A New Proposal to the High Intensity Gamma-Ray Source (HIγS) PAC-12

**Study of the pygmy dipole resonance in $^{181}$Ta and test of the statistical model**

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1 Experiment Summary

An improved experimental and theoretical description of photonuclear reactions and the inverse radiative-capture reactions is very important for the understanding of astrophysical processes. Dipole strength functions are an important ingredient for the calculation of reaction cross sections within the statistical model. Therefore, precise measurements of dipole strength distributions are needed for a correct determination of those cross sections. Our earlier photon-scattering studies using the HIγS facility as well as using the bremsstrahlung facility at the ELBE accelerator of the Helmholtz-Zentrum Dresden-Rossendorf (HZDR) have evidenced enhanced $E1$ strength below the neutron-separation energy that is considered as a pygmy dipole resonance. Calculations on the basis of statistical reaction models have shown that very pronounced pygmy strength increases the $(n, \gamma)$ cross section compared to cross sections calculated using phenomenological descriptions of strength functions.

A very special case is $^{181}$Ta. The properties of this nuclide are of paramount importance for the understanding of the production of the rarest existing isotope in the solar system, $^{180}$Ta. Possible production processes of $^{180}$Ta are slow or rapid neutron capture (s- or r-process, respectively), the $\gamma$-process or the $\nu$-process. The description of all those processes requires a precise knowledge of the dipole strength function of $^{181}$Ta below the neutron threshold in the region of the pygmy dipole resonance as well as above the threshold. In photon-scattering experiments using bremsstrahlung a huge number of states in the whole energy range up to the endpoint energy is excited and a huge number of transitions depopulating these states to the ground state or to lower-lying states form a quasi-continuum in the measured $\gamma$-ray spectrum. For the determination of the photoabsorption cross section it is necessary to correct the measured intensities for branching transitions. For this purpose, we apply simulations of statistical $\gamma$-ray cascades which are based on statistical model assumptions for the input strength functions and level densities. Because of the extremely large level density in $^{181}$Ta these techniques imply a huge correction of the data. Measurements with monoenergetic $\gamma$ beams enable a model-independent analysis of the data. Such benchmark measurements are crucial to a reliable extraction of photoabsorption cross sections and, in addition, they can be used to test statistical models.

The HIγS facility is a unique device for this aim. The spectra measured in scattering of monoenergetic photons allow us to deduce directly the intensities of elastic and inelastic transitions. In this way, branching ratios of elastic transitions and, hence, the photoabsorption cross section or the dipole strength, respectively, can be deduced without using assumptions for level densities. Hence, the proposed experiment at HIγS is expected to accomplish two goals: (i) the reliable determination of the photoabsorption cross section of $^{181}$Ta which is important for the understanding of production processes of $^{180}$Ta and (ii) the test of statistical models which are crucial for the extraction of dipole strength distributions from other experiments using photon-scattering with bremsstrahlung, neutron capture, or inelastic-scattering.