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What can we learn from studying PDR and GDR with microscopic theory including phonon coupling?

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The electric dipole response of the nucleus reveals important spectroscopic features of its structure and the mechanism of its interaction with external electromagnetic and hadronic fields. Here, we present new results on dipole strength distributions of direct and cascade transitions to GDR energies in neutron-excess nuclei from various mass ranges, obtained within a theoretical approach based on energy-density functional theory and the quasiparticle-phonon model [1]. The method and its recent developments, including a reaction theory [2, 3], have been successfully applied in spectroscopic studies of various types of nuclear excitations, including two-phonon states, pygmy, and giant resonances, demonstrating its effectiveness and reliability. In addition to the single-particle nature of the excited nuclear states from the PDR region, the analysis of inelastic photon and proton scattering data and branching ratios reveals various properties of the low-energy dipole strength, which can be used to investigate the role of quasi-continuum's coupling with the low-energy dipole strength [3, 4]. Due to this effect, we observe a shift in the dipole strength from the neutron threshold region and the low-energy GDR tail to low excitation energies in Fe-56, Mo-96, and Sn isotopes, as well as other nuclei of medium and heavy atomic mass. This clearly shows a strong increase in the overall low-energy dipole strength.
An interesting recent extension of our theoretical studies on PDR is the systematic investigation of electric dipole transitions between nuclear excited states with different spin and parity. We observe an enhanced electric dipole strength below the neutron threshold of Fe-56, which, based on its spectroscopic properties, strongly resembles a PDR mode built on the excited states of this nucleus. Furthermore, the γ-decay of the GDR has not been systematically studied to date. Recently, a novel NRF experiment on the γ-decay of the GDR of the deformed Sm-154 nucleus was conducted at HIγS to investigate its properties [5]. The obtained result from the GDR γ-decay branching ratio to the first 2+ and the ground state can serve as a new observable for interpreting the GDR structure. In this context, new theoretical results that could be of fundamental importance for these studies are discussed.
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