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Antimagnetic rotation in ^{104}Pd

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The electric quadrupole transition rates for the high-spin yrast states of ^{104}Pd have been measured by using the Doppler-shift attenuation method. These values decrease with the increase of angular momentum, which can be associated with the phenomenon of antimagnetic rotation. In the present work, a numerical calculation based on the semiclassical particle plus rotor model for antimagnetic rotation has been employed, giving a good description of the experimental Routhian and the transition rates and providing conclusive evidence of antimagnetic rotation in a nucleus other than cadmium.

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Antimagnetic rotation (AMR) is a novel mechanism for the generation of high angular momentum states in atomic nuclei and was first proposed by Frauendorf [1,2]. This excitation mode derives its origin from the shears mechanism, which is responsible for the origin of the $M1$ bands observed in $A \sim 180$, 130, and 100 regions [3,4]. In the semiclassical picture of the shears mechanism, the total angular momentum is generated by the angular momenta of the valence protons and neutrons and the single-particle configuration is such that it allows the perpendicular coupling of these two angular momentum vectors. Thus, at the bandhead, the angle between them (shears angle) is 90° and the higher angular momentum states of the band originate from the gradual closing of the two angular momentum vectors around the total, which resembles the closing of a pair of shears. AMR is a special case of a symmetric multishears configuration, which is formed by the two angular momentum vectors of a pair of deformation-aligned protons (neutrons) in time-reversed orbits ($\mathbf{j_h}^{(1)}$ and $\mathbf{j_h}^{(2)}$) and the angular momentum vector of multiple rotation-aligned neutrons (protons) ($\mathbf{j_p}$). This structure is symmetric because the shears angle (θ) between $\mathbf{j_h}^{(1)}$-$\mathbf{j_p}$ and $\mathbf{j_h}^{(2)}$-$\mathbf{j_p}$ is the same. Thus, the higher angular momentum states, in case of AMR, are generated by the simultaneous closure of the multishears around ($\mathbf{j_p}$) and is given by

$$I_{sh} = j_p + 2j_h \cos\theta. \tag{1}$$

The symmetry of this shears structure implies that the perpendicular components of the magnetic moment cancel each other. For this reason, the magnetic dipole transition rate vanishes for AMR. The cancellation of the magnetic moment has induced the name antimagnetic rotation because of its similarity to antiferromagnetism, where the dipole moment of one sublattice is in the opposite direction to the other half, leading to the absence of a net magnetic moment. However, as the $R_z(\pi)$ symmetry is retained, the rotational structure decays by weak electric quadrupole ($E2$) transitions. This transition rate is given by

$$B(E2) = \frac{15}{32\pi}(eQ)^2_{\mathrm{eff}}\sin^4\theta, \tag{2}$$

where Q_{eff} is the effective quadrupole moment of the core (rotor). Thus, the $B(E2)$ rates are expected to drop with increasing angular momentum for AMR. Equation (2) can be obtained from the expression for $B(E2)$ given in Ref. [5] and Eq. (1).

The falling trend of $B(E2)$ rates with increasing spin was first measured in ^{106}Cd by Simons *et al.* [5] and subsequently in ^{108}Cd by Datta *et al.* [6]. In both cases, this observation was associated with AMR through the $\pi(g_{9/2})^{-2} \otimes \nu[(g_{7/2}/d_{5/2})^2(h_{11/2})^2]$ configuration and the bandheads were found to be at $18\hbar$ and $16\hbar$ for ^{106}Cd and ^{108}Cd, respectively. The AMR mechanism accounted for an angular momentum gain of $8\hbar$, which corresponded to the complete alignment of the two proton holes.

The interplay between collective and antimagnetic rotations was first reported by Roy *et al.* [7] in ^{110}Cd, where the AMR band was built on the $\pi(g_{9/2})^{-2} \otimes \nu(h_{11/2})^2$ configuration. This interplay was found to span over an angular momentum range of $18\hbar$, of which $10\hbar$ was due to collective rotation. In this work, a semiclassical particle rotor model calculation could successfully reproduce the observed alignment features. The effect of the interplay was concluded from the slower fall of $B(E2)$ rates in ^{110}Cd as compared to the pure AMR bands in ^{106,108}Cd [7]. Such an interplay was later reported in ^{105,107}Cd [8,9]. The falling trend of $B(E2)$ values in ^{105}Cd was explained within the framework of tilted axis cranking based on covariant density functional theory [10,11] if polarization effects were taken into account. It is interesting to note that this framework also supported the two-shears-like mechanism in AMR.

Apart from cadmium isotopes mentioned above, experimental investigations of ^{100}Pd [12], ^{101}Pd [13], and ^{144}Dy [14] have indicated the possible existence of AMR bands in these nuclei. However, due to the absence of lifetime measurements,

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