Systematics of Antimagnetic Rotation in Cd isotopes

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In recent times it has been established that the high spin states (I>16h) of the positive parity yrast bands of ^{106,108}Cd originate due to "antimagnetic rotation"(AMR) [1,2]. The measured B(E2) values in both the cases, show a sharp decrease with increasing spin above I=16$\hbar$. This can be understood in the following way. The alignment of $h_{11/2}$ and $g_{7/2}$ neutrons leads to a spin of 16$\hbar$ and at this point the proton-hole vectors are almost anti-parallel. With increasing spin these vectors gradually aligns and the spherical symmetry is restores. The semi-classical model calculations involving AMR show good agreement with measured B(E2) values in both ^{106,108}Cd[1,2].

Recently we have also reported the measurement of B(E2) rates in ^{110}Cd[3]. In this case also, we have found the characteristic decrease in B(E2) values with increasing spin. However, the observed alignment plot for ^{110}Cd is strikingly different from that of ^{106,108}Cd. This plot is shown in Fig. 1.

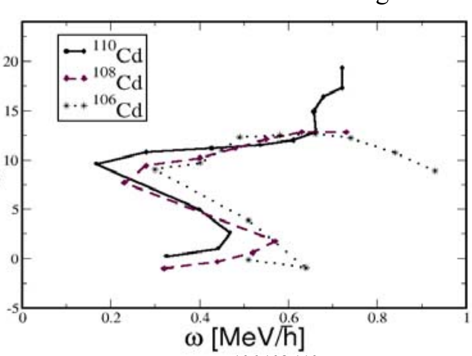

Fig. 1. Alignment plot of ^{106,108,110}Cd.

It is evident from the figure that for ^{106,108}Cd there is a clear alignment of a $\nu h_{11/2}$ pair at hω= 0.4MeV and a $\nu g_{7/2}$ pair at hω= 0.5 MeV. The region beyond 0.6 MeV is the region which has been identified with AMR. In case of ^{110}Cd, there is a clear alignment of a $\nu h_{11/2}$ pair at hω =0.6 MeV but no $\nu g_{7/2}$ alignment has been observed. Instead there seems to be a "backbend" beyond hω=0.65 MeV.

In the present work, we have explored this interesting feature through a classical particle-plus rotor model which was first proposed by *Macchiavelli et al.,* to study the competition between the shears mechanism and core rotation. [4, 5]

In this model, the high-j neutrons and high-j proton holes are represented by classical angular momentum vectors and the total energy is given by,

$$\boldsymbol{E(I)} = \frac{(I-j_{\pi1}-j_{\pi2}-2j_{\nu})^2}{2\mathfrak{I}} + V_{np}\frac{3(Cos\theta)^2-1}{2} - V_{pp}\frac{3([\![Cos2\,\theta)]\!]^2-3}{2} \quad \ldots\ldots\ldots\{1\}$$

The V_{np} term is the conventional particle-hole attractive interaction term for individual shears where theta is the angle between proton and the neutron blades. The V_{pp}-term is the hole-hole negative interaction term where 2θ is the angle between the two proton blades [6]. The functional form for this term has been assumed to be $P_2(\theta)$-1 so that this effective interaction vanishes at θ=0.

The angular momentum (I) is derived from energy minimization from equn.[1], by using $(dE/d\theta)_I = 0\ldots\ldots\{2\}$and $\omega = dE/d(Cos\theta) * d(Cos\theta)/dI \ldots\{3\}$.

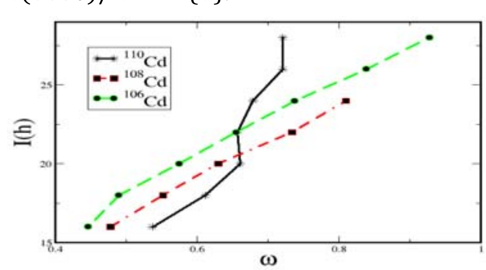

Fig. 2. Plot of experimental Routhian for I≥16h in ^{106,108,110} Cd.

Fig. 2. shows the experimental Routhian for $I>16\hbar$ in $^{106,108,110}Cd$ and Fig. 3. Shows the theoretical Routhian for $V_{pn}=2V_{pp}$ and $V_{pn}=4V_{pp}$. It is evident that the case of $V_{pn}=4V_{pp}$, reproduces the observed nature of the experimental routhian of $^{106,108}Cd$ while $V_{pn}=2V_{pp}$ describes the observed behavior of ^{110}Cd.

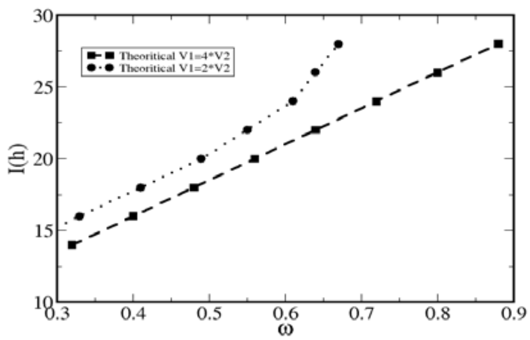

Fig. 3. The theoretical Routhian for $V_{pn}=2V_{pp}$ and $V_{pn}=4V_{pp}$ for AMR configuration.

This may be understood from the following fact. In case of $^{106,108}Cd$ the AMR band originates from the configuration $\pi g_{9/2}^{-2} \otimes \gamma (h_{11/2}^{2})(g_{7/2}^{2})$ which implies that there are eight possible particle-hole pairs as compared to one hole-hole pair. On the other hand in case of ^{110}Cd, the AMR band originates from the configuration $\pi g_{9/2}^{-2} \otimes \gamma h_{11/2}^{2}$ as the alignment plot (Fig.1.) does not indicate a $g_{7/2}$ alignment. This is also supported by the fact that the neutron AB alignment is predicted to be delayed in case of ^{110}Cd as compared to $^{106,108}Cd$.

Thus, in case of ^{110}Cd, there are four possible particle-hole pair and one hole-hole pair.

In conclusion it seems that the sharp upbend in the routhian of ^{110}Cd originates due to interplay between that attractive interaction between pairs and the repulsive interaction between the hole-hole pair. This interplay is absent in $^{106,108}Cd$ as the repulsive term is far weaker than the attractive term and in these cases the nature of the routhian is similar to that of a conventional shear band.

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