Novel band structure of odd-A ^{107}Cd

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Introduction

The odd-A ^{107}Cd nucleus is situated in a transitional region between spherical and deformed nuclei. In the 1970s and 1980s, a number of experiments to study the low spin states of ^{107}Cd were carried out by several authors. The high spin states of ^{107}Cd were studied by Jerrestam *et al.* [1] in 1992. In the present paper, we discuss the spectroscopic features and lifetimes of the negative parity band structure of ^{107}Cd.

Experimental details

An experiment populating the high spin states of ^{107}Cd nuclei was performed using the ^{94}Zr(^{18}O,5n) reaction at a beam energy of 85 MeV. The ^{18}O beam was produced by the 15-UD Pelletron accelerator at TIFR, Mumbai. The measurement of short liftimes ($\lesssim 1ps$) of states became feasible by using the DSAM technique. The de-exciting γ-rays were detected by using the Indian National Gamma Array (INGA) comprising of 18 Compton suppressed germanium clover detectors arranged in six rings with respect to the beam direction. A digital data acquisition (DDAQ) system based on Pixie-16 modules developed by XIA LLC [2] was used in the present experiment for the data collection. The trigger for data collection was set in γ-γ mode.

Offline calibration, gainmatching and sorting of the data was carried out. The 2-fold coincidence events were then sorted into the traditional $4K \times 4K$ $E_\gamma - E_\gamma$ symmetric as well as angle dependent asymmetric matrices. The spins and parities of the levels were assigned by using the directional correlation of oriented nuclei (DCO) ratio analysis followed by the linear polarization measurements of various transitions.

Results and discussion

We confirm the earlier published level scheme [1] with several modifications and addition of 7 new transitions. Fig. 1 shows a partial level scheme of ^{107}Cd showing the negative parity band structure as developed from our data. In the earlier work on this nucleus by Jerrestam *et al.* [1], the negative parity band 3 was proposed to be the yrast band for the nucleus and we expected the band to have an anti-magnetic rotation (AMR) nature. After extending band 2 to high spins ($39/2^-$), it is found that band 2 is the yrast band though both the bands 2 and 3 are very close in energy and compete to become yrast. But, the band 2 is much stronger in intensity than the band 3. The lifetimes of the levels in the negative parity band 2 were extracted by using the LINESHAPE analysis code. The measured $B(E2)$ values in band 2 are quite small and do not decrease significantly with increasing spin as one would normally expect in an AMR band. The intensity of band 3 being low, no reasonable estimate of its lifetimes could be made. The dynamic moment of inertia for both the bands is observed to vary significantly in both the bands 2 and 3. This also does not support

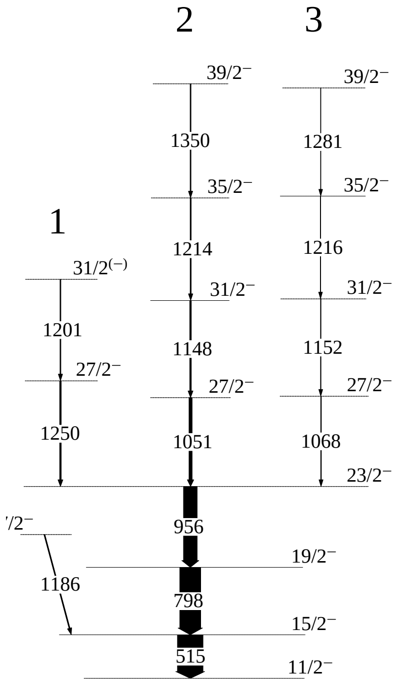

FIG. 1: Partial level scheme of ^{107}Cd showing the negative parity band structure.

the AMR nature in these bands. The variation of the quantity $\Im^{(2)}/B(E2)$ with spin for band 2 also does not support an AMR interpretation for this band.

The almost identical gamma transitions of $\Delta I = 2$ nature and having same spin-parity suggests a special symmetry-breaking. The symmetries of the mean-field Routhian (see ref. [3]) play a central role in the interpretation of the rotating mean-field solutions. If the mean-field Routhian has a lower symmetry, one speaks of spontaneous symmetry breaking. The different symmetries manifest themselves into different types of rotational bands. This makes it fruitful to classify the mean-field solutions according to their symmetry. With the assumption that the rotational axis is the z-axis, the Routhian for a rotating mean-field may be written as,

$$H' = H - \omega \hat{J}_z$$

where H, the rotationally invariant Hamiltonian has the pairing plus quadrupole interaction [3]. The two body Routhian may be invariant with respect to

1. $R_z(\psi)$: rotation by an arbitrary angle ψ about the z axis,
2. P: space inversion,
3. $R_z(\pi)$: rotation about the z axis by an angle π,
4. $TR_y(\pi)$: rotation about the y axis by an angle π combined with the time reversal T.

If the symmetry operations P and $R_z(\pi)$ keep the mean-field unchanged, and the symmetry operation $TR_y(\pi)$ changes the mean-field, it results in the appearance of two degenerate bands with the same I^π. The level sequence generated from such a combination of symmetry operations is $2I^+, 2(I+2)^+, 2(I+4)^+, ...$ Such a symmetry would show up as two identical $\Delta I = 2$ bands of given parity and signature. This type of level sequence has never been observed before. We speculate that the bands 2 and 3 of ^{107}Cd, based on the $\nu(h_{11/2}\ g^2_{7/2})$ neutron configuration, may be an example of partner bands arising due to the above mentioned symmetry breaking. The exact nature of the configuration and the type of coupling of the neutron/proton orbitals giving rise to such special kind of partner bands still needs to be explored. Further experiment is also needed to confirm the properties of these bands.

Acknowledgments

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