quasiparticle Random Phase Approximation (QRPA) when pairing is accounted. This methods are able to describe collective excitations from a microscopic point of view. However, they are very computationally costly. For this reason, there is a lack of systematic QRPA calculations in the literature with interactions other than Gogny D1M [2]. In this project, we take advantage of the supercomputing resources and robust codes available at CEA-DAM to perform systematic strength function calculations for all nuclei using several state-of-the-art interactions. Our codes implement the QFAM method [3], which allows us to significantly reduce the calculation time of strength functions by linearizing the QRPA equations.

An extensive study has been done with the covariant interaction DD-PC1 [4], calculating strength functions of giant resonances of all multipolarities. We have observed a dependence of the strength function with the basis parameters of the underlying HFB starting point. To overcome this, we have developed a series of strategies that allow us to produce robust results.

On the other hand, as part of the PAN@CEA collaboration [5], we have studied the impact of triaxiality in strength functions of giant resonances of ^{24}Mg by using a computationally heavy chiral interaction [6]. This nucleus plays a pivotal role in many astrophysical processes, and a good theoretical characterization is key to explain them.

References:

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