Presence of transverse and longitudinal wobbling in ^{183}Au

S. Nandi[1,2,*] G. Mukherjee[1,2], Q.B. Chen[3], R. Banik[1,2], S. Bhattacharya[1,2], Shabir Dar[1,2], S. Bhattacharyya[1,2], C. Bhattacharya[1,2], S. Rajbanshi[4], Sajad Ali[2,5], H. Pai[5], S. Chatterjee[6], S. Das[6], S. Samanta[6], R. Raut[6], S.S. Ghugre[6], S. Das Gupta[7], P. Chowdhury[8]

[1]*Variable Energy Cyclotron Center, 1/AF Bidhannagar, Kolkata 700064, INDIA*
[2]*HBNI, Training School Complex, Anushaktinagar, Mumbai-400094, India*
[3]*Physik-Department, TechnischeUniversitätMünchen, D-85747 Garching, Germany*
[4]*Department of Physics, Presidency University, Kolkata 700073, India*
[5]*Saha Institute of Nuclear Physics, Kolkata, 1/AF Bidhannagar, Kolkata 700064, INDIA*
[6]*UGC DAE CSR, Kolkata700098, INDIA*
[7]*Victoria Institution (College), Kolkata-700009, INDIA*
[8]*University of Massachusetts Lowell, Lowell, MA 01854, USA*
* *email:* s.nandi@vecc.gov.in

Introduction

The wobbling mode of excitation in triaxial nuclei ($\Im_m > \Im_s > \Im_l$) is analogous to the classical spinning motion of asymmetric top. A triaxial nucleus energetically favors rotation around an axis with largest moment of inertia (medium axis). But the non-zero value of the moment of inertia along the short and long axes of triaxial core generate a small amplitude oscillation of angular momentum about the medium axis which is called wobbling motion. The energy of the wobbling excitation with wobbling quanta n is given by $H=\hbar^2/2\Im_m(I(I+1))+(n+1/2)\hbar\omega_{wobb}$, where $\hbar\omega_{wobb}$ = wobbling frequency. Such exotic excitation has, so far, been observed only in 8 nuclei across the entire nuclear chart. According to Ref. [1] the wobbling mode in odd-A case can be categorized in two types based on the coupling of the odd particle with triaxial core: 1) ñtransverse wobblingò (TW) when odd particle aligns perpendicular to the medium axis and 2) ñlongitudinal wobblingò (LW) when odd particle aligns along the medium axis motion.

The most important signature of the wobbling band is the nature of the connecting transitions between the two wobbling partners. The nature of the connecting transitions between n=1 to n=0 are predominantly (ΔI=1) E2.

Experimental details

The excited states of the neutron deficient ^{183}Au nucleus were populated by using heavy ion induced fusion evaporation reaction ^{169}Tm(^{20}Ne,6n)^{183}Au at 146 MeV. The beam was delivered from the K-130 cyclotron at VECC, Kolkata and the gamma rays were detected using the INGA setup at VECC consisted of 8 Compton-suppressed Clovers and 2 LEPS detectors.A thick (23mg/cm^2)^{169}Tm target was used for the experiment.Two and higher fold coincidence data were recorded using PIXIE-16-digitizer based system developed by UGC-DAE-CSR, Kolkata Centre [2]. Total 1.5×10^9 events were collected. The data were processed using the IUCPIX package [2] and analyzed using the RADWARE software.

Experimental results and Discussions

The usual γ–γ matrix and γ–γ–γ cube were analyzed to establish the level scheme of ^{183}Au. We have observed most of the γ-rays reported in Ref. [3]. Typical double gated spectra projected from the γ–γ–γ cube are shown in Fig.1 and Fig.2. The proposed level scheme from the present work is shown in Fig.3. Two rotational bands based on $\pi h_{9/2}$ and $\pi i_{13/2}$ configurations have been clearly identified in this work along with their wobbling and signature partner bands. The signature partner band of $\pi i_{13/2}$ rotational band has been identified for the first time in this work. Most importantly, we have determined the linear polarization (P) from the measured polarization asymmetry ratio (Δ_{IPDCO}) and have measured the DCO (Directional Correlation from the Oriented states) ratio (R_{DCO}) of the γ-rays. These two parameters can give the mixing ratios (δ) of the connecting transitions. For that the experimental values of P and R_{DCO} are compared with the calculated values as shown in Fig.4. In this figure, the calculated values are for different mixing ratio δ.

