Experimental investigation of high-spin states in ^{90}Zr

P. Dey,[1,*] D. Negi,[1,†] R. Palit,[1,‡] P. C. Srivastava,[2] Md. S. R. Laskar,[1] B. Das,[1] F. S. Babra,[1] S. Bhattacharya,[3] Biswajit Das,[1] K. Rojeeta Devi,[4] R. Gala,[1] U. Garg,[5] S. S. Ghugre,[6] E. Ideguchi,[7] S. Kumar,[4] A. Kundu,[1] G. Mukherjee,[8,9] S. Muralithar,[10] S. Nag,[11] S. Nandi,[8,9] Neelam,[4] M. Kumar Raja,[12] R. Raut,[6] R. Santra,[1] A. Sharma,[13] S. Sihotra,[14] A. K. Singh,[15] R. P. Singh,[10] and T. Trivedi[3]

[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]*Department of Pure & Applied Physics, Guru Ghasidas Vishwavidyalaya, Bilaspur 495009, India*
[4]*Department of Physics & Astrophysics, University of Delhi, Delhi 110007, India*
[5]*Physics Department, University of Notre Dame, Notre Dame, Indiana 46556, USA*
[6]*UGC-DAE CSR Kolkata Centre, Kolkata 700098, India*
[7]*Research Center for Nuclear Physics, Osaka University, Ibaraki, Osaka 567-0047, Japan*
[8]*Variable Energy Cyclotron Centre, 1/AF Bidhan Nagar, Kolkata 700064, India*
[9]*Homi Bhabha National Institute, Anushaktinagar, Mumbai 400094, India*
[10]*Inter University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi 110067, India*
[11]*Department of Physics, Indian Institute of Technology (Banaras Hindu University), Varanasi 221005, India*
[12]*Department of Physics, GITAM Institute of Science, GITAM University, Visakhapatnam 530045, India*
[13]*Department of Physics, Himachal Pradesh University, Summer Hill, Shimla 171005, India*
[14]*Department of Physics, Panjab University, Chandigarh 160014, India*
[15]*Department of Physics, Indian Institute of Technology Kharagpur, Kharagpur 721302, India*

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High-spin states of ^{90}Zr have been investigated using the heavy-ion fusion-evaporation reaction ^{82}Se(^{13}C, 5n) at a beam energy of 60 MeV. Excited levels of ^{90}Zr have been observed up to an excitation energy of ≈13 MeV and a spin of ≈20$\hbar$ with the addition of thirty-two new γ-ray transitions to the proposed level scheme. Structures of both the positive- and negative-parity states up to the highest observed spin have been interpreted with shell-model calculations using the GWBXG interaction and a ^{68}Ni core. Calculations suggest the role of neutron excitations across the $N = 50$ shell gap for states with greater than 7 MeV excitation energy. High-spin states in these bands are interpreted to be generated by the recoupling of stretched proton and neutron configurations.

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I. INTRODUCTION

Nuclei in the vicinity of shell closures are of particular interest in nuclear structure studies because they provide a platform for scrutinizing the validity and details of shell-model theories. It is now computationally feasible to extend shell-model calculations to higher excitations that incur a larger model space and an increased number of valence nucleons, to be used for the purpose. High-spin states in the $A \approx 90$ mass region, with $Z \approx 40$ and $N \approx 50$, have been subjects of investigation in many studies, both experimentally and theoretically [1–31]. These states have multiquasiparticle configurations, with the $g_{9/2}$ orbital playing a significant role towards the generation of high-spin states. The contribution of proton $g_{9/2}$ orbital comes into the picture either due to the (proton) particle occupancy of the orbital, which is for nuclei with $Z > 40$, or due to excitations of protons from the fp orbitals into the $g_{9/2}$ orbital across the $Z = 40$ subshell gap. These excitations dominate the lower-energy part of the level scheme in these nuclei. Similarly, the role of neutron $g_{9/2}$ orbital towards the high-spin generation is seen to be either due to the already-present holes in it, which is the case for nuclei with $N < 50$, or to excitations across the $N = 50$ shell gap into the gd orbitals. Due to the larger energy of this gap, the contributions from these excitations underlying the high-spin states in $N = 50$ nuclei are observed at higher excitation energies. Such excitations of one or more neutrons from the $1g_{9/2}$ orbital into the $2d_{5/2}$ and $1g_{7/2}$ have been observed in the ^{86}Kr ($Z = 36$) [2], ^{87}Rb ($Z = 37$) [4], ^{88}Sr ($Z = 38$) [6], ^{89}Y ($Z = 39$) [11,12], ^{91}Nb ($Z = 41$) [21], ^{92}Mo ($Z = 42$) [23], ^{93}Tc ($Z = 43$) [27], ^{94}Ru ($Z = 44$) [29], and ^{95}Rh ($Z = 45$) [31] isotones, but it has yet to be confirmed in ^{90}Zr ($Z = 40$) [15]. The shell-model calculations have been used to describe observed excited states based on either proton excitation across $Z = 40$ or neutron excitation across $N = 50$. It will be intriguing to invoke the two excitations simultaneously for ^{90}Zr, which is the focus of the present study.

*piku.dey@tifr.res.in
†dinphysics@gmail.com
‡palit@tifr.res.in

