# Search for Anti-magnetic rotations in $^{104}$Pd

Niyaz Rather[1],* P. Datta[3], Santosh Roy[1], S. Chattopadhyay[1], A. Gowswami[1], S. Nag[4], R. Palit[2], S. Saha[2], J. Sethi[2], and T. Trivedi[2]
[1] *HENPP Division, Saha Institute of Nuclear Physics, Kolkata - 700064, INDIA*
[2] *Tata Institute of Fundamental Research, Mumbai-400005, INDIA*
[3] *Ananda Mohan College, 700009-Kolkata, INDIA and*
[4] *IIT, Kharagpur, West Bengal, INDIA*

Anti-magnetic rotation(AMR) was first reported in $^{106}$Cd [1] and subsequently in a number of its other isotopes [2–5]. It is interesting to note that the $\pi$-rotational symmetry is common to both the Principal axis rotation(PAR) and AMR. Thus, the band structures in both cases are very similar and it is not possible to distinguish these two modes of excitation from level energies and spins alone. On the other hand the measurement of level lifetimes is a definite marker to distinguish the two angular momentum generation mechanisms. In this communication we report the electrical quadrupole transition probabilities (B(E2)) of the high spin states of the yrast cascade of $^{104}$Pd which is the isotone of $^{106}$Cd.

These levels were populated by injecting 63 MeV $^{13}$C beam from 14-UD Pelletron at TIFR on a 1 $mg/cm^2$ $^{96}$Zr target on 9 mg/$cm^2$ Pb backing. The lineshapes were measured at $40^0$, $90^0$ and $157^0$ with respect to the beam direction using INGA array [6]. The level lifetimes were measured from the observed lineshapes by using LINESHAPE analysis code of Wells and Johnson [7]. The examples of the observed lineshapes are shown in figure 1. The fitted lineshapes are shown in solid lines with the contaminant peaks shown by dashed lines. The $90^0$ spectra have been shown as references so as to identify the lineshapes at forward and backward angles. The measured B(E2) values have been plotted in Fig 2(a), while the reported B(E2) values for $^{106}$Cd [1] are shown in Fig. 2(b).

It is obvious from the figure that the variation of B(E2) rates as a function of spin is completely different for the two isotones. The observed B(E2) transitions rates in $^{104}$Pd remain nearly constant as a function of angular momentum which is the characteristic of collective rotation with a specific single particle configuration. In the case of $^{106}$Cd, the reported B(E2) values show a sharp fall which is the characteristic of AMR.

Shape parameters for the yrast band in $^{104}$Pd can be estimated from the consistency of $Q_t$ and $J^{(1)}$ values in the spin interval of $16\hbar$ - $24\hbar$, where [8]:

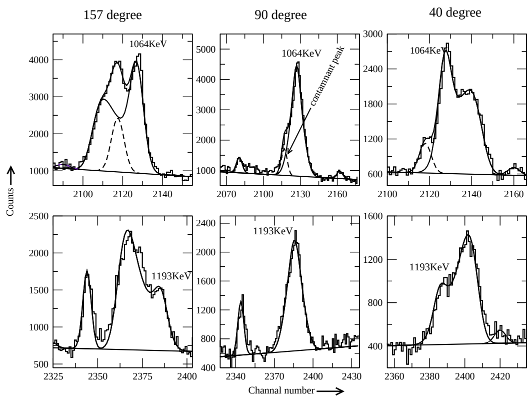


FIG. 1: Examples of experimental lineshapes and the fits at $157^0$, $40^0$ w.r.t the beam direction.

TABLE I: Table for BE2 Values as a function of Spin.

| $E_\gamma$(KeV) | $I_f(\hbar)$ | $\tau(ps)$ | B(E2)$(eb)^2$ |
|---|---|---|---|
| 927 | 16 | 0.73(2) | 0.16(2) |
| 1064 | 18 | 0.37(3) | 0.16(3) |
| 1193 | 20 | 0.21(2) | 0.16(2) |
| 1256 | 22 | 0.15(2) | 0.17(2) |
| 1365 | 24 | 0.10(3) | 0.17(2) |

*Electronic address: niyaz.rather@saha.ac.in

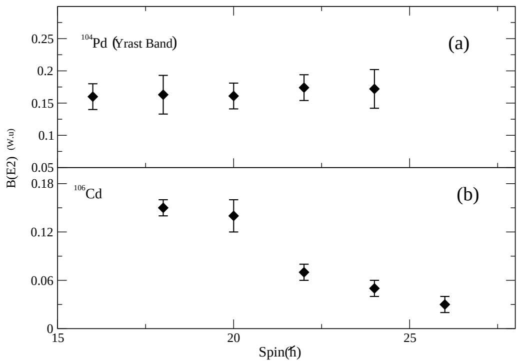


FIG. 2: B(E2) values vs Spin for $^{104}$Pd (a) and $^{106}$Cd (b).

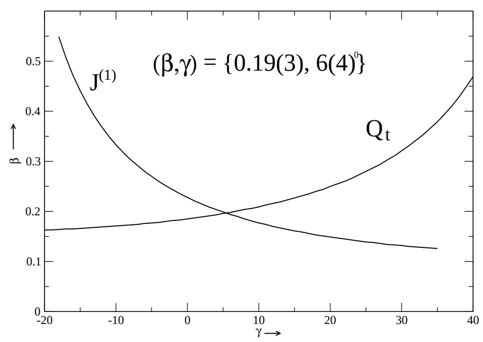


FIG. 3: Shape parameters for $^{104}$Pd.

$$Q_t = [3/(5\pi)^{1/2}]ZeR_0{}^2\beta cos(30+\gamma)/cos30 \quad (1)$$

and

$$J^{(1)} = \frac{2}{5}AR_0{}^2[1-(5/4\pi)^{1/2}\beta cos(120+\gamma) \quad (2)$$

The calculated values as a function of $\beta$ and $\gamma$ are shown in figure 3. The simultaneous consistency of the two values indicates an equilibrium deformation of $\beta = 0.19(3)$ and $\gamma = 6(4)^0$ for this band. Therefore, the high spin states of $^{105}$Pd between $16\hbar$ to $24\hbar$ seem to constitute a prolate band.

Thus, in case of $^{104}$Pd, the protons in high $\Omega$ orbitals of $g_{9/2}$ aligns to the rotational axis (Principal Axis) due to Coriolis interaction while the proton blades in $^{106}$Cd align with principal axis due to the hole-hole attractive interaction [9].

## Acknowledgements

The authors would like to thank the technical staff of TIFR-BARC pelletron facility for its smooth operation throughout the experiment. The first and second author (grant no. PSW-26/11-12) would also like to thank UGC for research support. .

## References

[1] A.J. Simons, et al., Phy. Rev. Lett. 91 (2003) 162501.

[2] P. Datta, et al., Phys. Rev. C 71 (2005) 041305(R).

[3] A.J. Simons, et al., Phys. Rev. C 72 (2005) 024318.

[4] D. Choudhury, et al., Phys. Rev. C 82 (2010) 061308(R).

[5] D. Choudhury, et al., Phys. Rev. C 87 (2013) 034304.

[6] S. Muralithar, et al., Nucl. Intrum. Methods A (2010).

[7] J. C. Wells, N. R. Johnson, Private Communication.

[8] A. Bohr and B. Mottelson, Nuclear Structure (Benjamin, New York, 1975), Vol. II.

[9] Santosh Roy, et al., Phys. Lett. B 694 (2011) 322 - 326.