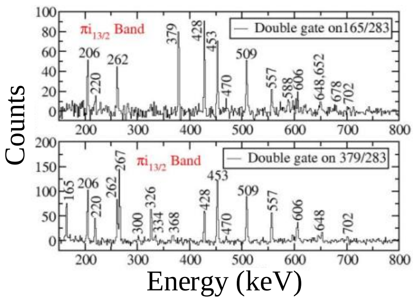

Fig. 1 Double-gated γ-ray coincidence spectra of $\pi i_{13/2}$ band in ^{183}Au.

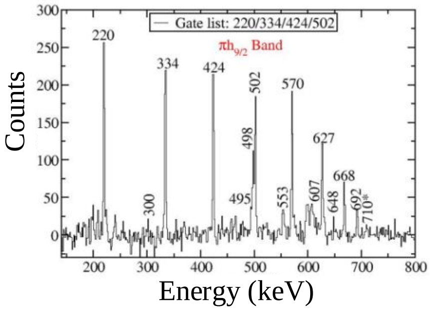

Fig. 2 Double-gated sum coincidence spectrum of $\pi ih_{9/2}$ band with a gate list of 4 γ-rays.

It can be seen from Fig. 4 that the measured mixing ratios δ for the ΔI = 1 connecting transitions between the wobbling partner band and the main band arelarge with around 90%E2 mixing. On the other hand, the E2 mixing ratio of the connecting transitions between the signature partner and the main band are very small with <2% E2.

The wobbling frequency vs. spin has been plotted for the two wobbling bands in Fig. 5. It clearly shows that the wobbling frequency for the $\pi h_{9/2}$ configuration decreases with spin while it increases for the $\pi i_{13/2}$ configuration. It confirms the presence of both the types of wobbling motion for the two configurations (with different parity) in a single nucleus.

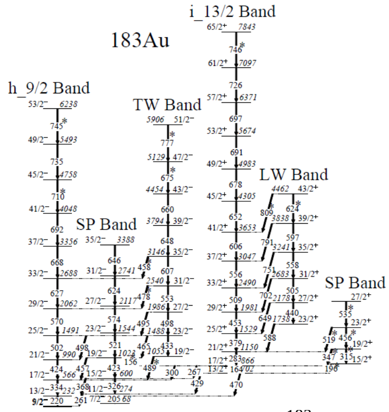

Fig. 3 Proposed Level scheme of ^{183}Au.

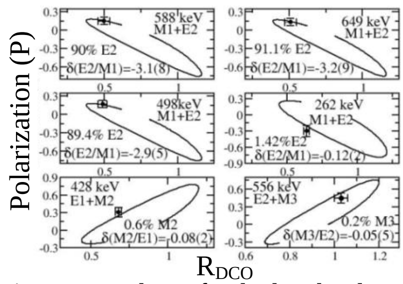

Fig. 4 Contour plots of calculated values (solid line) of polarization and R_{DCO}. The experimental points are also shown.

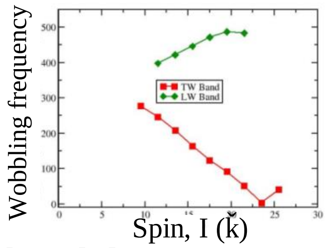

Fig. 5 Plot of wobbling frequency vs. Spin. Red (Green) points are for TW (LW).

Acknowledgement

The efforts of the cyclotron operators at VECC are acknowledged for good quality ^{20}Ne beam. The support of INGA collaboration is also acknowledged for setting up of INGA at VECC. INGA is partially funded by DST, Govt. of India (No. IR/S2/PF-03/2003-II).

References

[1] S. Frauendorf and F. Dönau, PRC**89**, 014322 (2014)
[2] S. Das et al., NIM.A**893**, 138 (2018).
[3] L. T. Song et al. PRC **71**, 017302 (2005)