High-K structure in the shape-coexistent nucleus ^{188}Pt

S. Mukhopadhyay[1],* D. C. Biswas[1], S. K. Tandel[2], L. S. Danu[1], Somnath Nag[3], B. N. Joshi[1], L. A. Kinage[1], G. Prajapati[1], Bency John[1], T. Trivedi[4], S. Saha[4], J. Sethi[4], B. S. Naidu[4], P. K. Joshi[5], and R. Palit[4]

[1]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai 400085, India*
[2]*UM-DAE Centre for Excellence in Basic Sciences, Mumbai 400098, India*
[3]*Dept. of Physics and Meteorology, IIT Kharagpur, Kharagpur 721302, India*
[4]*Dept. of Nuclear and Atomic Physics, TIFR, Mumbai 400005, India and*
[5]*Homi Bhabha Centre for Science Education, TIFR, Mumbai 400085, India*

Introduction

The presence of isomeric states in the A∼180 mass region is well established both in experiment and theory. The occurrence of these metastable states can be interpreted in terms of both protons and neutrons in high-Ω orbitals. In axially symmetric nuclei, transitions involving large changes in the projection of angular momentum on the symmetry axis, K, are highly hindered. This leads to long half-lives. With increasing proton and neutron numbers, beyond Z=72 and N=106, the nuclear shape becomes more prone to non-axial fluctuation, induced by multi-quasiparticle excitation. Indeed, in the self-consistent Relativistic Hartree-Bogoliubov (RHB) calculation, the gradual transition from the prolate deformed ^{186}Pt, through the region of triaxially deformed $^{188-198}$Pt, to the slightly oblate ^{200}Pt, and finally the spherical $^{202-204}$Pt isotopes is observed [1]. Overall, the experimental facts and theoretical calculations make a strong case to study ^{188}Pt nucleus in detail, which will not only paint the shape change or shape coexistence picture with more clarity, but will also reveal the gradual loss of axial symmetry as the neutron number is increased in the Pt chain of isotopes.

The experimental data on the excited states of ^{188}Pt are rather sparse. The latest work on this nucleus was reported by Yuan *et al.* where the ^{176}Yb(^{18}O,6n) reaction was used with a moderate array of thirteen HPGe detectors [2].

Experimental details

High-spin states in the residual nucleus ^{188}Pt were populated in the fusion-evaporation reaction ^{174}Yb(^{18}O,4n) using a 85 MeV beam provided by the Pelletron-Linac facility, TIFR, Mumbai. The enriched ^{174}Yb target of thickness 1.14 mg/cm^2 was prepared by electro-depositing on an Al foil of thickness $\sim$ 750 μg/cm^2. The de-exciting γ rays were detected by the Indian National Gamma Array (INGA) facility, then consisting of eighteen Compton suppressed clover Ge detectors. More than one billion two- and higher fold time-stamped coincidence events were recorded for further offline analysis.

Results and discussion

The data analysis has revealed several interesting features in the high-spin structure of ^{188}Pt. A partial level scheme relevant to the present discussion is shown in Fig. 1. With the addition of several new γ rays, the level scheme has been significantly extended with respect to the latest published work [2]. The DCO ratio measurement has been done for the complete level scheme. The 584 keV ($7^-\rightarrow6^+$) and 895 keV ($5^-\rightarrow4^+$) transitions have been found to be pure dipoles in character. On the other hand, the DCO ratio of the 544-keV transition ($9^-\rightarrow7^-$) points toward its mixed nature. The DCO ratio measurement has revealed ΔJ = 1 nature for the Seq. VI (Fig. 1).

