

High spin spectroscopy of ^{90}Nb

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I. INTRODUCTION

The study of nuclei near the mass-90 region helps to understand the different aspects of single-particle and collective excitation. The large-scale shell-model results showed a good agreement with the low- and high-spin regions. The observation of large $B(E3; 0^+ \rightarrow 3^-)$ in the Zr [1] isotopes is evident in the octupole collectivity. Additionally high-spin $\Delta=1$ band in ^{89}Zr indicates rotation the about longest axis which is a classical unfavorable phenomenon [2].

The study of odd-odd nucleus ^{90}Nb that has one proton particle and neutron hole in $1g_{9/2}$ can help us to understand the various possible couplings between the proton particle, neutron hole to the core, and various mechanisms for the generation of high-spin states. Previous studies [3–5] of ^{90}Nb showed the importance of proton-hole excitation from $2p_{1/2}$ to $1g_{9/2}$ for the generation of low-spin states. On the other hand, high-spin states have multiquasi configurations involving $1f_{5/2}$, $2p_{3/2}$, $2p_{1/2}$, and $1g_{9/2}$ proton orbitals. The earlier theoretical calculation [3, 4] of the level scheme of ^{90}Nb was either semiempirical [4] or approximated [3]. We reinvestigated the high-spin of ^{90}Nb and compared it with the large-basis shell-model calculation.

II. EXPERIMENTAL DETAILS

Excited states of ^{90}Nb were populated using $^{65}\text{Cu}(^{30}\text{Si}, 3n2p)$ reaction at a beam energy of 120 MeV. A hybrid array, INGA at TIFR Mumbai [6], composed of 16 Compton-suppressed clover detectors, was used to detect gamma rays. The data was collected with 2-

or higher-fold conditions using an XIA-based DDAQ that used 5 different 12-bit ADCs having a sampling frequency of 100 MHz. The data was sorted using an offline code MultipARAMeter time-stamped based COincidence Search [6](MARCOS) developed at TIFR Mumbai. MARCOS code was used to generate symmetric $E_\gamma - E_\gamma$ matrix, $E_\gamma - E_\gamma - E_\gamma$ cube, and angle-dependent ADO, polarisation matrices. A mixed source of EuBa was used for energy calibration. Radware software was used for further analysis using the cube and matrices. For assigning spin-parity of states angular distribution asymmetry ratio (R_{ADO}) and polarisation asymmetry ratio (Δ_{asym}) were used.

The R_{ADO} , and Δ_{asym} defined as:

$$R_{ADO} = \frac{I_{\gamma_1}(157^\circ), \text{gated by } \gamma_2 \text{ at other angles}}{I_{\gamma_2}(90^\circ), \text{gated by } \gamma_2 \text{ at other angles}} \quad (1)$$

$$\Delta_{\text{asym}} = \frac{a(E_\gamma)N_\perp - N_\parallel}{a(E_\gamma)N_\perp + N_\parallel} \quad (2)$$

For a stretched quadrupole and dipole R_{ADO} value is ~ 1.6 and ~ 0.7 respectively. And positive (negative) value of Δ_{asym} corresponds to electric (magnetic) nature of the γ -ray.

III. RESULTS AND DISCUSSION

In the present study, in addition to previously known transitions 18 new transitions and 9 new levels were observed (Fig. 1). We found a new E3 transitions at $I^\pi = 11^-$. However, experimental $B(E3) = 0.020(4)$ W.U. indicated that 11^- state is not collective. To interpret the experimentally observed levels, a Shell-model calculation was performed using GW-BXG interaction with ^{68}Ni . The GWBVG interaction has $1f_{5/2}$, $2p_{3/2}$, $2p_{1/2}$, $1g_{9/2}$ proton orbitals and $2p_{1/2}$, $1g_{9/2}$, $1g_{7/2}$, $2d_{5/2}$, $2d_{3/2}$, and $3s_{1/2}$ neutron orbitals. To make the calculation feasible we have employed truncation,

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