Dipole Response of Exotic Nuclei and Symmetry Energy - Experiments at the LAND-R^{3}B Setup

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The electric dipole strength distribution of nuclei is dominated by the Giant Dipole Resonance (GDR), located at excitation energies well above the neutron or proton separation threshold. This resonance mode is characterized by a high degree of collectivity and can be considered as an out-of-phase oscillation of the neutrons and protons of the nucleus. When the neutron-to-proton asymmetry increases, low-lying dipole strength appears near the neutron threshold and is commonly referred to as the Pygmy Dipole Resonance (PDR). Although the collectivity of this type of resonance is still up for debate, the PDR is often seen macroscopically as an oscillation of the isospin-symmetric core against the shell of excess neutrons. While the electric dipole strength has been extensively measured in stable nuclei in the past, the development of radioactive beam facilities provides an access to such measurements in unstable systems as well. Nuclei with larger neutron-to-proton ratios can thus be produced, extending the isospin range in which the PDR strength can be systematically investigated. This is of particular interest for the extraction of parameters of the nuclear equation-of-state from measured PDR strength distributions [1].

The LAND-R^{3}B setup at GSI has been used in the past years to investigate the dipole strength of unstable nuclei among other experimental programs. The PDR has been observed in neutron-rich Sn isotopes [1, 2], exhausting approximately 5% of the E1 energy-weighted sum rule strength. RPA calculations were performed for various sets of equation-of-state parameters, yielding correlations with PDR strength values. The experimental data sets in conjunction with the RPA calculations provide values for the neutron-skin thickness, as well as for the symmetry energy pressure and for the symmetry energy in pure neutron matter. The experimental technique used to determine the dipole response uses relativistic secondary beams with energies lying typically in the 500 AMeV range. The ions are excited electromagnetically by the heavy-ion-induced Coulomb interaction at the LAND-R^{3}B setup. Since the measurements are kinematically complete, the excitation functions can be determined directly by reconstructing the invariant mass. More recent experiments include the investigation of dipole strength in neutron-rich nickel isotopes, as well as in proton-rich argon isotopes, in which a PDR mode is also expected [3]. A future experiment on neutron-rich tin isotopes will also be presented. By improving the experimental conditions with respect to the previous Sn experiment, the range of isotopes will be extended beyond the closed N=82 shell, the giant quadrupole resonance will be investigated for the most abundant isotopes and the (γ,γ') channel will be studied, allowing a strength measurement also below the neutron threshold.

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