Study of A=79 Isobars in a microscopic framework of calculations

Chetan Sharma[1],* Dhanvir Singh[2], and Arun Bharti[4]
[1] Department of Physics , Govt. Degree College , R.S.Pura-181102, INDIA
[2] Department of Physics & Electronics, University of Jammu, Jammu-180006, INDIA
[3] Department of Physics & Electronics, University of Jammu, Jammu-180006, INDIA

* email: chetan24101985@gmail.com

Introduction

Nuclei in the mass-80 region with $N \sim Z$ represent an ideal opportunity to observe the interplay of collective and single-particle degrees of freedom. The presence of both valence protons and neutrons in the same orbitals in these nuclei leads to coherent polarizing effects which enhance the influence of shell structure on the nuclear shapes, while the low density of single-particle states leads to rapid structural changes when moving between neighbouring isotopes and isotones. This latter behavior is dramatically demonstrated by the presence of oblate and prolate shell gaps at nucleon numbers 36 and 38, respectively. Examples of phenomena found within a small range of A and Z include shape coexistence, rigid rotation, and extreme ground-state deformation [1-3]. This has resulted in considerable interest in the spectroscopy of these nuclei of particular interest is the onset of deformation along the isotopic chain of the nuclei in this region. In the preset work we have studied the nuclear structure properties of A=79 isobars using a microscopic framework of calculations known as projected shell model.

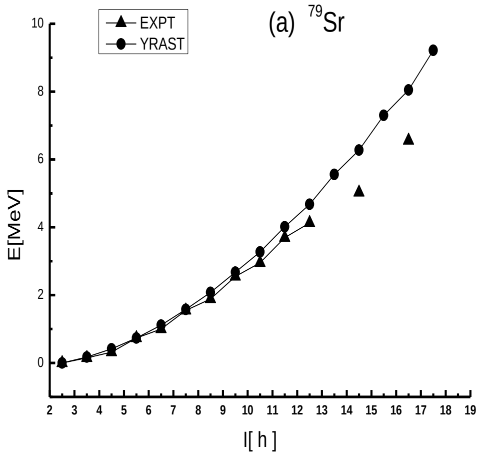
The Projected Shell Model (PSM) has been designed and developed, so to speak, in order to meet the quality of measurements made possible by modern experimental techniques. The PSM is the natural extension of the SU(3) Shell Model for deformed system, where the Nilsson + BCS scheme is used for the basis selection and the projection of these deformed basis onto good angular momentum is done numerically. The deformed basis provides us an efficient way to describe the Shell Model basis. The PSM has been developed as a shell model truncation scheme which is implemented in a deformed single-particle basis [4]. Pairing correlations are included in this basis, which is constructed by the quasiparticle (qp) states obtained from a Nilsson + BCS calculation. The PSM proceeds as follows: first, the shell model truncation is carried out by considering the low-lying multi-qp configurations around the Fermi levels; then the angular-momentum-projection method is used to restore the rotational symmetry violated in the deformed basis. Finally, the two-body Hamiltonian is diagonalized in the projected basis. The truncation achieved in this way is very efficient.

The inclusion of the 3-qp configurations is important for odd-mass nuclei for a description of the band-crossing phenomenon which is caused by a rotation alignment of a pair of quasineutrons. The Hamiltonian employed in the calculation is [4]

$$H = H_o - \frac{1}{2}\chi\sum_{\mu} Q_{\mu}^{+}Q_{\mu} - GP^{+}P - G_{Q}\sum_{\mu} P_{\mu}^{+}P_{\mu} \quad \ldots.(1)$$

where H_0 is the spherical single-particle Hamiltonian which contains a proper spin-orbit force. The second term in Eq. (1) is the quadrupole-quadrupole (QQ) interaction and χ represents its strength, which is determined by the self-consistent relation between the input quadrupole deformation ε_2 and the one resulting from the HFB procedure [4, 5]. The last two terms are the monopole and quadrupole pairing interactions, respectively.

In order to check the reliability of the PSM, we have done the calculations for the yrast states of ^{79}Sr and ^{79}Y nuclei. The comparison of the results of these calculations with the observed data[6,7] has been presented in Fig.1[a,b]. From the results of the calculations the conclusions drawn are that the PSM calculations of yrast bands for ^{79}Sr and ^{79}Y show a very good agreement with the corresponding experimentally observed bands for all the available values of spins. The other nuclear structure properties which we have calculated are band diagrams, transition energies and moment of inertia that will be presented in the full length paper to be presented at the conference.



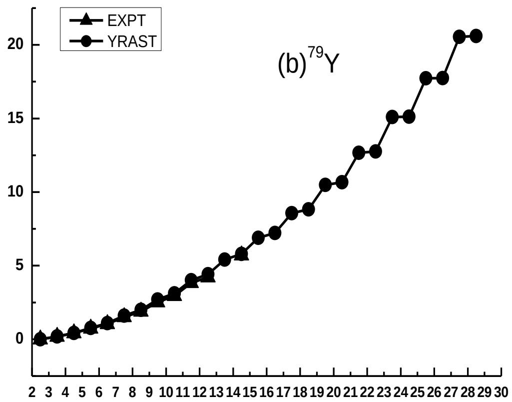


Table 1: The Comparison of experimental and theoretical yrast spectra of (a) ^{79}Sr and (b) ^{79}Y isotones

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