Projected shell model calculations and its comparison with measured shape evolution in ^{75}Br

T. Trivedi[1,2,*] R. Palit[2], D. Negi[3], Z. Naik[2], Y.-C. Yang[4], Y. Sun[4], J.A. Sheikh[5], A. Dhal[3], M. K. Raju[6], S. Appannababu[7], S. Kumar[8], D. Choudhury[9], G. Mahanto[3], R. Kumar[3], R.P. Singh[3], S. Muralithar[3], A.K. Jain[9], H.C Jain[2], S.C. Pancholi[3], R.K. Bhowmik[3], and I. Mehrotra[1]

[1] Department of Physics, University of Allahabad, Allahabad-211001, India
[2] Tata Institute of Fundamental Research, Mumbai-400005, India
[3] Inter University Accelerator Centre, New Delhi-110067, India
[4] Department of Physics, Shanghai Jiao Tong University, Shanghai 200240, P. R. China
[5] Department of Physics, University of Kashmir, Srinagar 190 006, India
[6] Department of Nuclear Physics, Andhra University, Visakhapatnam-530003, India
[7] Department of Physics, MS University of Baroda, Vadodara-390002, India
[8] Department of Physics and Astrophysics, University of Delhi, Delhi-110007, India and
[9] Department of Physics, IIT Roorkee, Roorkee-247667, India

Introduction

The neutron deficient isotopes with A $\sim$ 70 - 80, in particular, have drawn considerable attention due to remarkable diversity of shapes and rapid changes in structure with particle number, angular momentum and excitation energies. The ^{75}Br nucleus lies in the proximity of the N= 38 prolate and the N=Z= 34, 36 oblate shell gaps implies that nuclei may exhibit different shapes at different excitation energies. Theoretical investigations of the properties of these isotopes at low and intermediate spins is a challenge for microscopic models. In this article, the properties of experimentally observed high spin states of ^{75}Br nucleus are compared with the projected shell model (PSM) calculations.

Projected shell-model calculations

The projected shell model [1], which is a shell model based on deformed bases, has been used to understand the evolution of collectivity for the positive and negative parity bands of ^{75}Br up to high spins. In the PSM calculation, we employ a quadrupole plus pairing Hamiltonian, with inclusion of quadrupole-pairing term

$$\hat{H} = \hat{H}_0 - \frac{1}{2}\chi \sum_{\mu} \hat{Q}^{\dagger}_{\mu}\hat{Q}_{\mu} - G_M \hat{P}^{\dagger}\hat{P} - G_Q \sum_{\mu} \hat{P}^{\dagger}_{\mu}\hat{P}_{\mu}. \quad (1)$$

In the above equation, $\hat{H}_0$ is the spherical single-particle Hamiltonian which contains a proper spin-orbit force. The monopole pairing strength G_M is taken to be $G_M = [G_1 - G_2(N-Z)/A]/A$ for neutrons and $G_M = G_1/A$ for protons with $G_1 = 18.23$ and $G_2 = 15.12$ [2].

Results and Discussion

Recently, high spin states of ^{75}Br nucleus have been populated and the de-exciting gamma-rays were detected using Indian National Gamma Array (INGA) [3] (Experimental details are given in Ref. [4]). The lifetimes of the excited states have been measured above the band crossing for positive- and the negative-parity bands, using Doppler-shift attenuation method (DSAM). Reduced electric quadrupole transition probability B(E2) and the transition quadrupole moments Q_t values were obtained from the measured lifetimes. Fig. 1 shows the variation of transition quadrupole moments for the yrast positive parity band as a function of spin and it has been observed that the average value of

*Electronic address: tarkeshwar@tifr.res.in

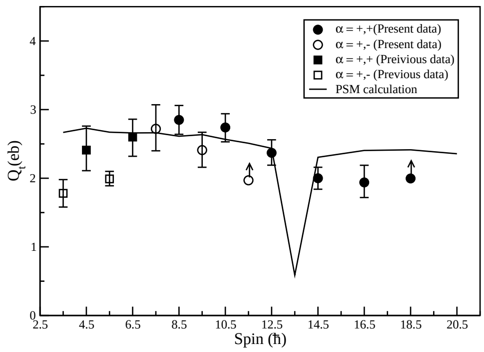

FIG. 1: Comparison of the measured transitional quadrupole moments Q_t as a function of spin for the positive-parity bands in ^{75}Br with the prediction of projected shell-model calculations.

transition quadrupole moment is 2.65 (eb) before the band crossing which decrease around 10% after the band crossing. Whereas, in case of negative-parity bands the average value of transitional quadrupole moments are around 2.8 (eb) before the band crossing and decreases sharply after the band crossing up to 1.25 eb.

To understand the variations in Q_t mentioned above, Projected shell model calculations have been performed. The study of band diagrams for the positive and negative parity bands suggest the differences in structure for the rotational bands before and after band crossing. A band diagram in the PSM contains some selected rotational bands in their pure configuration. In this way, it is easy to identify those important configurations of interest. For the positive parity states (Fig. 2), we found that the proton 1-qp band of $\frac{3}{2}$[431] lies lowest in energy in the low-spin region while the other two, the 1-qp $\frac{1}{2}$[440] and $\frac{5}{2}$[422] bands, lie respectively about 0.7 MeV and 1.4 MeV above according to band-head energy. However, the band can not retain its pure configuration when the nucleus rotates faster because the 3-qp configurations are seen to come down approaching or even crossing with the $K = \frac{3}{2}$ band at higher spins. Around the region of band crossing, the corresponding wave functions must undergo a configuration change due to band mixing. In fact, the data have shown a clear reduction in Q_t values near spin $I = 29/2$ (as seen in Fig. 1).

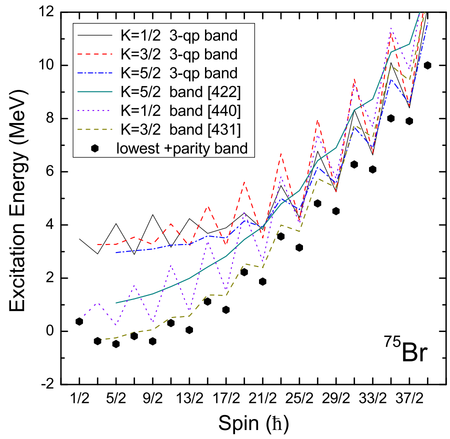

FIG. 2: Band diagram for the positive parity band of ^{75}Br.

Similar variations discussed above happen also in the negative parity band. In the band diagram for the negative parity states in the lowest band is the proton 1-qp $\frac{3}{2}$[312] band. The other 1-qp band, the $\frac{7}{2}$[303] band lie about 0.6 MeV above it. At $I = 21/2$ and 27/2, the calculation predicts two crossings of the $\frac{3}{2}$[312] band by two 3-qp bands. Due to the two crossings, a similar reduction in Q_t are expected, as in the positive parity case.

Acknowledgments

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References

[1] K. Hara and Y.Sun, Int. J. Mod. Phys. E **4**, 637 (1995).
[2] R. Palit et al., Nucl. Phys. A **141**, 686 (2001).
[3] S. Muralithar et al., Nucl. Instr. Method A **622**, 281 (2010).
[4] T. Trivedi et al., Phys. Rev C **81**, 047302 (2009).