Photon strength functions in rare-earth nuclei

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The γ decay of medium-weight and heavy nuclei at excitation energies above the pairing gap is not governed exclusively by structural effects as with increasing excitation energy the statistical properties are starting to play a dominant role. The decay of nucleus at these energies is believed to be described within the statistical model of nucleus.

The so-called Photon Strength Functions (PSFs) for different multipolarities are, together with the Nuclear Level Density (NLD), the key entities describing the statistical γ-decay, being at the same time directly related to the photoabsorption cross section. It is well known that PSFs and photoabsorption cross sections at energies above the threshold for particle emission are in almost all nuclei well described by the Lorentzian shape of the Giant Electric Dipole Resonance (GEDR) with the maximum near 15 MeV and a width of about 5 MeV [1]. On the other hand, despite the fact that the PSFs at the low-energy tail of GEDR (below energies for particle emission) has been studied for more than half a century the decay of they are known rather poorly.

The PSFs can be studied exploiting several different reactions and methods of data processing. The most widely used reactions for getting information on PSFs are (n, γ′),(γ , γ′), and reactions in which the excited states which decay by γ emission are produced by interaction of a charged-particle with the nucleus – (^{3}He,^{3}He ′γ), (^{3}He, αγ), (p, p ′γ), etc.

The main topic of the proposed PhD project is obtaining additional information on PSFs from (n, γ) reaction with the emphasis on deformed rare-earth nuclei. At the moment there exist available data from ^{167}Er(n, γ) reaction from two different experimental setups: (i) the multistep γ cascade (MSC) spectra following neutron capture in the resonance region has been measured with the DANCE detector located at the Los Alamos National Laboratory, and (ii) the two-step γ cascade (TSC) spectra following thermal neutron capture has been measured at the reactor in ˇReˇz near Prague. In addition, the MSC spectra from the ^{166}Er(n, γ) reaction are planned to be measured at the DANCE detector during the experimental campaign later this year. Information on PSFs and perhaps also NLD in studied nuclei can be obtained from comparison of experimental data from these experiments with predictions obtained from different models of PSFs and NLD.

The experimental MSC and TSC spectra of (n, γ) reactions for some other rare-earth nuclei in the resonance neutron energy region can be obtained in experiments at the n_TOF in CERN by using the new 4π BaF_2 total absorbtion calorimeter and in Dubna at the Intense REsonance Neutron source (IREN) of Frank Laboratory of Neutron Physics (FLNP).

Data from these experiments should shed more light especially on the behavior of the scissors magnetic-dipole resonance which is located near E γ= 3 MeV in well-deformed rare-earth nuclei. There seems to be interesting differences in reported properties of this resonance especially between even-even and odd nuclei [2].

References

[1] S. S. Dietrich and B. L. Berman, At. Data and Nucl. Data Tables 38 (1988) 199
[2] J. Kroll et al., Phys. Rev. C 88 (2013) 034317