Study of nuclear structure of some deformed nuclei within the neutron range $50 < N < 82$

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1. Introduction

The nuclear regions below Z = 50 closed proton shell within the neutron range $50 < N < 82$ are transition regions with complicated and demanding structural features, and so serve as a great testing ground for nuclear structure models. The existence of non-axial characteristics, one phonon γ-vibrational (γ) band, and two phonons γ-vibrational (2γ) bands in nuclei from this region prompt future research to solve this many-body problem with the incorporation of single-particle and collective degrees of freedom. This offers impetus for the work reported in this thesis to investigate shape evolution, triaxiality, and numerous intriguing structural features present in nuclei in the vicinity of the Z = 50 closed proton shell within this neutron range.

The research work is divided into six Chapters. The Introduction is given in the Chapter 1 and the theory of Models used is discussed in Chapter 2.

The Projected Shell Model technique [1] has been used in Chapter 3 of the thesis to conduct a comprehensive examination of negative parity yrast bands of odd-mass $^{99-117}$Pd nuclei [2]. Negative parity bands are reported to be created on the deformation-driving $h_{11/2}$ neutron orbital in odd-mass palladium (Pd) nuclei in mass region A$\sim$110. They provide rich testing grounds for current models as well as a suitable foundation for studying the deformation systematics of this mass region as well as other nuclear structural features. Along with a discussion of the results obtained through the current PSM calculations on various nuclear structure properties of these nuclei, such as yrast spectra, transition energies, electric quadrupole transitions, and so on, a comparison with experimentally available data is also presented in this chapter. PSM data has been found to reasonably reproduce experimental accessible data. Further, an attempt is made to comprehend the structure of these isotopes using band diagrams, which also give information on other nuclear structural phenomena, especially backbending in moment of inertia. The present PSM calculations predicts the structure of these palladium isotopes to be of 1-quasineutron nature in the low spin domain, which is, however, dominated by 3-quasiparticle (one quasineutron plus a pair of quasiproton) bands in the high spin region. It is pertinent to mention here that the quasi-deformed structure for these bands is also predicted from the E-GOS plots, as well as the $R_{2/1}$ and $R_{3/2}$ ratios.

Chapter 4 of the thesis records an attempt of studying odd-mass isotopic chain of $^{103-117}$Ag nuclei [3]. Odd-mass nuclei are good candidates for investigating putative structural changes beyond the valley of stability. Highly deformed odd-mass nuclei have been found in the A$\sim$110 mass region, provide opportunities to study the deformed rotational bands. Because of the vast variety of phenomena occurring in this mass region, nuclear theory has a difficult and exciting problem in attempting to derive a coherent account of the odd-mass nuclei in this mass region from a single Hamiltonian. So, the challenge was taken to study the odd-mass $^{103-117}Ag$ isotopes with the projected shell model. Calculations are comprehensively performed for the quasi-particle excitations. Good agreement between theory and experiment is obtained which supports the adequacy of the param-

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eters and the configuration used for the calculation. Some important characteristics of these nuclei are discussed which include the kinetic moment of inertia $2J^{(1)}$, backbending effects, E-GOS plots, AMR, etc. PSM wavefunctions have also been used to describe how proton and neutron orbitals interact in these silver nuclei. These computations enabled the description of rotationally induced structural changes at higher spins, as well as shape evolutions for deformed nuclei. It may be concluded that the experimental observables associated with the structure of the nucleus can be very accurately reproduced within PSM. However, much more experimental data is required to have a thorough knowledge of nuclear structure of these nuclei.

Chapter 5 includes the Triaxial Projected Shell Model study of even-even isotopic chain of cadmium (Z=48) nuclei [4]. The good angular-momentum states from the triaxially-deformed Slater determinant are projected out using a three-dimensional angular-momentum projection approach in this model. This method allows for the treatment of situations that would otherwise be difficult to comprehend in the axial-symmetry limit. The estimated yrast and γ-band are compared to existing experimental data, and the agreement between theory and experiment is found to be fairly excellent. The computation yields predictions for the γ- and $\gamma\gamma$-bands, where existing data is still poor and, in fact, not available at all for the $\gamma\gamma$-band. The systematics of the R_{42} ratio, the use of the E-GOS approach, and the fluctuating behavior of the staggering parameter all strongly suggest the presence of γ-vibrational or γ-deformation character in these nuclei. The odd-even staggering in the γ-band is very well reproduced by the TPSM calculations and it can be seen that the staggering magnitude for these isotopes follow the γ-soft potential predictions at lower spin states whereas at high spins, the amplitude of oscillation is not showing any particular trend with the increase in angular momentum. TPSM has also proved successful in characterizing experimental intra-band and inter-band B(E2) values. The change in B(E2) values can be attributed to the crossover of the ground band with two-quasineutron aligned bands emerging from the $h_{11/2}$ orbit. In addition to B(E2) values, intra-band and inter-band B(M1) values have been predicted. Finally, a detailed data, particularly for the γ-band, is required to explore and validate the the γ-softness evolution in these Cd isotopes.

Finally, Chapter 6 of the thesis provides a summary of the entire work. This chapter presents the major study findings derived from this entire work, which give helpful information on nuclear structure results of diverse nuclei. Furthermore, this chapter discusses how effectively nuclei in the medium mass region have been studied using PSM and TPSM techniques. Aside from that, it is implied that the outcomes of the applied frameworks should be seen with an eye toward future initiatives in this direction, since this study was an attempt to get some physical understanding into such computations.

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