Isomer decay spectroscopy of ^{164}Sm and ^{166}Gd: mid-shell collectivity around N=100[†]

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The deformation of nuclei around $A = 160$ may influence the elemental abundances in the rare earth element peak. Macroscopic-microscopic calculations show a deformation maximum close to $N = 104$ and $Z = 66$ (^{170}Dy)[1]. However, these calculations seem to be contradicted by recent experimental data[2,3]. We utilise the existence of K isomers in this deformed region, to reveal the low-lying excited states in $A \approx 160$ nuclei that can provide insight into their deformation.

Neutron-rich $Z = 62, 64$ isotopes were produced by in-flight fission of a 345 A·MeV ^{238}U beam with an average beam intensity of 10 pnA incident on a ^{9}Be target at the RIBF. The secondary RI beam containing the nuclei of interest is passed through BigRIPS and the ZeroDegree spectrometers that separate and identify the beam species on an ion by ion basis, using TOF, Bρ and ΔE. The ions of interest were implanted in a stopper and the γ rays emitted following isomeric decay were detected using EURICA (Euroball-RIKEN Cluster Array): 84 HPGe crystals arranged in a 4π configuration around the stopper.

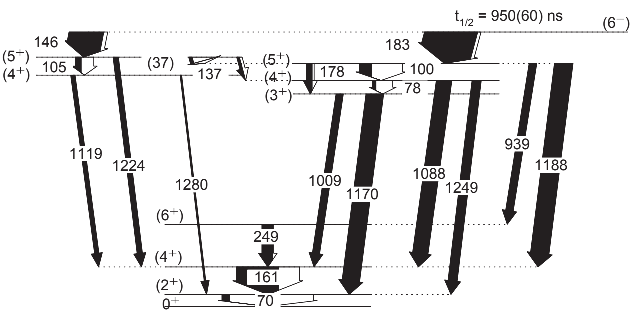

Fig. 1. Level scheme of ^{166}Gd obtained in this work.

The decay from isomeric states in ^{166}Gd and ^{164}Sm ($N = 102$) has been detected for the first time. The half-lives of the isomeric states have been measured to be 950(60) ns and 600(140) ns for ^{166}Gd and ^{164}Sm respectively. Their level schemes, seen in Figs. 1 and 2, were deduced from γ-γ coincidence analysis. Potential

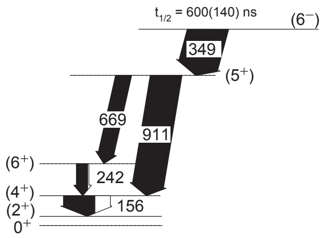

Fig. 2. Level scheme of ^{164}Sm obtained in this work.

energy surface calculations[4] with total energy minimised in $(\beta_2, \beta_4, \beta_6)$ deformation space and $\gamma = 0$ suggest a 6^- state with a 2-neutron $\nu\frac{5}{2}^-[512] \otimes \nu\frac{7}{2}^+[633]$ configuration is isomeric in both ^{166}Gd and ^{164}Sm.

A key feature of our results are the first 2^+ and 4^+ energies. The systematics of $E(2^+)$ and $E(4^+ \rightarrow 2^+)$ are shown in Fig. 3. The observed 2^+ and 4^+ energies of ^{166}Gd and ^{164}Sm are the lowest in their isotopic chains and of the $N = 102$ isotones, suggesting they are the most deformed $N = 102$ nuclei observed in this region to date. Our new points in the systematics also highlight the increase of $E(2^+)$ and $E(4^+ \rightarrow 2^+)$ at $N = 100$. This behaviour supports the appearance of a recently predicted deformed shell gap at $N = 100$[5] that will influence r-process abundance calculations.

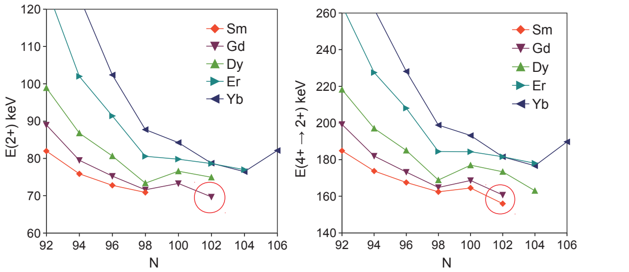

Fig. 3. Systematics of $E(2^+)$ and $E(4^+ \rightarrow 2^+)$ for Sm, Gd, Dy, Er and Yb isotopes. All data points from ENDSDF and this work.

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