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Isomeric Decays in Neutron-Rich ^{183,184}Hf isotopes at the KISS facility

The neutron-rich region of the nuclear chart, around mass numbers A~180–190, is of great interest for investigating nuclear shape transitions and isomerism in deformed nuclei. Isotopes like ^{183,184}Hf are predicted to host long lived isomeric states and approach a prolate-to-oblate shape/phase transition, which is expected to result in prolate high-K isomers decaying to oblate low-K states[1,2]. Despite good theoretical background, exploring this region is difficult due to the low production rates of neutron-rich isotopes and the refractory nature of elements, especially in the hafnium (Z=72) to platinum (Z=78) range, constraining possibilities for comprehensive studies.

We report on the study of isomeric transitions in neutron rich 183,184Ta populated via β-decay of ^{183,184}Hf, respectively. The experiment was conducted at the KEK Isotope Separation System (KISS) facility at RIKEN[3], using multi-nucleon transfer reactions. A 136Xe beam at 7.2 MeV/nucleon was directed onto a tungsten target, yielding neutron-rich isotopes that were slowed, neutralised, and transported in a gas cell. Laser resonance ionisation was used to selectively ionise hafnium isotopes, followed by mass separation using Isotope Separation On-Line techniques. The isotopes were implanted onto Mylar tape surrounded by a detector system consisting of a multi-segmented proportional gas counter for beta spectroscopy and high-purity-germanium clover detectors for gamma-ray spectroscopy, with measurements taken under precise timing conditions to separate isomeric and prompt events.

Time-correlated β–γ spectroscopy enabled the observation of delayed transitions consistent with the decay of isomeric states. A well-known isomer was used to check and confirm the timing setup and event selection. Other delayed transitions, which were strongly hindered, point to the presence of long-lived isomeric states related to specific nuclear configurations. These findings are interpreted in the context of neighbouring isotopic systematics and transition probability calculations.

This study highlights the capabilities of the KISS facility for probing isomeric phenomena in refactory, neutron-rich nuclei and provides insights into the isomeric and ground state decays of ^{183,184}Hf into ^{183,184}Ta, respectively.

References:

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