Long-lived K isomer and enhanced γ vibration in ^{172}Dy†

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The excitation spectrum in deformed nuclei is characterized by rotational and vibrational motion, the latter corresponding to oscillations around the equilibrium shape with a fixed orientation of the nucleus. For axially symmetric nuclei, the lowest order shape vibration is of quadrupole type (i.e., a phonon carries two units of angular momentum), which can be classified into two modes, β and γ vibrations, in terms of the component of (vibrational) angular momentum along the symmetry axis, denoted by K. The β-vibrational mode with $K^\pi = 0^+$ maintains axial symmetry, while the $K^\pi = 2^+$ γ vibration represents a dynamical distortion from axial symmetry, which may prelude the emergence of γ instability or rigid triaxial deformation approaching the transitional region where the nuclei have less-deformed quadrupole shapes.

In the present work, we have explored neutron-rich Dy isotopes ($Z = 66$) with a particular focus on the systematic behavior of the ground-state (g.s.) and γ-vibrational bands. Based on a simple assumption that the axial quadrupole deformation increases as the number of valence nucleons increases, it is conjectured that the maximum ground-state deformation occurs in the doubly mid-shell nucleus ^{170}Dy ($N = 104$). In actual nuclei, however, the stability of shape is likely to be sensitive to characteristic single-particle (Nilsson) orbitals near the Fermi surface. Experimentally, the existence of γ-vibrational levels at low excitation energy can be a signature of softening deformed shape with respect to the axially-asymmetric (γ) degree of freedom. In this report, the first spectroscopic results of the g.s. and γ bands in ^{172}Dy ($N = 106$) are presented. Its excited states have been populated through the decay from a long-lived isomeric state, which has the same configuration as the $K^\pi = 8^-$ isomers that had been identified in the $N = 106$ isotones from $Z = 68$ to 82[1]. Thus, the present work has extended a sequence of the $N = 106$ isomers to the previously inaccessible nucleus of $Z = 66$. It is notable that high-K isomers can serve as a useful probe for the underlying nuclear structure since their nature is sensitive to intrinsic orbits near the Fermi surface, pairing and other residual interactions, and the degree of axial symmetry[2].

The level structure of ^{172}Dy has been investigated by means of decay spectroscopy with the EURICA setup following in-flight fission of a ^{238}U beam. Prior to the present work, no spectroscopic information had been reported for this neutron-rich nucleus. The level scheme of ^{172}Dy established in the present work is displayed in Fig. 1. A long-lived isomeric state with $T_{1/2} = 0.71(5)$ s and $K^\pi = 8^-$ has been identified at 1278 keV, which decays to the ground-state and γ-vibrational bands through hindered electromagnetic transitions, as well as to the daughter nucleus ^{172}Ho via allowed β decays. The robust nature of the $K^\pi = 8^-$ isomer and the ground-state rotational band reveals an axially-symmetric structure for this nucleus. Meanwhile, the γ-vibrational levels have been identified at unusually low excitation energy compared to the neighboring well-deformed nuclei, indicating the significance of the microscopic effect on the non-axial collectivity in this doubly mid-shell region.

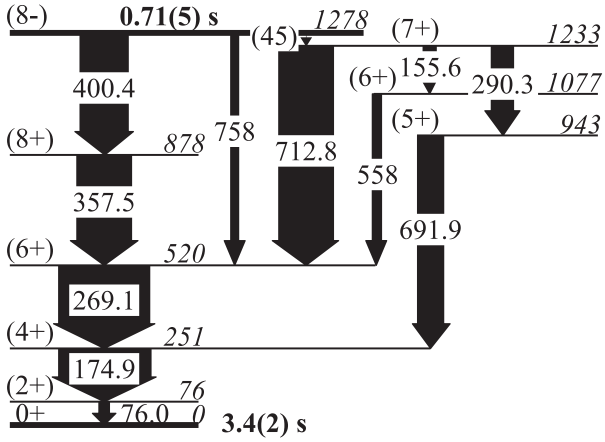

Fig. 1. Partial level scheme of ^{172}Dy constructed in the present work.

References
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2) G.D. Dracoulis: Phys. Scr. **2013**, 014015 (2013).

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