Normal deformed bands and possibility of TSD structures in the N=92 ^{166}W nucleus

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Introduction

Triaxial Strongly Deformed (TSD) band structures have been observed in several Lu-Hf-Ta isotopes in the $A\sim165$ region. The occurrence of TSD bands in Lu (Z=71) and Hf (Z=72) isotopes is not consistent with predicted proton and neutron shell gaps, probably due to inadequate knowledge of energies of high-j orbitals at large triaxiality. Based on calculated shell gaps, among the Lu isotopes, ^{165}Lu$_{94}$ and ^{168}Lu$_{97}$ are good candidates for TSD structures. However, the strongest TSD band in ^{163}Lu$_{92}$ is observed to be three times more strongly populated than the corresponding one in ^{165}Lu$_{94}$, and TSD structures have not yet been observed in ^{168}Lu$_{97}$. Further, no TSD bands have been observed in ^{166}Hf$_{94}$, which is located at the centre of the predicted TSD island. The above observations appear to indicate that, at large triaxiality, TSD structures may be favored at N=92 than at N=94.

Calculations by R. Bengtsson indicate that TSD band in ^{166}W, with a positive γ value should become yrast at spin, $I\sim44\hbar$. The aforesaid systematic calculations of TSD and Normal Deformed (ND) structures in Hf, Yb and W isotopes further suggest that the N=92 isotones in these three elements have higher excitation energies at normal deformation in the spin range of 30-50 $\hbar$ [1]. So, the favorable position of TSD bands in the N=92 isotones may be an outcome of the fact that the band at normal deformation goes up in energy for this neutron number.

There were two previous measurements to study high-spin states in ^{166}W. In the first measurement, a ^{28}Si beam was used by Gerl *et al.* [2] and four HPGe detectors were used to record data. In the second measurement by Simpson *et al.* [3], the *p2n* reaction channel was used, and the deexciting γ rays were detected using the POLYTESSA array. The positive-parity yrast band was observed up to an excitation energy of 9 MeV, and spin, $I = 30\hbar$, well below where possible TSD bands are expected to be yrast. Two other negative-parity rotational bands were also reported up to spin, $I = 23\hbar$.

Experimental details

The experiment was performed using the Argonne Tandem Linear Accelerator System (ATLAS) facility at the Argonne National Laboratory, USA, and employed a

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285 MeV ^{60}Ni beam to populate high-spin states in ^{166}W with the ^{110}Pd(^{60}Ni,4n) reaction. Two self-supporting ^{110}Pd foils of thickness ~540 μg/cm^2 were stacked together and used as targets. The emitted γ rays were detected with the Gammasphere array which, at the time of the experiment, comprised of 82 Compton-suppressed high-purity Ge detectors. Beam wobbling was employed during the measurement, and a total of 2.2 x 10^9 three- and higher-fold coincidence events were recorded for further analysis.

Results and Discussion

The data analysis has revealed seven new high-spin rotational band structures and more than one hundred new γ transitions. The band built on the ground state has been extended up to an excitation energy, E_x = 14.4 MeV and spin, $I = 40\ \hbar$. The other two previously known negative-parity rotational bands have also been extended (Fig. 1) up to $I = 41\ \hbar$ and $I = 38\ \hbar$ (bands 1 and 2 in Ref. [3], respectively). An analysis of DCO ratios was performed to determine multipolarities of the γ rays and spins of excited levels were correspondingly assigned.

Cranking calculations using the Ultimate Cranker code have been performed for ^{166}W and these indicate that the yrast positive-parity band built on the ground state has a prolate collective shape ($\epsilon_2 \approx 0.17$ and $\gamma \approx 0^o$). The first rotation alignment in this band can be attributed to the neutron $i_{13/2}$ AB crossing at 0.26 MeV (Fig. 2). The AB crossing is blocked in the negative-parity bands with 2-quasiparticle character, including an $i_{13/2}$ neutron, therefore the BC crossing leads to the first observed alignment at 0.34 MeV. Detailed results will be presented in the symposium.

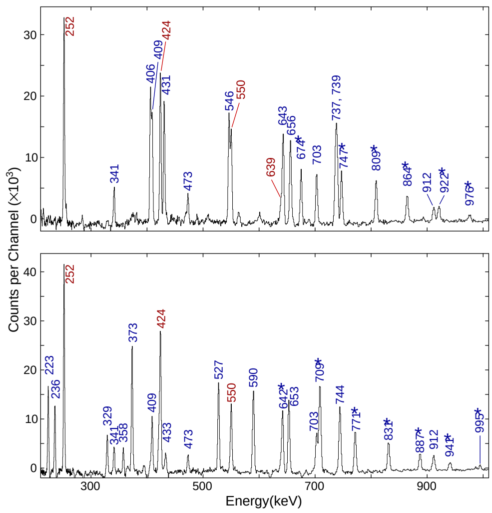

FIG. 1: Representative spectra of negative-parity rotational bands (bands 1 and 2 in upper and lower panels, respectively). The newly observed transitions are marked with an asterisk sign.

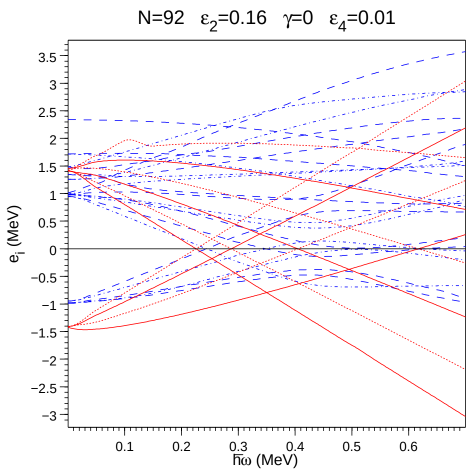

FIG. 2: Neutron quasiparticle levels in ^{166}W calculated using the Ultimate Cranker code.

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