A New Proposal to the High Intensity Gamma-Ray Source (HI\(\gamma\)S) PAC-10

Development of the dipole strength distribution with increasing nuclear deformation - study of the isotopes \(^{124}\text{Xe}\) and \(^{134}\text{Xe}\)

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1 Experiment Summary

Gamma-ray strength functions are an important ingredient for the determination of cross sections of photonuclear reactions such as $(\gamma, p)$, $(\gamma, n)$ or its inverse, $(n, \gamma)$. An improved experimental and theoretical description of the $(n, \gamma)$ reaction is important for next-generation nuclear technologies, in particular for the transmutation of long-lived nuclear waste. Analytical or microscopic descriptions of strength functions, as currently available from data bases such as RIPL-2, do not describe the $E1$ strength below the neutron-separation energy correctly. Therefore, precise measurements are necessary for a correct determination of reaction cross sections. Our earlier photon-scattering studies at the ELBE accelerator of the research center Forschungszentrum Dresden-Rossendorf (FZD) have revealed an enhanced $E1$ strength below the neutron-separation energy that increases with increasing neutron number in the chain of Mo isotopes. Calculations using our new code based on a quasiparticle-random-phase-approximation in a deformed Woods-Saxon basis suggest that this effect is a consequence of increasing nuclear deformation rather than of the neutron excess as described in the past in model calculations for non-deformed nuclei. A test of a possible deformation-induced effect requires the study of an isotopic chain, in which the deformation increases with decreasing neutron number. Such a chain is given by the Xe isotopes. The present project aims at the study of the deformed isotope $^{124}$Xe and the spherical isotope $^{134}$Xe. It will be part of the PhD thesis of Ralph Massarczyk from FZD.

The HI$\gamma$S facility is a unique device that allows us to obtain model-independent spectroscopic information because the spectra generated by monoenergetic photons allow us to deduce directly the intensities of elastic and inelastic transitions and branching ratios and, hence, to determine the photoabsorption cross section or the dipole strength, respectively. At the same time, the use of polarized photons gives information about the percentages of magnetic dipole and electric dipole strengths at high energy which is necessary for modeling photonuclear reactions and for nuclear structure models. We propose to measure $\gamma$-ray spectra at various beam energies for the nuclides $^{124}$Xe and $^{134}$Xe using linearly polarized photon beams and using the setup with four 60% detectors placed at azimuthal angles parallel and perpendicular to the polarization plane.

2 Introduction

Gamma-ray strength functions describe the probabilities of nuclear reactions including absorption or emission of $\gamma$ rays. Such reactions are neutron capture $(n, \gamma)$, inelastic neutron scattering $(n, n'\gamma)$, and the nuclear photo effect $(\gamma, x)$, where $x$ stands for an emitted particle (neutron, proton, $\alpha$ particle). The measurement of $(n, \gamma)$ and $(n, n'\gamma)$ cross sections is currently one of the main tasks of the study of important reactions for future nuclear technologies, for example for the transmutation of long-lived nuclear waste. In this context, new facilities at neutron