Search for twin-shears mechanism in odd-A ^{107}Cd

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Introduction

In contrast to the phenomenon of magnetic rotation (MR) found in a large number of nuclei [1], the twin-shears mechanism dubbed as the anti-magnetic rotation (AMR) is a much rarer phenomenon. Till date, firm experimental evidence of AMR has been reported in only two even-even nuclei namely ^{106,108}Cd [2–4]. The first discovery of AMR in an odd-A nucleus ^{105}Cd was recently reported by us [5]. Tentative claims do exist in some other nuclei (see [5] and references therein). The presence of twin-shears mechanism can be reasonably verified by semi-classical approaches to particle-rotor model. Recently, AMR in ^{105}Cd has been investigated in a fully microscopic way by the tilted axis cranking (TAC) method based on the covariant density function theory (DFT) [6]. While confirming the interpretation provided by the semi-classical model (SCM), this calculation also provides a much clearer picture of the mechanism. In the present work, we discuss the lifetime measurements of the negative parity states of ^{107}Cd using the doppler shift attenuation method (DSAM) with the aim of searching for AMR in this nucleus.

Experimental details

Excited states of ^{107}Cd nuclei were populated by the ^{94}Zr(^{16}O,5n) reaction at a beam energy of 93 MeV. The ^{16}O beam was provided by the 14UD TIFR-BARC Pelletron facility at TIFR, Mumbai. An isotopically enriched ^{94}Zr target of thickness 1.35 mg/cm^2 on ^{197}Au backing of thickness 8.86 mg/cm^2 was used. The emitted γ-rays were detected in two fold coincidence, by using the Indian National Gamma Array (INGA) comprising of 15 Compton suppressed clover detectors arranged in six rings [7, 8].

Data analysis and results

After calibration and gain matching, the coincidence events were sorted into the traditional $4k \times 4k$ $E_\gamma - E_\gamma$ symmetric as well as angle dependent asymmetric matrices. Further analysis of the data was carried out using the analysis program RADWARE. The energies and relative intensities of the $\gamma-$ray transitions in ^{107}Cd were determined using various energy gates and the earlier known level scheme of ^{107}Cd [9] was confirmed. Fig. 1 shows a partial level scheme of ^{107}Cd showing the negative parity yrast band of our interest. Using the angle dependent asymmetric matrices, lifetimes of the states are being extracted by fitting the Doppler broadened $\gamma-$ray energies using the LINESHAPE code. Fig. 2 shows lineshape fits for the transition energy 1215 keV ($39/2^- \rightarrow 35/2^-$) for the backward (140°) and forward (40°) angle spectra with gate on the 515 keV ($15/2^- \rightarrow 11/2^-$) transition. Preliminary results indicate that the lifetime of the levels are in the range $0.1 - 0.5$ ps giving decreasing $B(E2)$ values with increase in spin. This more or less confirms the presence of AMR.

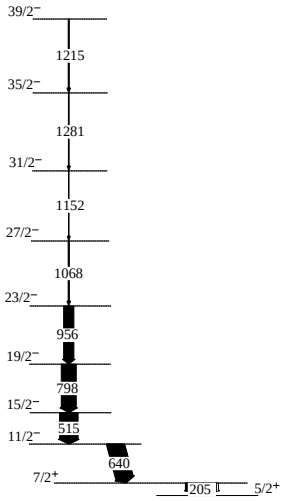

FIG. 1: Partial level scheme of ^{107}Cd showing the negative parity yrast band.

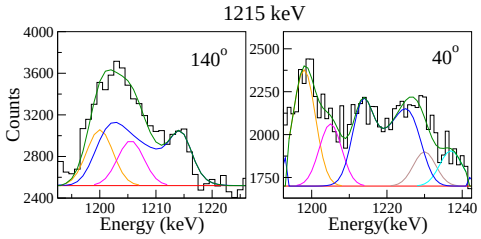

FIG. 2: Lineshape fit for the 1215 keV peak.

Discussions

The negative parity yrast band of ^{107}Cd is built upon $\nu(h_{11/2})$ [9]. A pair of $g_{7/2}$ neutrons aligns at a rotational frequency of $\sim$ 0.42 MeV [9]. Beyond spin 23/2, the angular momentum generation is expected to be due to the gradual alignment of two $g_{9/2}$ proton hole angular momentum vectors $\vec{j}_\pi$ towards the total neutron angular momentum vector, $\vec{J}_\nu$, i.e. by the twin-shears mechanism so that the configuration becomes $\pi(g_{9/2})^{-2}\otimes\nu[h_{11/2}(g_{7/2})^2]$. Constant $\Im^{(2)}$ and large $\Im^{(2)}/B(E2)$ ratio increasing with spin also support the AMR nature of the band. We calculated the I $vs.$ ω for this band from spin 23/2 using the SCM for AMR [5]. Fig. 3 shows a comparison of the

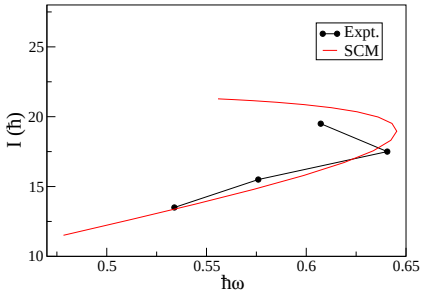

FIG. 3: Comparison of the measured and calculated I $vs.$ ω values.

measured and calculated I $vs.$ ω values. The effective interaction between each nucleon pair and the core moment of inertia are found to be smaller in value compared to that of the AMR band of ^{105}Cd [5]. Detailed results will be presented.

Acknowledgments

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