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}Dy(^{16}O,4n)[3], and then studied by via ^{150}Nd(^{28}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 ^{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 μg/cm^2, with approximately 500 μg/cm^2 of Au on the front and 50 μg/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.

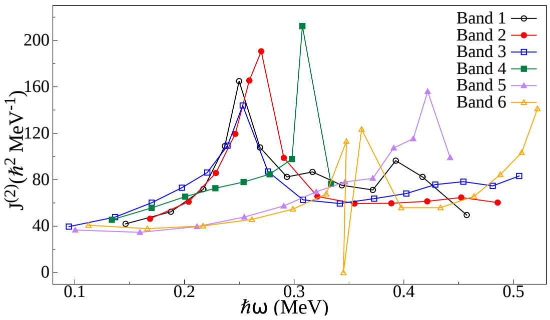

FIG. 1: Dynamic moment of inertia in the 1-quasiparticle rotational sequences as a function of the rotation frequency indicating the various band-crossing.

Results and Discussion

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

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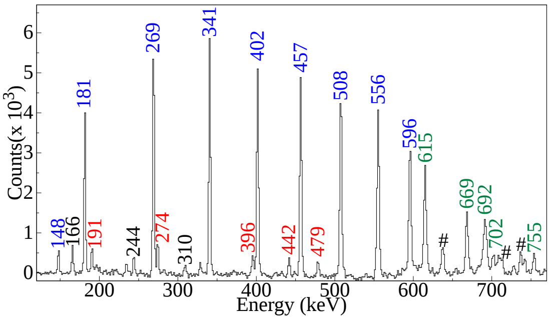

FIG. 2: Transitions in the high-spin rotational sequence built on the $K^\pi = \frac{1}{2}^-$ band, with simultaneous gates on three γ rays in a four-dimensional hypercube. The ones labeled in green are newly established transitions of band 4, red and blue labels represent known transitions of band 3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