Thesis abstract Corentin Hiver

«Nuclear physics, Shape isomers, Fission isomers, Gamma back-decay, Gamma spectroscopy, nu-Ball 2»

Shape isomers (SI) in actinide nuclei are metastable states lying in the second super-deformed prolate potential well with a rugby ball-like shape. Their main decay mode is spontaneous fission. However, a previous experiment presented strong evidence for the existence of a competing γ back-decay branch, depopulating the SI back to normally deformed states in 236 U. This experiment, carried out at GSI in 1989, reported σ a relative cross-section of σ prompt γ ≈ 3 × 10 −4 . delayed γ
The main aim of this thesis is to reproduce and refine this experiment using state-of-the-art technology. To carry out this experiment, the nu-Ball2 spectrometer was constructed at the ALTO facility of IJCLab, then characterized. This complex hybrid spectrometer allows for high-resolution gamma spectroscopy thanks to its 24 HPGe Clovers, and calorimetry capabilities thanks to the high-efficiency and large solid angle coverage of the BGO anti-Compton shields and additional 72 PARIS phoswich detectors. The DSSD placed in the reaction chamber allows for light particle energy measurement.
The 235 U (d, p) 236 II U and 232 Th (d, x) reactions were used to produce the SI of interest. The main experimental goals are to perform a high-resolution spectroscopy of a) the γ-back decay of the SI 236 II U, b) the prompt γ-feeding of the SI from states in the deformed potential well and c) of the as-yet-unobserved SI in 231,232,233 Th isotopes.
A novel side-result shows the previously unobserved prompt γ-feeding of the K−isomer connecting states populated in the normally deformed potential well.
However, despite having a very high experimental sensitivity, the results of the previous experiment are not confirmed. This suggests that the size of the gamma branch, if it exists at all, must be lower than 10-4 and comparable in size to that of the fission branch.
After a re-analysis of the isomeric fission half-lives systematics, it appears that contrary to the "conventional wisdom", there is no need to postulate the existence of a gamma branch in the Uranium isotopes, since their lifetimes closely follow the underlying trend with fissility.
The conclusion is that SI are still very poorly understood and need to be reexamined using modern techniques to understand better the nature of the states in the second minimum and their decay modes.