Search for octupole correlation in ^{73}Br

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Introduction

The response of spatial distribution of nuclear wave function leads to range of phenomena involving shape changes and variety of geometrical shapes. Nuclei near the shell closure are usually spherical or nearly spherical in shape whereas with increasing proton/neutron number one expects modifications of the nuclear mean-field potentials, resulting in axially symmetric shapes. Due to breaking of the reflection symmetry in the intrinsic frame, some of nuclei appear to have octupole shapes. Experimentally, octupole correlations were first observed in ^{224}Ra using α decay reaction and subsequently it has been observed in A $\sim$ 150 and A $\sim$ 80 region. Indeed, compared to A$\sim$200 and $\sim$150 mass regions, A$\sim$80 region is a relatively new and less studied territory for the investigation of octupole correlations. Recently, multiple chiral doublet bands with octupole correlations have been observed in the ^{78}Br isotope [1].
In ^{73}Br nucleus, octupole driving pair of $g_{9/2}$ and $p_{3/2}$ proton orbitals are available at low excitation energy, which makes it an ideal case to exhibit octupole correlations. With this motivation in the present work, seventeen new inter connecting transitions and two new bands have been added in the previously known level scheme [2]. The lifetime of high spin states have been measured using Doppler shift attenuation method. The experimental results have been interpreted in terms of total Routhian surface (TRS) calculations.

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Experimental Details

The experiment was performed with Indian National Gamma Array (INGA) at Inter University Accelerator Center (IUAC), New Delhi, using ^{50}Cr(^{28}Si,$\alpha p\gamma$)^{73}Br reaction. The ^{28}Si beam of 90-MeV energy was bombarded on ^{50}Cr target of thickness 550 μg/cm^2 backed with 12 mg/cm^2 Au [3]. The γ rays were detected using 17 Compton-suppressed clover detectors during the experiment. The detector were placed at five different angles 32°, 57°, 90°, 123°, and 148°. The coincidence data were stored in the γ -γ matrix using INGASORT program.

Results and Discussion

The partial level scheme of ^{73}Br was established using the coincidence relationship, intensity (I_γ) measurements, Directional Correlation oriented nuclei (R_{DCO}) values, Angular Correlation oriented nuclei measurement (R_θ) and integrated polarization directional oriented

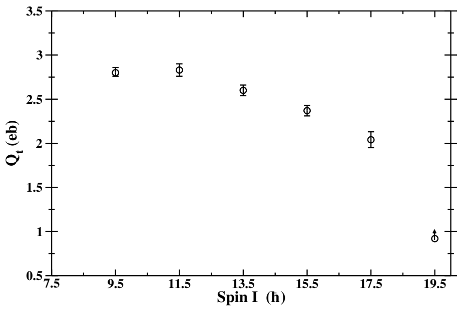

FIG. 1: Variation of transition quadrupole moment (Q_t) with spin for yrast negative-parity band in ^{73}Br from present data.

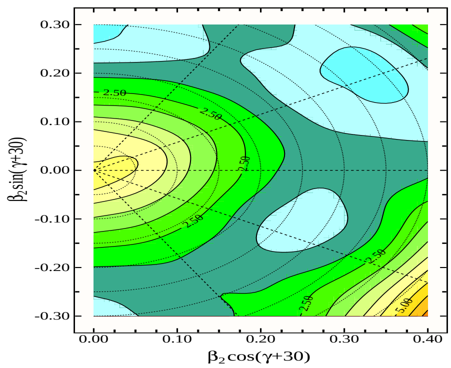

FIG. 2: (Color online) Contour plots having the 0.250 MeV energy different between two consecutive contours of the TRS calculations for the positive parity quadrupole band A in ^{73}Br. The rotational frequency ($\hbar\omega$) for the calculations 0.100 MeV.

nuclei (IPDCO) measurements. In the present studies, two new $\Delta I = 2$ positive parity bands, consisting of nine new transitions have been identified and placed in the level scheme. The two new inter-connecting transitions (782, 934 keV) have also been placed in between positive and negative parity bands. The R_θ, R_{DCO} and IPDCO value for 782 keV transition confirm it as a E1 transition. Further, lifetime of high spin states in ^{73}Br have been measured by Doppler shift attenuation method using LINESHAPE code. In fitting procedure, χ^2 & QFN minimization technique is used to get the transition quadrupole moment Q_t and lifetimes τ of maximum possible states (18 states)for the positive and negative parity bands. The reduced electric quadrupole transition probability B(E2) are extracted from the measured lifetimes. A representative figure showing the variation of transition quadrupole moment for yrast negative parity band as a function of spin is shown in Fig.1. The transition quadrupole moment decreases from 2.80 eb at spin $15/2^-$ to 0.92 eb at spin $39/2^-$, showing loss of collectivity. The experimental signatures of octupole correlations are enhance *E1* transition strength between opposite parity bands as well as value of B(*E1*)/B(*E2*) ratio. In ^{73}Br nucleus, the extracted value of B(*E1*)/B(*E2*) ratio for $11/2^-$ and $15/2^-$ states are 0.017×10^{-6}fm^{-2} and 0.004×10^{-6}fm^{-2}, respectively. Whereas, reduced transition probability B(*E1*) for 782 keV transition is $0.46(9){\times}10^{-4}$ W.U. and $0.64(6){\times}10^{-4}$ W.U for 933 keV transition. These enhanced values of B(*E1*) strength in ^{73}Br are quite comparable with ^{78}Br nucleus [1]. To understand the shape of ^{73}Br nucleus the total Routhian surface (TRS) calculations have been performed for positive parity and negative parity bands, in compliance with the experimentally observed frequency. The tri-axiality has been found at 0.100 MeV energy for positive parity positive signature band with $\gamma \sim 50°$ and $\gamma \sim 0°$ shown in Fig. 2. However, at higher frequency the structure retains prolate deformation.

In summary, the existence of inter-connecting *E1* transitions between yrast negative and positive parity bands along with measured B(*E1*)/B(*E2*)ratio as well as enhanced B(*E1*)transition strength clearly indicates the existence of octupole correlations in ^{73}Br.

Acknowledgments

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