Search for Anti-magnetic rotation in ^{105}Cd

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Introduction

Over the past few years, rotational-like bands connected by strong M1 transitions have been observed in the neutron deficient Pb isotopes and in many other nearly spherical nuclei [1]. Such Magnetic Rotation (MR) Bands arise due to anisotropic current distribution and are built on multi-quasiparticle configurations. The nuclei in mass~110 region (Z~50) involve proton holes(s) in high-Ω $g_{9/2}$ orbitals coupled to j_π and low-Ω $h_{11/2}$, $g_{7/2}$ neutrons to j_υ with small nuclear deformation ($\beta \leq 0.15$). Frauendorf [2] proposed the Shears mechanism and developed the TAC model to explain MR bands. At the band head, j_π and j_υ are nearly perpendicular to each other and the total angular momentum lies in between. This leads to a large magnetic dipole moment perpendicular to J. The gradual alignment of j_π and j_υ along J leads to rapid decrease of magnetic moment and B(M1) values with increase in spin. An alternate arrangement of the j_π and j_υ has also been observed in weakly deformed nuclei in the same mass regions as the MR. This is the case of Anti-magnetic Rotation (AMR) in which the spin vectors of high-j proton holes are in stretched mode and the neutron spin vector stands in the middle and is perpendicular to both of them. It is like having two shears like sub-systems operating together. There is no net magnetic dipole moment of the total system. The symmetry of the system demands that the AMR band levels differ in spin by 2ħ and are connected by weak E2 transitions. Higher angular momentum states are generated by the closing of the two proton vector blades along the direction of total angular momentum. Hence there is rapid decrease of the B(E2) values and increase of $\mathcal{J}^{(2)}$/B(E2) with increasing spin as the $\mathcal{J}^{(2)}$ values remain nearly constant with spin.

The only firm evidence of AMR was reported in the yrast positive parity band in ^{106}Cd [3]. Other claims for AMR bands also exist in ^{108}Cd [4], ^{109}Cd, ^{100}Pd, ^{110}Cd. Recently AMR has also been predicted in ^{144}Dy [5]. In the present work, we discuss lifetime measurements by DSAM technique with the aim of searching Anti-magnetic Rotation in the negative parity yrast band 3[6] of ^{105}Cd.

Experimental Details

High spin states in ^{105}Cd nuclei were populated through the ^{94}Zr(^{16}O,5n) reaction at a beam energy of 93 MeV. The ^{16}O beam was delivered by the 15-UD Pelletron accelerator at the Inter-University Accelerator Centre (IUAC), New Delhi. An isotopically enriched ^{94}Zr target of thickness 1.35 mg/cm^2 with ^{197}Au backing of thickness 8.86 mg/cm^2 was used to carry out lifetime measurements by the Doppler Shift Attenuation Method (DSAM). The de-exciting γ-rays were detected using the Indian National Gamma Array (INGA) which at the time of the experiment comprised of 14 Compton suppressed clover detectors arranged in five rings *viz.* 32^0, 57^0, 90^0, 123^0 and 148^0 with respect to the beam direction. The experiment was carried out for 9 shifts. The efficiency and energy calibrations were carried out by using ^{133}Ba, ^{60}Co and ^{152}Eu radioactive sources. Both two fold and three fold coincidence data were acquired online in list-mode form using CANDLE, an acquisition system developed at IUAC.

Data analysis and results

Offline calibration, gain matching and sorting of the data was carried out using the CANDLE and INGASORT analysis programs. The coincidence events were sorted into 4K × 4K $E\gamma$ - $E\gamma$ symmetric as well as asymmetric matrices. The negative parity yrast band of ^{105}Cd (in which we predict AMR) was established up to $I^{\pi} = 47/2^{-}$ in the previous works [6,7], which is found to be in good agreement with the present result. Fig.1 shows the coincidence γ-ray spectrum of the yrast band with a gate set on the 539 keV transition. The angle dependent asymmetric matrix will be used to study the lineshapes of the transitions in the band of interest. Fig.2 shows the Doppler broadened peaks (towards low energy) of transition energies 905, 1044 and 1180 keV in the backward angle detectors at 148° angle with respect to the beam direction. This clearly indicates the possibility for the lifetimes of the states to be in the range of < 1 ps. Further analysis of the data is presently in progress and lineshape fitting is yet to be done to find the lifetimes of the states within the expected AMR band. Semi-classical model and TAC calculations will be carried out for theoretical study.

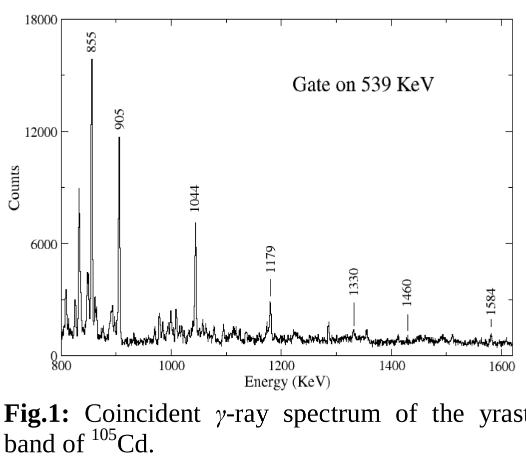

Fig.1: Coincident γ-ray spectrum of the yrast band of ^{105}Cd.

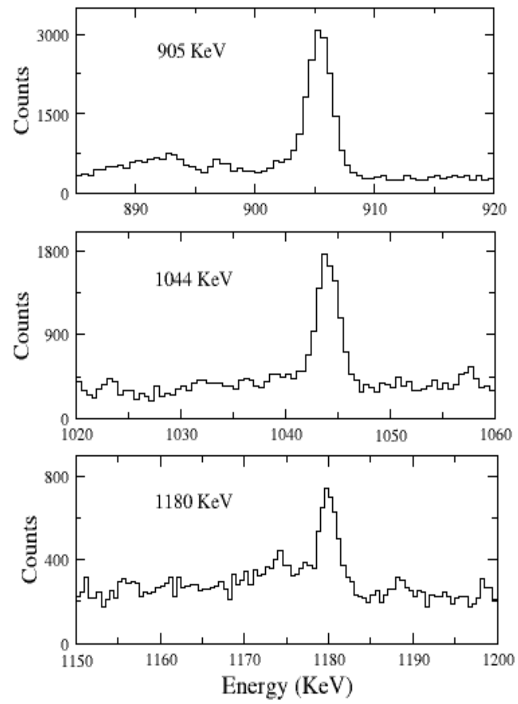

Fig. 2 : Representative spectra for the 905, 1044 and 1180 keV gamma rays in the yrast band of ^{105}Cd taken from the backward ring detectors at 148° angle from the beam direction. There is a broadening (lineshape) in the peaks towards the low energy side.

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