Core excitation in ^{92}Mo

Vishal Malik,[1,*] R. Palit,[1] P. C. Srivastava,[2] Deepak Patel,[2] P. Dey,[1] A. Sindhu,[1]
U. Garg,[3] Biswajit Das,[1] Nidhi Goel,[4] A. Kundu,[4] Somnath Nag,[4] D. Negi,[5] and R. Raut[6]

[1] *Department of Nuclear and Atomic Physics, Tata Institute of Fundamental Research, Mumbai 400005, INDIA*
[2] *Department of Physics, Indian Institute of Technology Roorkee, Roorkee 247667, INDIA*
[3] *Physics Department, University of Notre Dame, Notre Dame, Indiana 46556, USA*
[4] *Department of Physics, Indian Institute of Technology BHU, Varanasi 221005, INDIA*
[5] *Department of Physics, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal 576104, India*
[6] *UGC-DAE Consortium for Scientific Research, Kolkata Centre, Kolkata 700098, INDIA*

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. The low-spin part of the level scheme around Z $\approx$ 40 and N $\approx$ 50 can be interpreted as excitation involving fp orbitals. However, for nuclei with N > 49, core excited configurations are required to be invoked for generating the high-spin states. Huang *et al.* [2], in their study of ^{92}Mo, reported few high energy transitions ($\sim$ 2 MeV). These transitions were interpreted as either Z = 38 cross-shell excitation or Z = N = 50 core excitation. Additionally, the E1 transitions are strictly forbidden within the $p_{3/2}f_{5/2}p_{1/2}g_{9/2}$ model space. These transitions are very weak having B(E1) $\sim 10^{-5}$ W.u. However, ^{94}Ru an enhancement in the B(E1) by a factor of 100 has been observed [3].

We reinvestigated the level scheme of ^{92}Mo and compared it with the large basis shell model calculations. Additionally, lifetime measurements have been carried out for a few selected high-spin states using the Doppler Shift Attenuation Method (DSAM) to probe transition probabilities. The goal is to probe the enhancement in B(E1) which is the signature of mutual core excitation of proton and neutron across Z = N = 50 shell gap.

*Electronic address: vishal_047@tifr.res.in

II. EXPERIMENTAL DETAILS

The experiment was performed at the Tata Institute of Fundamental Research (TIFR), Mumbai. ^{18}O and ^{30}Si beams at 99 MeV and 120 MeV energy were impinged on 1.4 mg/cm^2 thick ^{80}Se having 1.5 mg/cm^2 ^{27}Al backing and on 1.0 mg/cm^2 ^{65}Cu with a backing of 6.5 mg/cm^2 ^{197}Au, respectively. The gamma rays were detected using the Indian National Gamma Array (INGA) at TIFR, Mumbai. The data was collected using PIXIE-16 digital data acquisition (DDAQ) manufactured by XIA, LLC. Five ADCs having 100 MHz sampling frequency were used in the experiments to process the raw signals from HPGe clovers with two or fold coincidence condition. The data was further sorted offline using Multi pARameter time-stamped based COincidence Search (MARCOS) code, developed at TIFR, Mumbai. It generated $E_\gamma - E_\gamma$ matrix, $E_\gamma - E_\gamma - E_\gamma$ cube and angle dependent matrices polarization and angular distribution measurement. The spin-parity, I^π, of the states was assigned using the Directional correlation of Oriented states ratio (R_{DCO}) and polarization measurement.

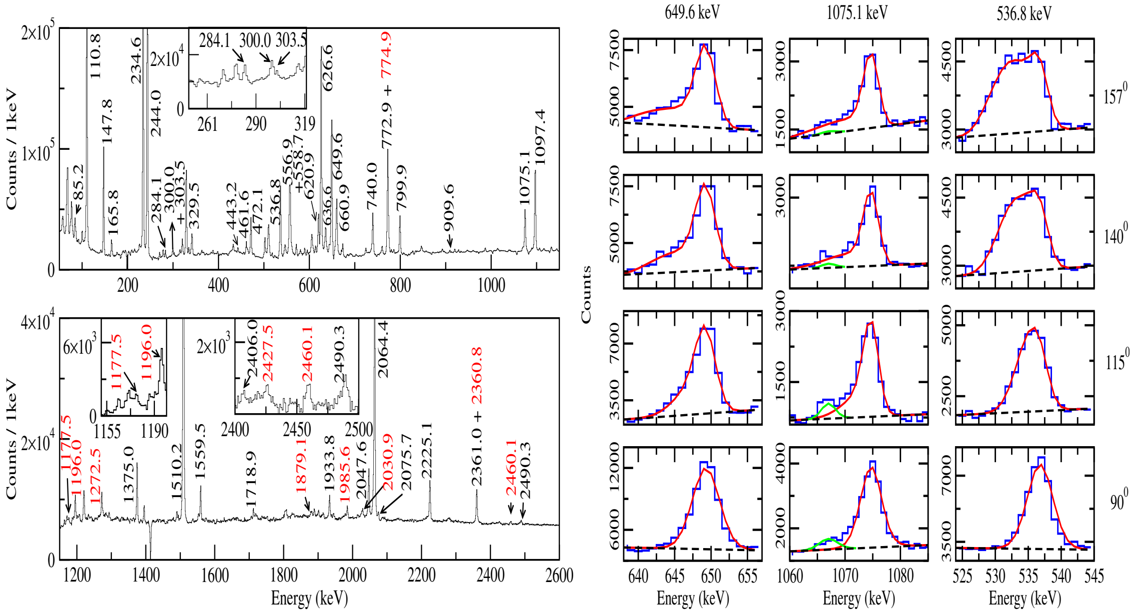

FIG. 1: Representative (left) sum of γ gated spectra with gates on 772.9-,1097.4-, 2361.0-keV, and spectra shown in the left panel are generated using a gate on 244.0 keV transition along with the simulated lineshape in different angles.

III. RESULTS AND DISCUSSION

In the present study, in addition to previously known transitions 9 new transitions were observed. The spin-parity of high spin states was fixed from our multipolarity and parity measurement. To interpret the experimentally observed levels, a shell-model calculation was performed using GWBXG interaction [4] with ^{68}Ni as a core. The GWBXG 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, for this we have completely filled the neutron orbital $2p_{1/2}$, and performed $1p-1h$ excitation across $N = 50$ in the $1g_{7/2}$, $2d_{5/2}$, $2d_{3/2}$, and $3s_{1/2}$ neutron orbitals. The theoretical calculations predict multi-quasiparticle configurations with proton excitation across Z=38. The higher lying states were interpreted as coupling of excited proton and neutron core structure. Additionally, lifetime measurement of 15^- state at 8386.2 keV sheds light on the simultaneous excitation of proton and neutron across Z = N = 50 shell gap which is forbidden in this mass region.

Acknowledgements

This work is supported by the Department of Atomic Energy, Government of India, under Project No. RTI4002 and the U.S. National Science Foundation (Grant No. PHY-2011890).

References

[1] Ł.W. Iskra *et al.*, PLB 788, 396 (2019).
[2] Z. Huan *et al.*, PRC 106, 064331 (2022).
[3] F. Ghazi Morad *et al.*, PRC 89, 014301 (2014).
[4] A Hosaka *et al.*, Nucl. Phys. A 76, 444 (1985).