

Nucleon alignments and signature inversion in ^{173}W

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Introduction

In the $A \approx 170$ -180 region, both protons and neutrons occupy high- Ω orbitals near their respective Fermi levels, conditions which are conducive for the exhibition of nuclear structure phenomena like anomalous band-crossings, large signature splitting, and signature inversion *etc.* These phenomena are associated with nucleon-pair breaking, γ -softness, and the possible presence of triaxial nature in these nuclei. Measurements of the aligned angular momentum and signature inversion frequencies from these rotational bands offer insights into the nucleon-nucleon interaction and deformation of these nuclei [1–4]. Among these phenomena, the signature inversion wherein the initially favored signature eventually lies higher in excitation energy than its partner is observed in odd- A nuclei, and is not well understood, though many descriptions have been proposed. This has motivated our present work on ^{173}W , and a search for more such phenomena and their explanation.

Experiment and Data Analysis

The ^{173}W nucleus was first investigated via the $^{161}\text{Dy}(^{16}\text{O},4n)$ [3], and then studied by via $^{150}\text{Nd}(^{28}\text{Si},5n)$ [5] reactions, wherein levels upto a spin of $49/2 \hbar$ and excitation energy up to 5.5 MeV had been established in rotational bands built on three 1-quasiparticle configurations. In the present work, the ^{173}W nucleus has been populated in two separate experiments using the Gammasphere array, using a beam of ^{50}Ti ions incident on thick and thin

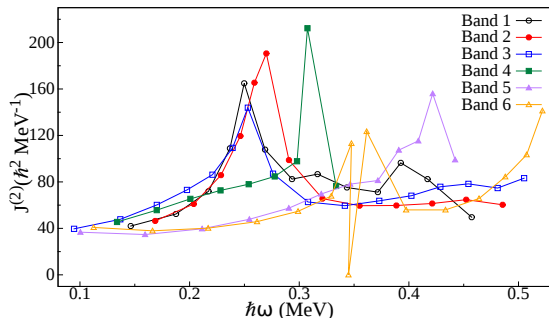


FIG. 1: Dynamic moment of inertia in the 1-quasiparticle rotational sequences as a function of the rotation frequency indicating the various band-crossing.

^{128}Te targets, respectively. The former was backed by 50 mg/cm^2 of ^{nat}Pb and irradiated at beam energies of 215 and 225 MeV, while the latter ones had a thickness ranging from 235 to $370 \mu\text{g/cm}^2$, with approximately $500 \mu\text{g/cm}^2$ of Au on the front and $50 \mu\text{g/cm}^2$ on the back and irradiated at beam energy of 230 MeV. The thick- and thin-target experiments enabled the study of isomers and high-spin rotational bands, respectively. Data were collected both in the prompt and delayed regimes and sorted into a large number of two-, three- and four-fold histograms involving energy and time parameters. These were subsequently analyzed for establishing the level structure of ^{173}W , along with the identification of several new rotational bands and the determination of their band properties.

Results and Discussion

Thirteen rotational sequences (seven of which are new) have been identified and over 200 γ rays (~ 120 of which are new) have been

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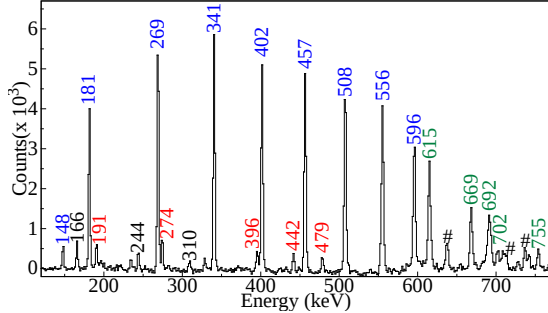


FIG. 2: Transitions in the high-spin rotational sequence built on the $K^\pi = \frac{1}{2}^-$ band, with simultaneous gates on three γ rays in a four-dimensional hypercube. The ones labeled in green are newly established transitions of band 4, red and blue labels represent known transitions of band 3 and 4, black labels represent new interband transitions in band 3 and 4, and # represents transitions in the sidebands.

observed in this nucleus from the above experiments. The existing 1-quasiparticle sequences have been extended upto spin $\approx 40 \hbar$, and nucleon alignments have been mapped out for all six rotational sequences as shown in Fig.1, similar to those in ^{174}W [6]. It is found that $i_{13/2}$ neutron and $h_{11/2}$ proton crossings are responsible; this is validated by the results of our calculations using the Ultimate Crank code[7]. A 1-quasiparticle band with configuration $\nu[512]5/2$ ($h_{9/2}$ orbital) also shows signature inversion at high spin. This behaviour is consistent with the neighbouring isotones *i.e.*, ^{171}Hf and ^{175}Os , and is yet to be explained theoretically since 1-quasiparticle bands are generally not expected to demonstrate this phenomenon. Several possible explanations

include the presence of triaxiality, Coriolis mixing of large number of bands, or the influence of proton-neutron interactions. Several interband transitions from levels in the $h_{9/2}$ band to those in the $i_{13/2}$ band have also been established. Seven new rotational sequences(sidebands) have been identified from this work; these are in addition to six sequences established earlier. The present work has, therefore, spanned the study of both intrinsic and collective excitation modes in ^{173}W , and led to several interesting insights which will be presented in detail at the symposium.

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References

- [1] S.K. Tandel *et al.*, Phys. Rev. C 73, 044306 (2006).
- [2] G.D. Dracoulis, Nucl. Phys. A 752 (2005) 213c.
- [3] P.M. Walker *et al.*, J. Phys. G 4, 1655 (1978).
- [4] R. Bengtsson *et al.*, Nucl. Phys. A 415, 189 (1984)
- [5] H.X. Wang *et al.*, Phys. Rev. C 86, 044305 (2012).
- [6] S.K. Tandel *et al.*, Phys. Rev. C 77, 024313 (2008).
- [7] T. Bengtsson *et al.*, Phys. A. 496, 56 (1989).