Experimental Investigation Shell Model Excitations of ^{89}Zr up to High Spin and its Comparison with ^{88,90}Zr

S. Saha[1],* R. Palit[1],† J. Sethi[1], T. Trivedi[1], P.C. Srivastava[2], S. Kumar[3], B.S. Naidu[1], R. Donthi[1], S. Jadhav[1], D.C. Biswas[4], U. Garg[5], A. Goswami[6], H.C. Jain[1], P.K. Joshi[1], G. Mukherjee[7], Z. Naik[8], S. Nag[9], V. Nanal[1], R.G. Pillay[1], S. Saha[6], and A.K. Singh[9]

[1]*Department of Nuclear and Atomic Physics, Tata Institute of Fundamental Research, Mumbai - 400005, INDIA*

[2]*Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de México, 04510 México, D.F., Mexico*

[3]*Department of Physics and Astrophysics, University of Delhi, Delhi- 110007, INDIA*

[4]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA*

[5]*Physics Department, University of Notre Dame, Notre Dame, Indiana 46556, USA*

[6]*Saha Institute of Nuclear Physics, , Kolkata 700064, INDIA*

[7]*Variable Energy Cyclotron Centre 1/AF Bidhan Nagar, Kolkata 700064, INDIA*

[8] *Physics Department, Sambalpur University, Sambalpur, India and*

[9]*Department of Physics & Meteorology, Indian Institute of Technology Kharagpur, IN-721302, India*

Introduction

The excited states of nuclei near N=50 closed shell 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. In particular, the structure of N = 49 isotones (and Z =32 to 46) with one hole in N=50 shell gap have been investigated using different reactions [1–3]. Interestingly, the high spin states in these isotones have contribution from particle excitations across the respective proton and neutron shell gaps and provide suitable testing ground for the prediction of shell model interactions describing theses excitations across the shell gap. In the literature, extensitive study of the high spin states of heavier N = 49 isotones starting with ^{91}Mo up to ^{95}Pd are available. Limited information existed on the high spin states of lighter isotones [4]. Therefore, the motivation of the present work is to extend the high spin structure of ^{89}Zr and to characterize the structure of these levels through comparison with the large scale shell model calculations based on two new residual interactions (JUN45 and jj44b) in $f_{5/2}pg_{9/2}$ model space. In addition the comparison of the high spin states of ^{89}Zr with that of ^{88,90}Zr isotopes will give information on the role of the coupling of odd neutron (particle or hole) with the excitations of the adjacent even-even Zr isotopes.

*email: sudiptajit@tifr.res.in
†email: palit@tifr.res.in

I. EXPERIMENTAL DEATAILS

Excited states of ^{89}Zr were produced in the in-beam experiment using ^{13}C + ^{80}Se reaction at 50 MeV beam energy. In addition, the excited states ^{88,90}Zr were also observed in the experiment. The ^{13}C beam was provided by the Pelletron Linac facility at Mumbai. The target consisted of $\sim$ 800 μg/cm^2 ^{80}Se evaporated on Au backing. The Indian National Gamma Array (INGA) consisting of eighteen Compton suppressed clover detectors was used to detect γ-rays emitted in the reaction. Two and higher fold clover coinci-

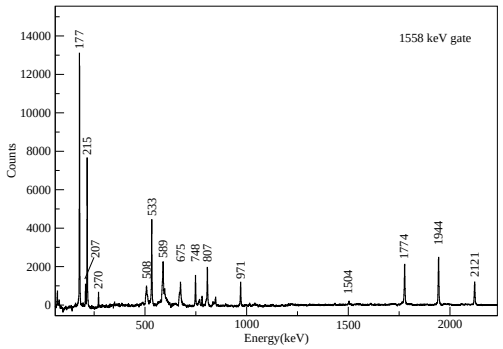

FIG. 1: 1558 keV gated spectrum showing the transitions among the negative parity states.

dence events were recorded in a fast digital data acquision system based on Pixie-16 modules of XIA LLC [5]. The data sorting routine "Multi pARameter time-stamped based COincidence Search program (MARCOS)" developed at TIFR, sorts the time stamped data to generate $E_\gamma - E_\gamma$ matrix and $E_\gamma - E_\gamma - E_\gamma$ cube.

II. RESULTS AND SUMMARY

The excited levels of ^{89}Zr have been observed up to $\sim$ 10 MeV excitation energy and spin $\sim 37/2\hbar$ using the Indian National Gamma detector Array (INGA). The angular distribution, directional correlation and polarization measurements were carried out to assign the spin and parity of the newly reported states. Each of the four clover detectors present at 90° was used as Compton-polarimeters to assign the electric or magnetic nature of γ-rays . The 1558 keV gated spectrum given in Fig. 1 indicates the different transitions decaying from the negative parity states and its connection with the positive parity states.

The level scheme of ^{89}Zr establsihed in the present work indicates the persistence of shell model-like excitations, and thereby, suggesting the continuation of spherical structure up to the observed highest spin. To interpret the experimental data for low-lying spectra and several high-spin states of ^{89}Zr the state-of-the-art shell-model calculation using two different interactions have been performed. The shell-model calculations have been carried out in the 28-50 valence shell composed of the orbits $1p_{3/2}$, $0f_{5/2}$, $1p_{1/2}$ and $0g_{9/2}$. The calculations have been performed with two recently derived effective shell model interactions, JUN45 and jj44b [6, 7]. The results of JUN45 and jj44b interaction for $f_{5/2}pg_{9/2}$ space are showing overall good agreement with experimental data. The results of the JUN45 interaction is surprisingly close to the measured negative parity states with less than 100 keV above $J^\pi = 15/2^-$. The shell model calculations indicate the important role played by interactions between the excitation of the valence protons outside the Z = 40 major shell. Additional new polarization data on ^{88,90}Zr will be presented along with the comparison of their high spin states with that of ^{89}Zr.

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