Octupole correlations and γ-vibrational band in ^{72}Se nucleus

A. Mukherjee[1], S. Bhattacharya[1], T. Trivedi[1], R. P. Singh[2], S. Muralithar[2], D. Negi[3], R. Palit[3], S. Nag[4], S. Rajbanshi[5], M. Kumar Raju[6], S. Kumar[7], D. Choudhury[8], R. Kumar[2], R. K. Bhowmik[2], S. C. Pancholi[2], and A. K. Jain[9]

[1]*Department of Pure & Applied Physics, Guru Ghasidas Vishwavidyalaya, Koni, Bilaspur-495009, India*

[2]*Inter University Accelerator Center, Aruna Asaf Ali Marg, New Delhi-110067, India*

[3]*Department of Nuclear and Atomic Physics, Tata Institute of Fundamental Research, Mumbai-400005, India*

[4]*Department of Physics, IIT(BHU), Varanasi-221005, India*

[5]*Department of Physics, Presidency University, Kolkata-700073, India*

[6]*Department of Physics, GITAM Institute of Science, Vishakhapatnam-530045, India*

[7]*Department of Physics and Astrophysics, University of Delhi, Delhi-110007, India*

[8]*Department of Physics, Indian Institute of Technology, Ropar, Punjab-140001, India and*

[9]*Amity Institute of Nuclear Science & Technology, Amity University, Noida-201313, India*

Introduction

In recent years, the nuclei lying in the mid-shell region have attracted considerable attention as they exhibit a class of remarkable phenomena such as octupole correlations, shape coexistence, γ-vibration, etc. In particular, octupole collectivity is attributed to the angular momentum difference of $3\hbar$ between normal parity and intruder parity orbitals near the Fermi surface. A prominent signature of such reflection asymmetric structure is the occurrence of enhanced *E1* transitions, arising due to the separation of center-of-mass and center-of-charge of a nucleus. An abundance of evidence, confirming octupole collectivity, is available in A $\approx$ 220 to 230 having Z(or N) $\approx$ 88, 134 having normal parity orbitals ($f_{7/2}$, $g_{9/2}$) and intruder orbitals($i_{13/2}$, $j_{15/2}$), respectively. However, these studies in A $\approx$ 70 mass region are limited, in spite of the presence of intruder parity $g_{9/2}$ orbital and normal parity $p_{3/2}$ orbital, which may lead to asymmetric structure. Recently, octupole correlations has been explored in ^{78}Br [3] and ^{73}Br [4] isotopes where inter-connecting enhanced *E1* transitions have been identified between positive and negative parity bands. Another interesting structural feature observed in this deformed region is the observation of triaxiality, which is characterized by the presence of a γ-band built on the excited 2^+ state. Such a sequence of γ-vibrational states has been observed in ^{74,76}Kr isotopes, whereas rigid-triaxial deformation in ^{76}Ge was proposed from the odd-even staggering of the γ-band. A similar staggering pattern has also been observed in ^{78}Ge nuclei. Further, γ-vibrational band has also been reported in neutron deficient ^{70,74,76}Se isotopes.

In the present study, a detailed γ-ray spectroscopy of ^{72}Se is performed to explore the presence of octupole correlations and γ-vibrational bands.

Experimental details

High-spin states of the ^{72}Se were investigated using ^{50}Cr(^{28}Si, $\alpha 2p$)^{72}Se reaction and Indian National Gamma Array (INGA) at IUAC, New Delhi. The ^{28}Si beam of 90-MeV energy, provided by the 15UD Pelletron accelerator, was incident on a ^{50}Cr target of thickness 550 μg/cm^2 backed with 12 mg/cm^2 gold. The deexciting γ-rays were detected using 17 Compton-suppressed clover detectors during the experiment. The coincidence data, sorted in a $\gamma-\gamma$ matrix, was analyzed using the RADWARE and ROOT software packages. The details of the experimental setup can be seen in Ref. [4].

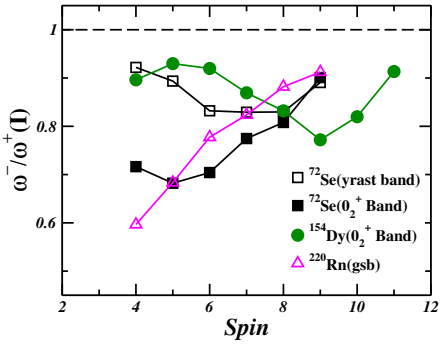

FIG. 1: (Color online) Frequency ratios ω^-/ω^+ between negative and positive parity bands, as a function of spin deduced for ^{72}Se has been compared with that of ^{154}Dy [6], and ^{220}Rn [5].

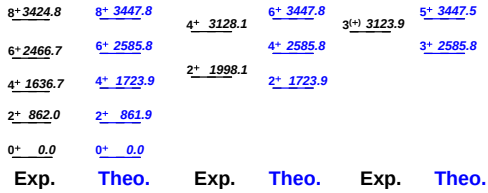

FIG. 2: (Color online) Comparison of experimental and the calculated level energies using IBA formalism in ^{72}Se. The level energy associated with the states are given in keV.

Results and Discussion

In the present work, the previous level scheme of ^{72}Se nucleus [1] has been confirmed, and the $K^\pi=0_2^+$ band has been extended up to 10^+ state [2]. In addition, several new interconnecting *E1* transitions have been identified and placed between the negative and positive parity bands. The observation of the interconnecting *E1* transitions decaying from negative parity band to both $K^\pi=0^+$ bands provides a scope to study the presence of octupole collectivity in ^{72}Se nucleus. The degree of octupole collectivity can be estimated from the ratio of ω^-/ω^+, where ω^- is the rotational frequency of the negative parity octupole band, and ω^+ is the rotational frequency of the positive parity band. The value of this ratio is equal to 1 for perfectly reflection-asymmetric nuclei. In Fig. 1, the variation of frequency ratio between negative and positive parity bands with that of spin for ^{72}Se has been compared with ^{220}Rn [5] and ^{154} Dy [6], respectively. The octupole vibration established in ^{220}Rn [5] can be seen from the plot of frequency ratio with that of spin , whereas octupole correlation was shown for ^{154} Dy [6] nucleus. Similarly, in Fig. 1, it is observed that the ratio for the yrast band paired with the negative-parity band in ^{72}Se is nearer to $\omega^-/\omega^+ \approx 1$ as compared to the pairing of the $K^\pi=0_2^+$ band with the negative-parity band. Also, the B(*E1*)/B(*E2*) ratio and the enhanced B(*E1*) values of ^{72}Se are quite comparable to that of ^{78}Br [3], and ^{73}Br [4] isotopes, indicating the presence of octupole correlations.

Moreover, a low spin γ-vibrational band has been identified at an energy of 1998.1-keV along with 3_γ^+ and 4_γ^+ states. The S(4) parameter is a quantitative parameter required to measure the degree of γ-softness. The value of S(4) parameter is calculated to be -1.36 which lies close to the vibrator structure. The low-spin level structure of ^{72}Se nucleus is also well interpreted in terms of interacting boson approximation (IBA) model calculations as shown in Fig. 2.

Acknowledgments

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