Octupole Correlations in Neutron Deficient Light Se and Br Isotopes

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Introduction

The nuclei lying in the vicinity of mid shell region are vulnerable to shape changes due to rotational alignment of quasi-particle pairs. For instance, the reduction in pairing correlation occurs due to alignment of quasi-particles in higher-j intruder orbital, demanding less collective rotation to generate angular momentum. Such energetically favored quasi-particle configuration crosses the ground state configuration at finite angular momentum leading to the generation of aligned bands. A variety of such phenomena have been observed in 70 mass region due to the presence of $g_{9/2}$ intruder orbital.

An exciting feature of A = 70 mass region is the presence of octupole correlations which occurs mainly due to the presence of $p_{3/2}$ and $g_{9/2}$ intruder orbitals and angular momentum difference of Δj=3, near the Fermi surface. Recently, various experimental studies were carried out to explore octupole correlations in A=75 mass region. This includes the observation of octupole correlations in ^{78}Br [1] and ^{73}Br [2] from experimental B(E1)/B(E2) branching ratios and the energy displacement δE between the positive and the negative-parity bands. In the present work, a detailed comparison of octupole correlations is done among different neutron deficient Se and Br isotopes.

Experimental Details

The high spin states of ^{72}Se was populated using fusion evaporation reaction ^{50}Cr(^{28}Si, α2p)^{72}Se. A ^{28}Si beam at an energy of 90 MeV was provided by the 15UD Pelletron accelerator at IUAC, New Delhi and bombarded on a ^{50}Cr target of thickness 550 μg/cm^2 backed with 12 mg/cm^2 gold. The decaying gamma rays were detected using Indian National Gamma Array consisting of seventeen Compton-suppressed clover detectors. The detectors were placed at five different angles of 32° (two clovers), 57°(four clovers), 90°(five clovers), 123°(two clovers), and 148°(four clovers). After calibration and gain matching of individual crystals, add-back spectra were generated for all the clovers and the coincidence data were stored in a γ-γ matrix. The RADWARE software package was used for the analysis of the matrix.

Results and Discussion

A bulk of evidence for the presence of octupole collectivity comes from even even nuclei

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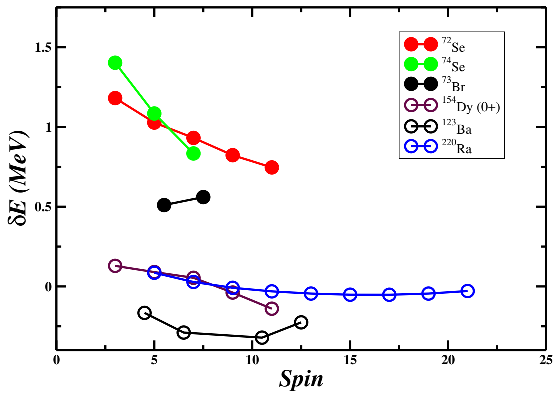

FIG. 1: Variation of δE with spin

TABLE I: Calculated B(E1)/B(E2), B(E1) values for octupole bands.

Nucleus	E_γ(keV)	$\frac{B(E1)}{B(E2)} 10^{-6} fm^{-2}$	B($\sigma\lambda$) W.U.
^{73}Br[2]	781.9	0.017(6)	0.46(9)$\times10^{-4}$
	933.3	0.004(6)	0.64(6)$\times10^{-4}$
^{72}Se[3]	1449	0.036	0.8 $\times10^{-4}$
	1337	0.012	0.2 $\times10^{-4}$
^{125}Ba[4]	475	0.05(1)	0.8 $\times10^{-4}$
	777	0.18(3)	3 $\times10^{-4}$
	807	0.07(2)	1 $\times10^{-4}$
	680	0.015(7)	0.15 $\times10^{-4}$
	631	0.027(8)	0.2 $\times10^{-4}$

such as ^{220}Rn, ^{226}Ra due to the presence of Z or N = 34, 56, 88, 134 with a difference of angular momentum Δj=3 between the intruder orbital and normal parity orbital, near the Fermi surface. A detailed study for the observation of this phenomenon is rigorously done in A=220$\sim$150 mass region whereas A=70 mass region is comparatively less explored region of nuclear chart. The presence of enhanced E1 transitions between positive and negative parity bands are one of the key experimental signature for observation of such a reflection asymmetric phenomena. Thus, the B(E1)/B(E2) ratio and B(E1) values of neutron deficient ^{72}Se nuclei are compared with ^{73}Br and ^{125}Ba nuclei. The observed results for ^{72}Se are almost similar with ^{73}Br, whereas B(E1) values are slightly higher than that of ^{125}Ba nucleus, as shown in Table. I. These characteristics reveal the octupole collectivity of slightly lower strength in 70 mass region because of weaker interaction strength in intruder orbital. Another parameter to describe the octupole deformation is the energy differences δE between positive and negative parity bands. From the Fig. 1, it is evident that in ^{72}Se, the value of δE is quite high, indicating the existence of octupole vibration similar to that of ^{74}Se. Since for ^{73}Br only two experimental E1 transitions have been observed, it is established to exhibit octupole correlation. Moreover, the observed trend of ^{123}Ba shows negative octupole correlation whereas octupole deformation is well established in ^{220}Ra nucleus.

Further, the experimental results are compared with total Routhian surface(TRS) calculations in the framework of Cranked Shell Model with the Strutinsky shell correction. In ^{72}Se nucleus, the quasi-proton routhian single paricle energy against the rotational frequency ($\hbar\omega$) plot describes the first band crossing for negative parity odd signature band at $\sim$0.60 MeV frequency. At frequency $\hbar\omega$ = 0.4 MeV, the contour β_2 -γ mesh plot shows a prolate structure (γ=0°) with β_2 =0.35, where as, for frequency $\hbar\omega$ = 0.7 MeV, it changes to oblate shape (γ=60°) with β_2 =0.30. These characteristics show the presence of shape co-existence at higher excitation energy.

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