Enhanced dipole strength and its consequences for reaction rates

Ronald Schwengner

Institut für Strahlenphysik, Helmholtz-Zentrum Dresden-Rossendorf,
PF 510119, 01314 Dresden, Germany

Our systematic study of dipole strength distributions in photon-scattering experiments at the electron accelerator ELBE of the Helmholtz-Zentrum Dresden-Rossendorf has been continued with experiments on the $N = 50$ nuclide ^{86}Kr, the $N = 80$ nuclide ^{136}Ba, the $N = 82$ nuclide ^{139}La [1] and the doubly magic ^{208}Pb [2].
To estimate the distribution of inelastic transitions from high-lying levels at high level density to low-lying levels, simulations of γ-ray cascades were performed. On the basis of these simulations, intensities of inelastic transitions were subtracted from the experimental intensity distributions that include the resolved peaks as well as a quasicontinuum formed by unresolved transitions, and the intensities of elastic transitions to the ground state were corrected for their branching ratios. The photoabsorption cross sections obtained in this way are combined with (γ,n) and (γ,p) data and give detailed information about the dipole strength distributions in the energy range from about 4 MeV up to the giant dipole resonance (GDR). Enhanced dipole strength compared to Lorentzian-like approximations of the tail of the GDR is found in the energy range from about 5 MeV up to about the respective particle thresholds analogously to our earlier results for the chain of Mo isotopes [3,4] and for $N = 50$ isotones [5,6,7].
The experimental results are compared with predictions of the Instantaneous-Shape Sampling (ISS) model developed to describe the dipole strength in transitional nuclei [8,9]. For the doubly magic ^{208}Pb, an alternative approach is presented. Shell-model calculations including (2p–2h) excitations performed for this nuclide show that the higher-order excitations are the main mechanism for the fragmentation of the strength and hence for the spreading of the GDR [2].
To investigate possible consequences of the enhanced dipole strength for reaction rates of photonuclear reactions such as (γ,n) and (γ,p) and the inverse (n,γ) and (p,γ) reactions, calculations of cross sections using the statistical codes TALYS [10] and NON-SMOKER [11] were carried out, in which the experimental dipole strength distributions were used as an input. The results are compared with those obtained by using standard approximations for the strength functions.

This work was supported by the German DFG under contracts KA2519/1-1 and SCHW 883/1-1, by the US DOE Grant No. DE-FG02-95ER4093 and by the US NSF Grant No. PHY-0758099.

References

[1] A. Makinaga et al., Phys. Rev. C 82, 024314 (2010).
[2] R. Schwengner et al., Phys. Rev. C 81, 054315 (2010).
[3] G. Rusev et al., Phys. Rev. C 77, 064321 (2008).
[4] G. Rusev et al., Phys. Rev. C 79, 061302(R) (2009).
[5] R. Schwengner et al., Phys. Rev. C 76, 034321 (2007).
[6] R. Schwengner et al., Phys. Rev. C 78, 064314 (2008).
[7] N. Benouaret et al., Phys. Rev. C 79, 014303 (2009).
[8] S. Q. Zhang et al., Phys. Rev. C 80, 021307(R) (2009).
[9] I. Bentley et al., Phys. Rev. C 83, 014317 (2011).
[10] A.J. Koning, S. Hilaire and M.C. Duijvestijn, EDP Sciences, 2008, p. 211.
[11] T. Rauscher and F.-K. Thielemann, At. Data Nucl. Data Tables 88, 1 (2004).