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Evolution of the pygmy dipole resonance in the Sn mass region studied with the Oslo method

The pygmy dipole resonance (PDR) is commonly associated with an excess $E1$ strength on top of the low-energy tail of the giant dipole resonance (GDR) close to the neutron-separation energy in stable and unstable heavy nuclei. While its detailed structure, properties, and origin remain a matter of ongoing debates and research, the neutron-skin oscillation picture of this feature still prevails and suggests some dependence of the PDR strength on neutron excess. This might have further consequences for neutron-capture rates relevant for heavy-element nucleosynthesis [1], making a systematic investigation of the PDR and the low-lying $E1$ strength in general in different isotopic chains particularly interesting from the nuclear structure and astrophysical perspectives.

This work presents the most recent update on a consistent systematic study of the low-lying electric dipole strength and the potential PDR in stable and unstable Pd, Cd, In, Sn, and Sb isotopes with the Oslo method [2]. The analysis focuses on dipole γ-ray strength functions (GSF) below the neutron threshold extracted from particle-γ coincidence data from light-ion induced reactions studied at the Oslo Cyclotron Laboratory (OCL). The most recent $(p, p'\gamma)$ and $(\alpha, p\gamma)$ experiments have been performed with a new array of 30 LaBr3(Ce) scintillator detectors (OSCAR) with an improved energy resolution and timing properties for the selection of particle-γ events as compared to the earlier experiments done with the NaI(Tl) detector array CACTUS. All previously published GSFs of the ^{105,106,111,112}Cd [3] and $^{105-108}$Pd [4] isotopes have been re-analysed to provide a more consistent analysis of the strengths in the Sn mass region.

With a wide span of isotopes (from unstable, neutron-deficient ^{109}In to unstable, neutron-rich ^{127}Sb), these dipole strengths provide an excellent case for investigation of the PDR evolution with increasing proton-neutron asymmetry, comparing it with different theoretical approaches, and revealing a possible impact of this feature on the astrophysical radiative neutron-capture processes. Combining these data with available (γ, n) cross sections and the $E1$ and $M1$ strengths from relativistic Coulomb excitation experiments allows us to extract the low-lying $E1$ component from the total dipole strength in each case. It was found to exhaust $\approx 1-3\%$ of the classical Thomas-Reiche-Kuhn (TRK) sum rule, being nearly constant throughout the whole chain of Sn isotopes and weakly increasing with neutron number in Cd and Pd isotopes. This finding is in contradiction with the majority of theoretical approaches, such as, e.g., relativistic quasi-particle random-phase and time-blocking approximations, predicting a strong, steady increase in the low-lying $E1$ strength with neutron number. Moreover, a presumably isovector component of the PDR was extracted for $^{118-122,124}$Sn. The most neutron-deficient case of ^{109}In studied recently at the OCL, on the contrary, exhibits little to no excess $E1$ strength below the neutron threshold, thus standing out among the neighboring Cd and Sn isotopes.

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