Abstract of Thesis

Name （ Mukul Khandelwal ）	
Title	β-γ spectroscopy of neutron-rich rare-earth nuclei ^{156,157,158}Pr and ^{158}Nd (中性子過剰希土類原子核^{156,157,158}Prおよび^{158}Ndのβ-γ核分光)

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The neutron-rich rare-earth nuclei in the mass A~160 region belong to one of the deformed sectors of the nuclear chart. The systematic reduction of the first excited 2^+ state energy, E(2^+), for even-even nuclei, with varying proton number Z or neutron number N, is widely recognized as an indicator for the presence of ground-state deformation for nuclei in this mass region. Based on the E(2^+) systematics, the Nd (Z=60) nuclei are identified as the most deformed nuclei, with the deformation expected to decrease away from Nd. In the present study, we aim to explore this change in deformation around Nd by examining two neighboring odd-odd nuclei, ^{156}Pr (Z=59) and ^{158}Pm (Z=61), which share the same neutron number (N=97) and lie on opposite sides of Nd. This investigation is carried out through β-γ decay spectroscopy of even-mass nuclei, ^{156}Pr and ^{158}Nd. In addition, this work also aims to measure the $2^+ \rightarrow 0^+$ transition energy in ^{158}Nd (N=98), which has not yet been directly measured and is essential for interpreting the deformation trend in the Nd isotopes. The present work also reports the β-γ decay spectroscopy result for ^{157}Pr.

The experiment was conducted at the Radioactive Isotope Beam Factory, RIKEN Nishina Center, within the Euroball RIKEN Cluster Array (EURICA) campaign. The neutron-rich rare-earth nuclei were produced via in-flight fission of a ^{238}U beam with an energy of 345 MeV/nucleon and an intensity of ~5 pnA, incident on a 4-mm-thick ^{9}Be target. The fragments produced were separated and identified using the BigRIPS separator and delivered to the experimental setup placed downstream. An active stopper composed of five double-sided silicon-strip detectors, called WAS3ABi, was used for ion- and β-ray detection, while an array of Ge detectors, EURICA, was utilized for γ-ray detection following β-decay, enabling the performance of β-γ spectroscopy.

The ^{157}Nd nucleus is investigated for the first time via the β-decay of ^{157}Pr, revealing one short-lived delayed-γ-ray photopeak along with several low-intensity peaks. For ^{158}Nd, the previously unobserved $2^+ \rightarrow 0^+$ transition energy has been measured for the first time through the β-decay of ^{158}Pr. It is observed that, based on the E(2^+) energy systematics, the deformation in Nd nuclei would increase at least up to the N=100 isotope. In the case of ^{158}Pm, nine new γ-rays and seven new excited states have been identified following the β-decay of ^{158}Nd, enabled by the first-ever construction of the β-decay scheme of ^{158}Nd to ^{158}Pm. Within this scheme, tentative spin-parity assignments are suggested for the ground and newly observed excited states in ^{158}Pm. Similarly, eight new γ-rays and five new excited states in ^{156}Nd have been established through the β-decay of ^{156}Pr, based on the first-ever construction of the β-decay scheme of ^{156}Pr to ^{156}Nd. Spin-parity assignments to the parent ^{156}Pr ground state, and the newly excited states in ^{156}Nd are tentatively proposed based on the obtained β-decay scheme.

Interestingly, to explain the observed β-decay scheme of ^{156}Pr to ^{156}Nd, a tentative spin-parity assignment of (4^-) is proposed for the ground-state of ^{156}Pr. This involves a change in the neutron Fermi surface at N=97 in the Nilsson diagram, shifting from the commonly occupied ν5/2[523] orbital to the ν5/2[642] orbital. Such a change may potentially indicate a reduction in nuclear deformation when moving from Pm (Z=61) to Pr (Z=59) across the Nd (Z=60) nuclei.

This thesis reports the first β-γ decay spectroscopy results for ^{156,157,158}Pr and ^{158}Nd nuclei.