Band structures in neutron-rich odd mass Dysprosium nuclei

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The structure of a nucleus is a fingerprint of how neutrons and protons interact in this many particle system to form a bound nucleus. Measuring nuclear properties is of great importance to understand the interactions which bind the protons and neutrons together in an isotope. These basic properties allow us to derive directly or indirectly information on the nuclear structure, as well as, on the strong nuclear force. Comparison of experimental properties of very exotic nuclei to calculations performed with different nuclear models allow testing the predictive power of these models when going to the extremes, or give a hint on how to further improve the nuclear models and their parameters. Neutron-rich nuclei are of particular current interest since they are predicted to reveal new aspects of nuclear structure associated with an excess of neutrons.

The odd neutron nuclei with neutron number N =97-103 appear with the maximum quadrupole deformation ($\varepsilon \approx 0.27$) in the rare-earth region [1]. Dysprosium isotopes belonging to this region of deformed rare-earth nuclei are members of the well known prolate deformed nuclei [2]. $^{159-165}$Dy are some such examples with known irregularities of rotational motion [3,4]. Some of these irregularities especially backbending phenomenon is attributed to the crossing of ground state band with a band built on a broken $i_{13/2}$ neutron pair [5]. A lot of experimental and theoretical work has been done on these nuclei in the past for many years. Some nuclear structure properties of the nuclei falling in this region have been studied, but with the development of advanced and improvised equipments like gamma-ray detector, Gammasphere and Euroball, it has now become possible to study the nuclear structure phenomenon, even at higher spins in these nuclei. Though considerable information about the high spin states is available for the neutron-deficient nuclei in this region, however, for the neutron-rich isotopes, the information is still meager. Hence in the present work, we have undertaken the study of some odd mass Dysprosium isotopes with mass number varying from A=159 to A=165 using a framework of calculations known as Projected Shell Model (PSM) [6]. The Hamiltonian used in the calculations is Pairing (monopole and quadrupole) plus quadrupole one. Also, here we have included active particles from three oscillator shells, N=3,4,5 for protons and N= 4,5,6 for neutrons.

Besides obtaining a good agreement for the experimental and theoretical properties like yrast spectra and transition energies, present study also reveals a shape co-existence in the above mentioned nuclei. Thus, it is found that low spin states of these nuclei arise from 1 quasi-particle (1-qp) state while the high spin states are due to multi quasi-particle states.

In Figures 1[a-d], the transition energies [E(I)-E(I-1)] versus spin I (ħ) of $^{159-165}$Dy isotopes are presented.

References

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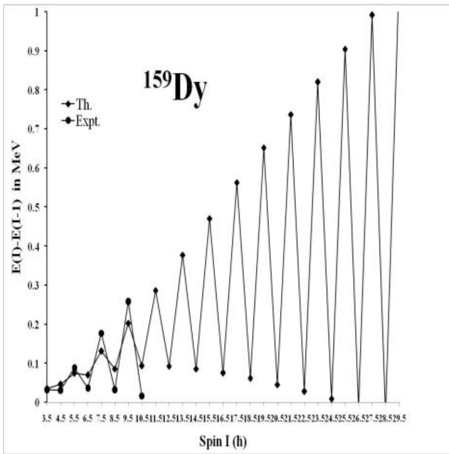
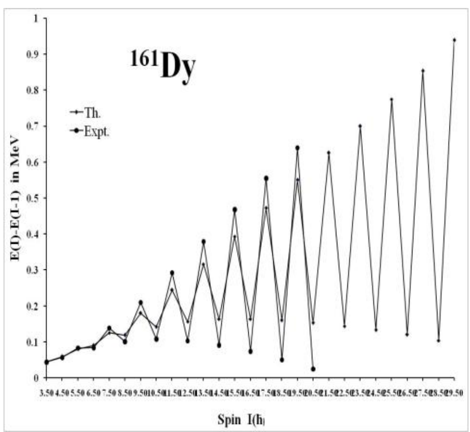
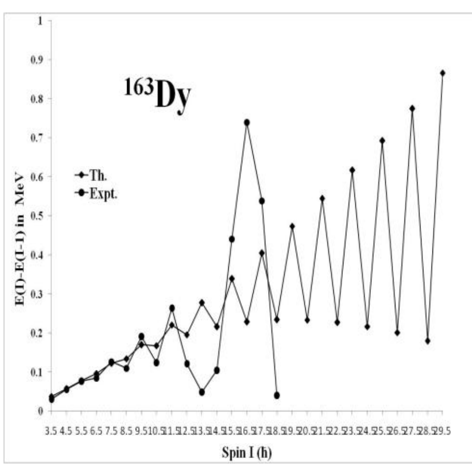


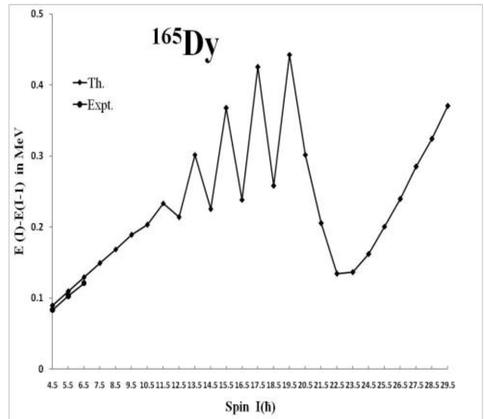
(a)



(b)



(c)



(d)

Fig.1 Comparison of calculated (Th.) and Expeimental (Expt.) transition energies [E(I)-E(I-1)] versus spin I (ħ) for ^{159}Dy (b) ^{161}Dy (c) ^{163}Dy (d) ^{165}Dy