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Complete E1 and spin-M1 response in nuclei from polarized proton scattering at zero degree

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Scattering of polarized protons with energies of a few 100 MeV at angles close to and including 0° has been established as a new spectroscopic tool for the study of the electric and spin-magnetic dipole response in nuclei. Complete electric dipole strenth distributions can be extracted between about 5 and 20 MeV with two independent methods based on a multipole decomposition analysis of the cross sections and the combined information from spin transfer observables. A case study of ^{208}Pb demonstrates excellent agreement with other probes but reveals the presence of previously unknown E1 strength just above the neutron threshold [1]. Furthermore, the Coulomb-nuclear interference term in the cross sections shows sensitivity to the underlying structure of E1 transitions, allowing for the first time an experimental extraction of the pygmy dipole resonance (PDR) [2].

A variety of problems are presently addressed with this new method including the first evidence for the PDR in heavy deformed nuclei, an extraction of the true low-energy E1 strength in tin isotopes [3], a test of contradictory results for gamma strength functions from different experimental methods [4,5] and a direct test of the Axel-Brink hypothesis in the region of astrophysical relevance around neutron threshold [6]. The data also provide a survey of the spin-M1 strength distributions in light and heavy nuclei including the reference case of ^{48}Ca, where a recent measurement at HIGS [7] contradicts the established result from electron scattering [8], which in turn would question the common interpretation of quenching of the spin-isospin response in nuclei [9]. The new data also serve as a crucial test of state-of-the-art nuclear structure calculations of collective modes including beyond-mean field degrees of freedom (see., e.g. Refs. [10-14]).

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