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Microscopic description of isoscalar giant monopole resonance: The case of 132Sn

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The study of nuclear giant resonances has long been a subject of extensive theoretical and experimental research. The multipole response of nuclei far from the beta-stability line and the possible occurrence of exotic modes of excitation present a growing field of research. In particular, the study of the isoscalar giant monopole resonances (ISGMR) in neutron-rich nuclei is presently an important problem not only from the nuclear structure point of view [1] but also because of the special role they play in many astrophysical processes such as prompt supernova explosions [2] and the interiors of neutron stars [3]. One of the successful tools for describing the ISGMR is the quasiparticle random phase approximation (QRPA) with the self-consistent mean-field derived from Skyrme energy density functionals (EDF) [4]. Due to the anharmonicity of the vibrations there is a coupling between one-phonon and more complex states [5]. The main difficulty is that the complexity of calculations beyond standard QRPA 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 forces one can overcome this numerical problem [6-8].
In the present report, we study the effects of phonon-phonon coupling on the monopole strength distributions of neutron-rich tin isotopes. Using the same set of the EDF parameters, we describe available experimental data for 118,120,122,124Sn [9] and give prediction for 132Sn [10]. The effects of the phonon-phonon coupling leads to a redistribution of the main monopole strength to lower energy states and also to higher energy tail. We analyze thoroughly the properties of the low-energy 0+ spectrum of two-phonon excitations of 132Sn. We give prediction for the excitation energy of the lowest two-phonon state around Ex=8 MeV in comparison to 11.5 MeV in the case of the lowest 0+ state within the random phase approximation.

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