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Isoscalar giant monopole resonance in the Ca isotopes

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A comprehensive analysis of the isoscalar giant monopole resonance (ISGMR) has long been a subject of extensive theoretical and experimental research [1,2]. The ISGMR properties are presently an important problem not only from the nuclear structure point of view [2,3] but also because of the special role they play in many astrophysical processes such as prompt supernova explosions [4] and the interiors of neutron stars [5].

The random phase approximation (RPA) with the Skyrme-type energy density functional (EDF) is the most widely used theoretical model for describing the ISGMR [2,3]. The study of the monopole strength distribution in the region of giant resonance involves taking into account a coupling between the simple particle-hole excitations and more complicated (two- and three-phonons) configurations [3,6]. The main difficulty is that the complexity of calculations beyond standard RPA increases rapidly with the size of the configuration space, and one has to work within limited spaces. Using a finite rank separable approximation for the residual particle-hole interaction derived from the Skyrme EDF one can overcome this numerical problem [7,8].

In the present report, we discuss the effects of the coupling between one-, two-, and three-phonon terms in the wave functions on the monopole strength distribution in the double-magic nuclei 40,48Ca. Using the same set of parameters, we describe available experimental data [9,10]. The effects of the phonon-phonon coupling (PPC) lead to a redistribution of the main monopole strength to lower energy states and into higher energy tail [11]. The PPC predictions of the fine structure of the ISGMR in the Ca isotopes are in good agreement with the fine structure which is extracted from experimental data analysis [12].

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