Pygmy Dipole Strength and Neutron Skins in Exotic Nuclei

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The properties of exotic nuclei are ideally studied in inverse-kinematics experiments at high beam energies using the FRS-LAND facilities at GSI. The LAND reaction setup allows exclusive measurements of all projectile-like particles following the excitation of the projectile in a high-Z target (Pb). At a beam energy of about 500 AMeV electromagnetic excitations are dominated by dipole transitions, and the Coulomb excitation cross sections can be transformed into photoabsorption cross sections using the method of equivalent photons within a semi-classical approach.

In an experiment utilizing secondary beams of neutron-rich Sn isotopes $^{129-132}$Sn and neighbouring nuclei with similar A/Z ratio a substantial fraction of dipole strength at energies below the giant dipole resonance (GDR) is observed. For ^{130}Sn and ^{132}Sn this strength is located in a peak-like structure around 10 MeV and exhibits a few percent of the Thomas-Reiche Kuhn (TRK) sum-rule strength [1]. Several calculations (see, e.g., [2,3]) predict the appearance of dipole strength at low excitation energies in neutron-rich nuclei. This low-lying strength is often referred to as pygmy dipole resonance (PDR) and, in a macroscopic picture, is discussed in terms of a collective oscillation of excess neutrons out of phase with the core nucleons. For the odd Sn isotopes a substantial amount of dipole strength is found at even lower excitation energies, allowing for a direct comparison with results obtained from real-photon scattering measurements in stable nuclei below the particle threshold [4]. Recent random-phase-approximation calculations show a strong correlation of the PDR strength to the density dependence of the symmetry energy and thus a link to the neutron skin size [5,6]. Consequences from the experimental findings in ^{130}Sn, ^{132}Sn and ^{208}Pb [7] for the neutron-skin sizes, the symmetry energy and the neutron equation of state (EoS) will be discussed. Constraints on the EoS of infinite neutron matter are highly desirable for a description of the largest system of neutron matter known in nature, the neutron star.

The Coulomb-excitation method allows to determine cross sections for the inverse capture processes (n,γ), (p,γ) in exotic nuclei, which are relevant in astrophysical scenarios. As an example, the capture cross section for ^{14}C(n,γ)^{15}C was determined from a LAND-FRS experiment including a separation of ground-state and excited-state contributions [8].

An overview will be given on a series of experiments aimed at studying the (γ,p) cross sections which are carried out this year after the recent upgrade of the LAND setup. As an outlook the experimental opportunities at the future R^{3}B setup at FAIR will be discussed in the context of astrophysical questions.

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