Theoretical investigation of positive-parity bands in some doubly-odd N=45 isotones

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Introduction

Deformed odd-odd nuclei provide valuable information on the interplay between collective and single-neutron and -proton degrees of freedom in atomic nuclei. In general, odd-odd nuclei are difficult to study, both experimentally and theoretically, due to the complexity of their low-lying spectra. However, stimulating new data have been accumulated, in recent years, on the odd-odd nuclei due to rapid and wide developments of experiments, in the outer region of the nuclear chart around the *pf* shell. The data suggest that doubly odd nuclei with mass A ~ 80 exhibit a complex low spin structure with an evolution to regularly spaced rotational levels above an excitation energy of 0.5-1.0MeV. Because of a rich variety of phenomena found in this mass region, it is a challenging and intriguing task for nuclear theory to seek for a unified description of the nuclei falling in this mass region from a single Hamiltonian. One of such reliable methods that uses a separable-force Hamiltonian is the Projected Shell Model (PSM).

Projected Shell Model, which has been broadly applied to study the various nuclei in the nuclear chart, has rather less extensively used for studying the doubly odd nuclei. The first major application of the projected shell model approach to the medium mass odd-odd nuclei was made by Palit et al. [1]. Since then, not much effort has been devoted to study the doubly odd nuclei within the context of PSM. So, we decided to use this approach to study the odd-odd N=45 isotones in the mass 70-80 region. Using the angular-momentum projected two-quasiparticle states with the employment of a simple quadrupole-quadrupole + monopole-Pairing + quadrupole-pairing Hamiltonian, we have performed calculations on positive-parity yrast energy levels and reduced transition probabilities [B(M1)'s] and have also studied features like intrinsic band structure of yrast band, back-bending in moment of inertia, etc. for ^{74}Cu, ^{76}Ga and ^{78}As nuclei. However, in this abstract, we will discuss about the yrast energy levels and the B(M1)'s only. The other properties would be discussed at the time of presentation in the symposium.

Caculational Details

The detailed description of PSM can be found in review article [2] however, a brief explanation of the method along with the important input parameters used in the present calculations is given hereunder.

The PSM calculation usually begins with the deformed Nilsson single-particle states at a deformation ε_2. Pairing correlations are incorporated into the Nilsson states by BCS calculations. The consequences of the Nilsson-BCS calculations provide us with a set of quasiparticle (qp) states [for the present case, the qp-states used are $|\phi_\kappa\rangle = a_\nu^\dagger a_\pi^\dagger |0\rangle$] that define the qp vacuum in the intrinsic frame. One then constructs the shell model bases by building multi-qp states. The broken symmetry in these states is recovered by angular momentum projection (and particle number projection, if necessary) to form a shell model basis in the laboratory frame. Finally, a two-body shell model Hamiltonian is diagonalized in the projected space.

In the present PSM calculations, we have used three major shells (N=2,3,4) for both protons and neutrons. The shell model space is truncated at a deformation ε_2 ~ 0.40. Other input parameters such as monopole and quadrupole pairing strengths etc. are kept same as used by Palit et al. [1] in the mass 80 region. We have also obtained the reduced magnetic dipole transition probability $B(M1)$ which is computed by using the expression

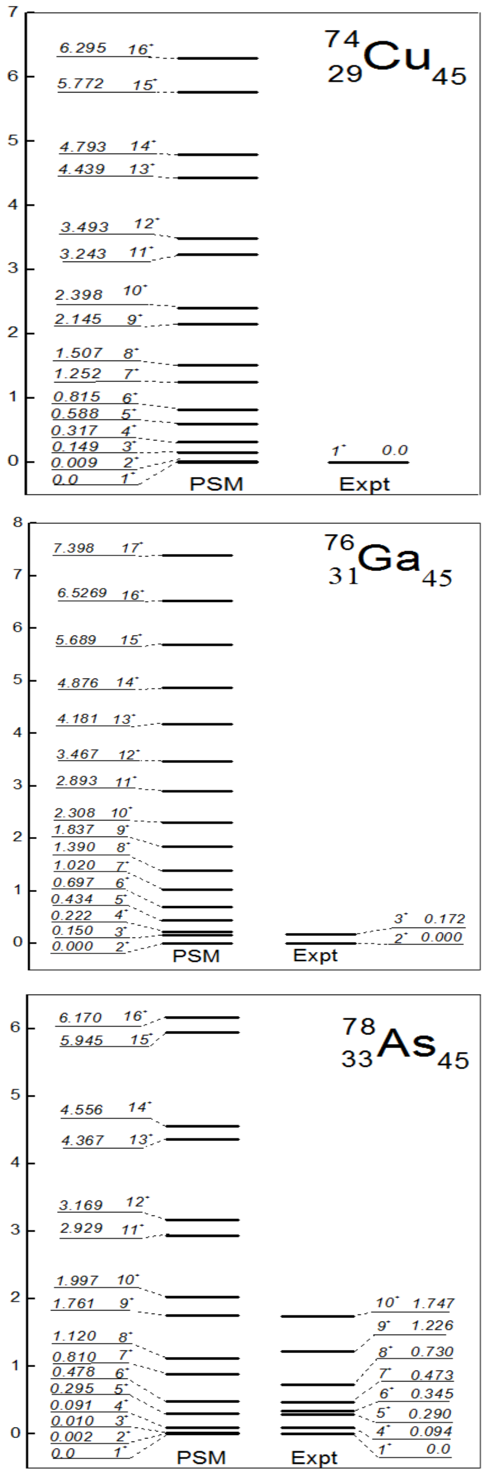

Fig. 1 Positive-parity yrast bands in ^{74}Cu, ^{76}Ga, ^{78}As. Experimental data is taken from [3,4,5].

$$B(M1, I_i \rightarrow I_f) = \frac{\mu_N^2}{2I_i + 1} \left| \langle \sigma_f, I_f \| \hat{M}_1 \| \sigma_i, I_i \rangle \right|^2$$

Results and Discussions

We have calculated the Positive-parity yrast energy levels in ^{74}Cu, ^{76}Ga and ^{78}As. The results are shown in Fig.1 along with their experimental counterparts. On comparing PSM results with the experimentally available data, an overall good comparison has been found. The consistency of our data with the experiments shows the reliability of this model in the mass 80 region. Besides this, the calculated B(M1)'s are shown in Fig.2.

It is worth mentioning that prior to the present work, there was no information concerning the B(M1)'s. It can be noted from the figure that in all three nuclei, staggering between the odd- and even-spin states is clearly present in these nuclei.

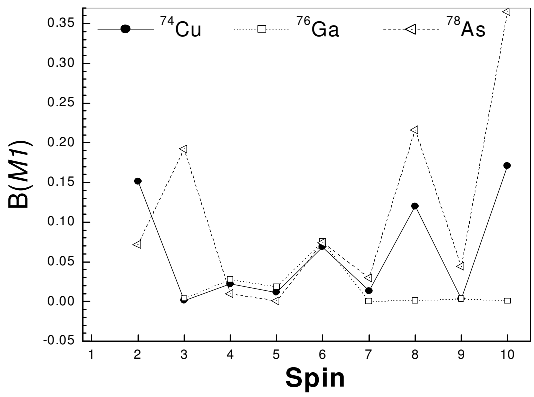

Fig. 2 B(M1) values for Positive-parity yrast bands in ^{74}Cu, ^{76}Ga and ^{78}As.

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