High Spin Structure of Nuclei Near N=50 Shell Gap and Search for High-spin Isomers Using Time Stamped Data

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Introduction

The excited states of nuclei near closed shell at high angular momentum states have attracted lot of attention in theoretical and experimental research [1]. They provide suitable laboratory for testing the interactions of shell model states, possible presence of high spin isomers and help in understanding the shape transition as the higher orbitals are occupied. Information on the high-spin states of nuclei promises to provide stringent test of the interaction of the Hamiltonian used in the calculation due to smaller basis space for high J-values. It is reported in a recent shell model review that no interaction is optimized for the region of interest around N=50 and Z=40 shell closure. The detailed spectroscopic information of the medium and high spin states in these nuclei is required to understand the shape transition between spherical and deformed shapes at N=60 as the higher orbitals are filled. Structure of isomers near shell closure carries important information of, for example, the extent of core excitation. In the present work, we will discuss the spectroscopic study of the high spin states of ^{89}Zr isotope.

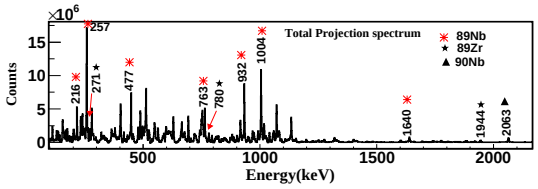

FIG. 1: The total projection spectrum showing the gamma rays of different isotopes produced in the ^{28}Si + ^{65}Cu reaction.

Details of Experiment and Analysis

Excited states of ^{89}Zr and ^{89,90}Nb were produced in an in-beam experiment using ^{28}Si + ^{65}Cu reaction at 105 MeV beam energy. The ^{28}Si beam was provided by the Pelletron Linac facility at Mumbai. The emitted gamma-rays were detected by using the Indian National Gamma Array (INGA) comprising of Compton suppressed clover detectors arranged in seven rings at 23, 40, 65, 90, 115, 140 and 157 with respect to the beam direction. Two fold clover coincidence events were recorded in a fast digital data acquision system based on Pixie-16 modules of XIA LLC [2, 3]. The data sorting routine "Multi pARameter time-stamped based COincidence Search program (MARCOS)" developed at TIFR, sorts the time stamped data to generate gamma-gamma matrix and gamma-gamma-gamma cube in a Radware compatible format for further analysis. Angle dependent asymmetric gamma gamma matrices were constructed for the measurements of the di-

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rectional correlations and polarization asymmetry of the emitted gamma-rays, in order to assign the spin-parity to the excited states. A total projection spectrum was shown in Fig 1 along with the strong transitions of different nuclei produced in the above experiment.

I. RESULTS AND SUMMARY

The level scheme of ^{89}Zr was extended up to ~ 10 MeV excitation energy and $37/2\hbar$ spin with addition of 25 new transitions compared to the previously known level scheme [4]. A cascade of gamma-rays decaying to the $9/2^+$ ground state with energies 1944, 781, 271, 1740, and 1291 keV form the yrast positive parity levels up to $27/2^+$. Similarly, the negative parity levels were extended up to 5492 keV with spin $25/2^-$. A series of $\Delta I = 1$ transitions with 455 - 687 - 755 - 732 keV energies consitute a regular band with band head spin of $29/2^+$.

Shell model calculations have been performed to compare the experimental findings using Nushell code. Shell model calculations have been performed using $jj44pn$ model space and an effective interactions developed by Lisetskiy by the analysis and fit of the experimental data for ^{77}Cu -^{100}Sn [5]. In the calculations ^{76}Sr was taken as a core and valence proton and neutrons are distributed over the single particle orbits $\pi 2p_{1/2}$, $\pi 1g_{9/2}$, and $\nu g_{9/2}$, respectively. We have listed experimental and theoretical low lying states of ^{89}Zr and corresponding levels are drawn in Fig 2. The results of the present priliminary shell model calculation are in fair agreements with the experimental data at lower spin.

The prompt - delayed coincidence matrix was generated from the time stamped data to look for the long-lived isomers. The 11^- state of ^{90}Nb (produced in the same reaction) at 1880.9 keV excitation energy is an isomeric state and decays by 1067.5 and 813.4 keV transitions. The decay spectrum obtained from the time difference between the time-stamps of 1774 - 1067 keV transitions reproduced the previously known isomer with half

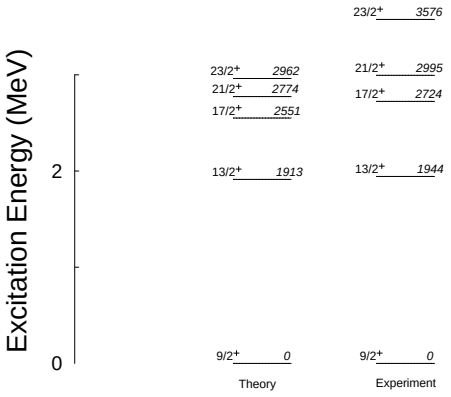

FIG. 2: Comparison of experimental and calculated level scheme for ^{89}Zr.

life of 470(10) nsec. Further analysis of the prompt - delayed correlation is in progress for search of high spin isomers in these nuclei.

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