A new sequence of γ-rays (Seq. IV in Fig. 1) has been observed above the 10^+_3 state. Al-

*Electronic address: somm@barc.gov.in

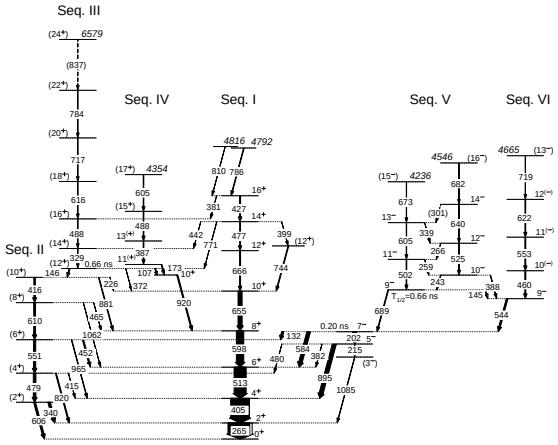

FIG. 1: Partial level scheme of ^{188}Pt, deduced from the present data set.

though no linking transition has been observed between Seq. IV and the yrast positive parity Seq. III, efforts are being put to understand their side-by-side co-existence in terms of energetics.

The most significant finding of the present work is the high-K band structure on $I = 9^-$ isomer at E$_x$ = 2456 keV (Fig. 2 and Seq. V in Fig. 1). The half-life ($T_{1/2}$ = 0.66 ns) of this level was measured earlier using recoil shadow method [3]. For this high-K structure, the $K^\pi = 9^-_2$ bandhead de-excites via both a K-allowed 145 keV transition to the $K^\pi = 9^-_1$ state and a relatively more intense K-forbidden E2 transition of energy 689 keV

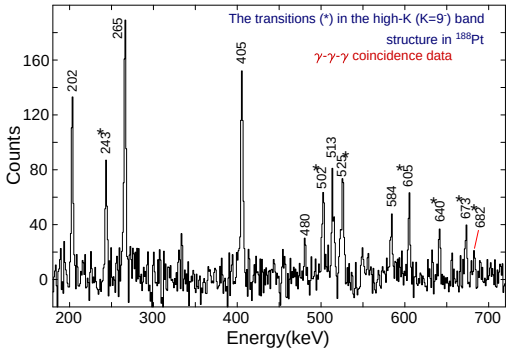

FIG. 2: Representative gated spectrum showing the transitions in the high-K band in ^{188}Pt.

to the 7^- isomeric state of a sequence of levels with $K^\pi = 3^-$. Reduced hindrance or the hindrance per degree of K-forbiddenness (f_ν) which gives an estimate for the 'goodness' of the K-quantum number, has been calculated for this particular case. This is given by $f_\nu = [F_W]^{1/\nu}$, where $\nu = \Delta K - \lambda$, λ is the multipolarity of the transition and F_W is the ratio of the partial γ-ray half-life to the Weisskopf single-particle estimate. The 689 keV transition from the 0.66 ns isomer at 2456 keV excitation energy has f_ν=2. Comparison of the rate of this decay with similar transitions in nearby nuclei is in progress, which will essentially reveal the systematic trend of reduced hindrance with increasing/decreasing proton and neutron number. Preliminary configuration assignment for the $K^\pi = 9^-_2$ state has been made based on the systematic trend of the experimental alignments. It is proposed that this state is built on $\frac{11}{2}^+[615] \otimes \frac{7}{2}^-[503]$ two-quasineutron coupling. This configuration assignment is tentative, and further support for this assignment will be sought by comparing the experimental $B(M1)/B(E2)$ ratio with the calculated values from the semiclassical formula of Dönau and Frauendorf, as well as by extracting g-factors from the branching ratios in the strongly coupled band. The experimental results and their implications will be presented at length during the symposium.

Acknowledgments

The INGA collaboration is acknowledged for making the detectors available during this measurement. Thanks are due to all the operation staffs of the Pelletron-Linac facility at TIFR, Mumbai, for their effort in running the accelerator. Special thanks go to Dr. Suparna Sodaye, RCD, BARC, for preparing the target.

References

[1] T. Nikšić, D. Vretenar and P. Ring, Prog. Part. Nucl. Phys. **66**, 519 (2011).
[2] L. Yuan *et al.*, Chin. Phys. Lett. **25**, 1633 (2008).
[3] L. Richter *et al.*, Nucl. Phys. A **319**, 221 (1979).