Evidence of antimagnetic rotational motion in ^{103}Pd

A. Sharma,[1,*] R. Raut,[2] S. Muralithar,[3] R. P. Singh,[3,†] S. S. Bhattacharjee,[3] S. Das,[2] S. Samanta,[2] S. S. Ghugre,[2] R. Palit,[4] S. Jehangir,[4] N. Rather,[5] G. H. Bhat,[6] J. A. Sheikh,[7] S. S. Tiwary,[8] Neelam,[9] P. V. Madhusudhana Rao,[10] U. Garg,[11] and S. K. Dhiman[1]

[1]*Department of Physics, Himachal Pradesh University, Shimla - 171005, India*
[2]*UGC-DAE Consortium for Scientific Research, Kolkata Centre, Kolkata - 700098, India*
[3]*Nuclear Physics Group, Inter-University Accelerator Centre, New Delhi - 110067, India*
[4]*Department of Nuclear and Atomic Physics, Tata Institute of Fundamental Research, Mumbai - 400005, India*
[5]*Department of Physics, Islamic University of Science and Technology, Awantipora, Jammu and Kashmir - 192122, India*
[6]*Department of Physics, SP College Srinagar, Jammu and Kashmir, 190001, India*
[7]*Department of Physics, University of Kashmir, Srinagar, 190006, India*
[8]*Department of Physics, Institute of Science, Banaras Hindu University, Varanasi - 221005, India*
[9]*Department of Physics and Astrophysics, University of Delhi, New Delhi - 110007, India*
[10]*Department of Nuclear Physics, Andhra University, Visakhapatnam - 530003, India*
[11]*Department of Physics, University of Notre Dame, Notre Dame, Indiana 46556, USA*

(Received 9 October 2020; revised 6 January 2021; accepted 2 February 2021; published 25 February 2021)

Lifetime measurements have been carried out for the levels of the negative parity yrast sequence in ^{103}Pd nucleus using the Doppler shift attenuation method. The levels were populated via ^{94}Zr(^{13}C, $4n\gamma$) ^{103}Pd fusion-evaporation reaction at a beam energy of 55 MeV. De-exciting γ rays were detected by utilizing the Indian National Gamma Array. The extracted transition probabilities and other auxiliary observations indicate that the sequence may be resulting from the antimagnetic rotational (AMR) motion of valence nucleons. The key characteristic feature of the AMR motion is the steady decrease of the $B(E2)$ transition probability with spin, which is seen in the present measured transitions for ^{103}Pd. The experimental results are compared with the theoretical predictions of tilted axis cranked approach based on the covariant density functional theory. It is noted that the properties of the AMR band structure for ^{103}Pd predicted in this model analysis are in good agreement with the present experimental findings. Further, semi-classical particle-rotor model has been employed to substantiate the AMR interpretation of the observed band structure in ^{103}Pd and it is shown that results are similar to the band structures observed in the neighboring isotopes, which have also been considered as candidates for AMR motion.

DOI: 10.1103/PhysRevC.103.024324

I. INTRODUCTION

Most of the nuclei are known to exhibit rotational spectra similar to that observed in molecules with energy roughly proportional to square of the angular momentum. Quadrupole deformation of nucleus leads to these rotational bands with strong $E2$ transitions between the states. The bands are well understood as a collective rotation of many nucleons around an axis perpendicular to the symmetry axis of the deformed density distribution [1]. Such band structures have been well investigated, both experimentally and theoretically, for many decades now. It has been recently observed that valance nucleons occupying high-j orbitals around doubly magic core may result into a new kind of structural phenomena such as the magnetic rotation (MR) and the antimagnetic rotation (AMR) [2–5]. These are sequences of transitions bearing tentative similarity with rotational bands, but are observed in nuclei around the shell closures and typically with small deformation. In an MR band, the total angular momentum is generated by the coupling of proton and neutron angular momentum vectors oriented almost perpendicular to each other at the band head. The angular momentum along the band is generated by the alignment of the two spin vectors along the rotational axis in a way that resembles closing the blades of a pair of shears, thus also rendering the name shears band to such sequences. The MR bands can be differentiated from the conventional rotational bands by the cascade of strong $M1$ intra-band transitions and weak crossover $E2$ transitions. The AMR bands are understood in terms of a twin shears mechanism, wherein the angular momentum is generated by the simultaneous closing of the two (or more) symmetric and antialigned proton-hole blades onto the neutron-particle angular momentum vectors [5]. The antialignment of the two (or more) proton-hole blades cancel the perpendicular component of each others magnetic moment leading to the absence of magnetic dipole transitions. This cancellation of

*anupriya.jotu@gmail.com
†rajeshpratap07@gmail.com

