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High precision spectroscopy of fission shape isomers with Nu-Ball2 : Exploring the gamma back-decay

Fission shape isomers (SI) are poorly understood metastable states characterized by a second superdeformed potential energy minimum co-existing with normal deformed states in the low-spin regime [1]. Although many such isomers have been observed in the actinide region, our understanding of the states in the second minimum remains very limited. For most SIs, the only available information is their half life, determined via their exclusive decay mode - delayed fission. However, an interesting possibility of competing γ back-decay branches opens up as the number of protons decreases and fission barriers become harder to penetrate. The nature of this back-decay, however, remains poorly understood, owing to the fact that at the time of their discovery (several decades ago) the techniques of γ ray spectroscopy were not sufficiently well-developed.

In this context, we recently performed high precision γ ray spectroscopy experiments to study ^{236f}U and ^{232f}Th using the Nu-Ball2/PARIS spectrometer. Nu-Ball is a hybrid spectrometer that combines 24 High Purity Germanium (HPGe) Clovers and 64 phoswiches ($LaBr_3$/NaI) of the PARIS collaboration [2], covering more than 90% of the total solid angle. In addition, a Double-sided Stripped Silicon Detector (DSSD) [3] was used to measure the energy of the outgoing light charged particles. Each detector was managed by a state-of-the art fully digital FASTER electronics [4] that allowed for triggerless data acquisition at high data rates. The exceptional selectivity of such a setup comes from a combination of the high resolution of the HPGe detectors, high energy efficiency, charged particle selection, and calorimetry to determine prompt and delayed energy balances.

The full characterisation of these back-decay γ rays enables a unique and precise way to determine the parameters of fission barriers, which play an essential role in the theory of fission. Moreover, spectroscopy in the second well will allow for a better understanding of nuclear structure of these mysterious high-deformation states. Here, the first results of the nu-Ball2/PARIS fission shape isomer experiments will be presented.

[1] P.G. Thirolf, D Habs, Progress in Particle and Nuclear Physics 49 (2002) 325.
[2] F. Camera and A. Maj, The PARIS White Book, ISBN 978-83-63542-22-1 (2021)
[3] https://www.slcj.uw.edu.pl/en/coulomb-excitation-at-the-warsaw-cyclotron/
[4] D. Etasse et al. https://faster.in2p3.fr

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