Quasi-particle Structure of Odd-Mass ^{115}I Nucleus

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Introduction

The nucleus, as a unique many-body system, possesses a rich variety of quantum-mechanical excitations. The competition and resulting balance between the single particle and collective degrees of freedom are important factors in the determination of the nuclear structure. The single-particle structure that exists for spherical nuclei near closed shells gives way to more collective rotational structure for deformed nuclei that have a large number of valence nucleons outside closed shells. The iodine (Z = 53) nuclei lie between the spherical (Z = 50) and the well-deformed (Z = 58) region and are of considerable interest because of competing shape driving tendencies of the orbitals occupied by the neutrons and the protons. The orbitals available near the Fermi surface of these nuclei are $h_{11/2}$, $g_{9/2}$, $g_{7/2}$, and $d_{5/2}$ for protons and $h_{11/2}$, $g_{7/2}$, $d_{5/2}$, and $d_{3/2}$ for neutrons. Spectroscopic investigations [1,2] carried out in the odd-A ^{115}I nuclei have revealed several bands based upon $\pi g_{7/2}(d_{5/2})$ and $\pi h_{11/2}$ orbitals. These bands are associated with moderately deformed prolate and oblate shapes. In addition, bands based upon particle-hole excitations involving $\pi g_{9/2}$ extruder orbitals, which play a decisive role in the development of collective bands in Sn and Sb nuclei, also persist in the iodine nuclei. High-spin structures in these nuclei are described by abrupt appearance of energetically favoured noncollective oblate states and coexistence of weakly collective and non-collective quasiparticle-aligned configurations. In the present work, PSM [3] calculations for oblate band structure for ^{115}I has been analyzed. We have calculated some nuclear structure properties (such as yrast spectra, band diagrams, etc.) corresponding to oblate quadrupole deformation and the experimental data is very well reproduced by the PSM wave function.

Projected Shell Model

Since, in the present work, we have applied PSM to study the various nuclear structure properties of ^{115}I nucleus, so in this section, we present the basic input parameters used in the PSM calculations The detailed theory of PSM is available in a review article [3]. The total Hamiltonian employed in the present work is

$$\hat{H}=\hat{H}_o-\frac{\chi}{2}\sum_{\mu}\hat{Q}^{\dagger}_{\mu}\hat{Q}_{\mu}-G_M\hat{P}^{\dagger}\hat{P}-G_Q\sum_{\mu}\hat{P}^{\dagger}_{\mu}\hat{P}_{\mu}$$

where $\hat{H}_o$ is the spherical single-particle Hamiltonian which contains a proper spin-orbit force. The second term in the above equation is the quadrupole-quadrupole (QQ) interaction and χ represents its strength whose value is adjusted via self-consistent conditions with a given quadrupole deformation ε_2, and the last two terms are the monopole and quadrupole pairing interactions, respectively. The monopole pairing force constant G_M is adjusted to give the known energy gaps. In the present calculations, the monopole pairing strength is described as

$$G_M=\left(G_1\mp G_2\frac{N-Z}{A}\right)\frac{1}{A}(\mathrm{MeV})$$

where – (+) is for neutron (proton) while, in this work, G_1 and G_2 are chosen as 24.00 and 13.00 MeV, respectively. The strength parameter G_Q for quadrupole pairing is assumed to be proportional to G_M. i.e

$$G_M=\gamma G_Q$$

and value of γ is taken as 0.20. For the present work, the quadrupole deformation parameter $\varepsilon_2 = -0.23$ has been used.

Summary

The PSM calculations, carried out for positive-parity yrast spectra for ^{115}I nucleus, show a satisfactory agreement with experimental data. The calculations reproduce the band head spin correctly for the ^{115}I nucleus which turns out to be $5/2^+$. The results on band diagrams show that the yrast spectra in ^{115}I nucleus for positive-parity do not arise from a single intrinsic state. The low-lying states are found to arise from 1-qp states. As we go to higher angular momentum states, it is found that the intrinsic state changes and has 3-qp configurations. The back-bending phenomenon has also been discussed for ^{115}I in the present work, as shown in fig.3. The presentation of the results would be made in detail during the conference.

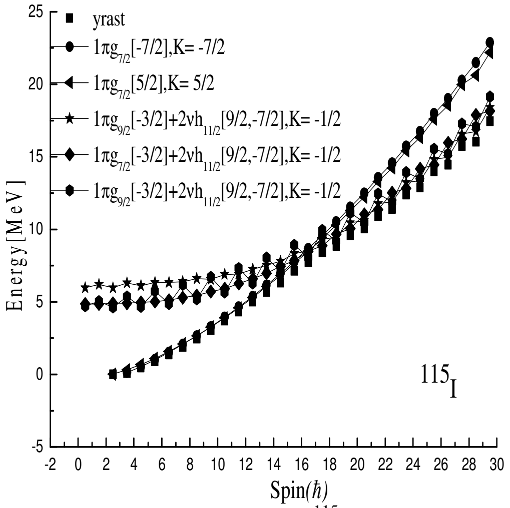

Fig. 1 Band diagram for ^{115}I.

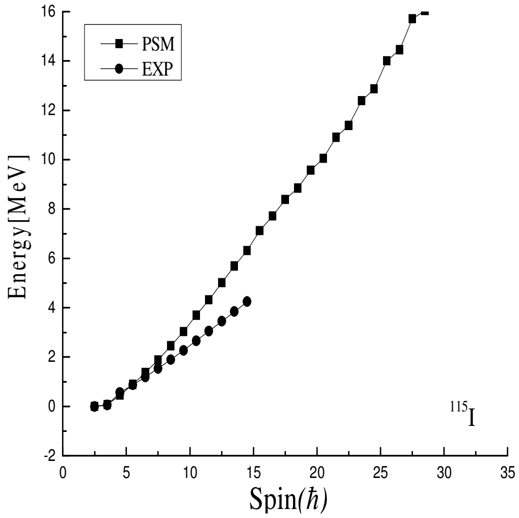

Fig. 2 Comparison of experimental and calculated yrast spectra for ^{115}I.

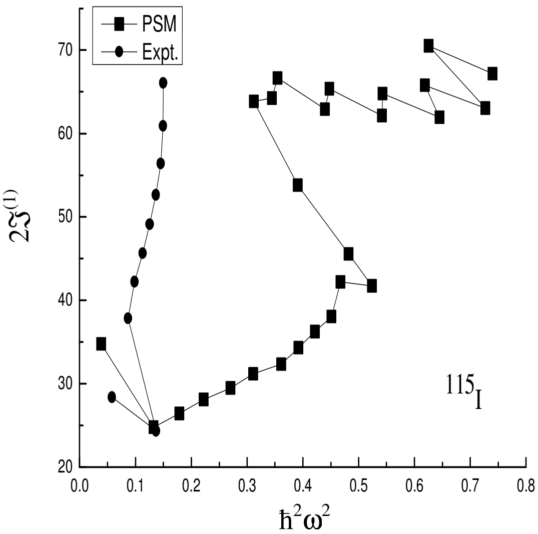

Fig. 3 Comparison of experimental and calculated back-bending in moment of inertia for ^{115}I.

References

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