High Spin Spectroscopy of ^{90}Zr

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Introduction

The excited states of nuclei near $N = 50$ closed shell have attracted lot of attention in theoretical and experimental research. They provide suitable laboratory for testing the effective interactions used in the shell model calculations, possible presence of high spin isomers and help in understanding the shape transition as the higher j-orbitals are occupied. In a series of experiments, the high spin states of ^{88,89}Zr and ^{89}Nb have been investigated using the Indian National Gamma Array (INGA) which showed dominance of shell model excitation up to $I \sim 20\ \hbar$ [1–3]. Very recently, a new dipole band extending up to $I^{\pi} = 49/2^{-}$ has been observed in ^{89}Zr and interpreted as a result of rotation about the longest axis of the nucleus [4]. It is important to extend this systematic study to heavier Zr isotopes to look for similar regular bands at high spin. The main motivation of the present work is to extend the previously known level scheme of ^{90}Zr to test the shell model excitations at low spin and search for regular bands at high spin.

Experimental Details

The high spin states in ^{90}Zr were investigated using heavy-ion fusion evaporation reaction ^{82}Se(^{13}C, 5n)^{90}Zr. Two separate experiments have been carried out for the present study using INGA at TIFR and then INGA at IUAC. In the first experiment, 1 mg/cm^2 ^{82}Se target with 4.26 mg/cm^2 thick Au-backing was used. For the second experiment, aimed at accessing higher spins, 500 μg/cm^2 thick ^{82}Se target with Al-backing of 80 μg/cm^2 thickness was used. The γ-rays emitted in the reaction have been measured with INGA at TIFR and IUAC consisting of 11 and 18 Compton suppressed clover detectors respectively which have been placed at various angles of a 4π geometry. Two- and higher-fold clover coincidence events were recorded and sorted into $E_\gamma - E_\gamma$ matrices and $E_\gamma - E_\gamma - E_\gamma$ cubes which have been further analyzed with the RADWARE software package [5].

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Analysis and Results

The previously known level scheme of ^{90}Zr [6] has been substantially extended with the addition of 25 new γ-transitions. A regular M1 band at high-spin has also been observed. Some of the newly placed transitions marked with asterisks have been shown in FIG. 1.

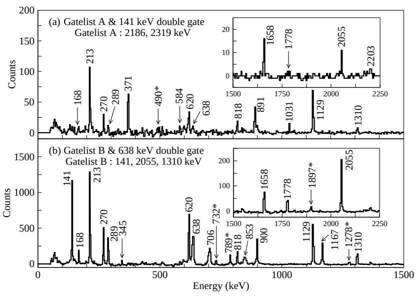

FIG. 1: Spectra generated by using different gates. Newly observed γ-rays are marked with asterisks.

Multipolarities of the transitions were obtained from the angular distribution and directional correlation of oriented states (DCO) ratios (R_{DCO}). The angular distribution suggested $\Delta J = 1$ for 1658 keV and $\Delta J = 2$ for 2055 keV transitions which have been confirmed with the previous work. Mainly, these two transitions were used for gating purpose. A two-dimensional coincidence matrix was constructed with 90° and 148° detectors along the two axes for R_{DCO} measurements. Parities of the excited states were determined by measuring the polarization asymmetry (Δ_{asym}) ratios of the transitions. To evaluate Δ_{asym}, the asymmetry between the number of γ-transitions scattered parallel and perpendicular to the reaction plane have been calculated for the 90° detectors. The experimentally measured R_{DCO} and Δ_{asym} have been plotted with γ-energy in FIG. 2 and FIG. 3 respectively. To explain the established level scheme, the large scale shell model calculation is in progress.

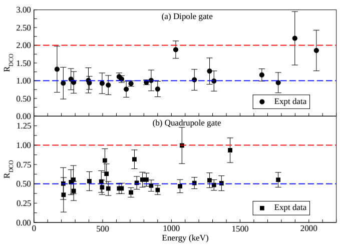

FIG. 2: Plot for R_{DCO} with γ-energy. R_{DCO} of stretched dipole and quadrupole transitions are $\sim$0.5(1.0) and $\sim$1.0(2.0), respectively, for a pure quadrupole (dipole) gate.

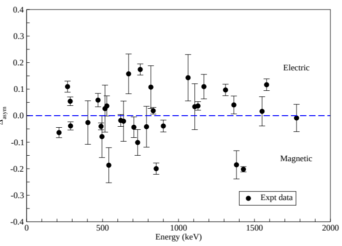

FIG. 3: Plot for polarisation asymmetry, Δ_{asym} with γ-energy. A positive (negative) value of Δ_{asym} indicates its electric (magnetic) nature.

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