Search for γ- softness & Z(4) symmetry in ^{68}Ge.

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Introduction

Atomic nuclei in nature are found to exhibit a quantum mechanical phase transitions in the equilibrium shape and structure of the low-lying states. This has revealed the critical-point symmetries which describes the structure of nuclei at phase-transitional points. One of the fundamental signature for the critical point symmetry is the value of $R_{4^+/2^+}$ ratio. This value for the first critical symmetric point is 2.91 and the second critical symmetric point is 2.19 [1]. Another signature for identifying empirical symmetric structures are $R_{2^+_\gamma/2^+}$ ratio and the quasi-γ band staggering index, S(4). Using the above observables, two dynamical symmetries have been established: E(5) for a transition between spherical and γ -soft nuclei and X(5) for a transition between spherical and axially symmetric deformed nuclei [2]. However, if the ratio $R_{4^+/2^+}$ is 2.23 and $R_{2^+_\gamma/2^+}$ value is 1.77, then the low lying structure is governed by another structural symmetric shape Z(4) which is close to the E(5) critical point symmetry. The low lying states in ^{64}Zn show the evidence of E(5) structural symmetry based on $R_{4^+/2^+}$ and quasi- γ band staggering parameter [2]. However, ^{76}Ge nucleus gives the evidence of rigid triaxial deformation associated with the low-lying states of a γ- vibrational band based on the amplitude and phase of the S(J) energy staggering parameter as a function of spin [3]. In order to probe the critical point symmetry in other lighter Ge isotopes, we have performed the investigations on ^{68}Ge nucleus and we have observed the one phonon quasi- γ vibration band with its signature partner band along with the second phonon quasi- γ vibration band for the first time.

Experimental Details

In order to understand the high spin structure of ^{68}Ge, an experiment was performed with Indian National Gamma Array (INGA) at Tata Institute of Fundamental Research (TIFR), Mumbai, using ^{58}Ni(^{16}O,α2pγ)^{68}Ge reaction. The ^{16}O beam of 85-MeV energy was bombarded on ^{58}Ni target of the thickness 1.08 mg/cm^2 backed with 12 mg/cm^2 Au. The excited γ rays were detected using 15 Compton-suppressed clover detectors during the experiment. The detectors were placed at six different angles 40°, 65°, 90°, 135°, 140°, and 157°. 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 using MARCOS program [4]. The RADWARE software package was used for the analysis of the matrix.

Results and Discussion

The partial level scheme of ^{68}Ge was established using the coincidence relationship, in-

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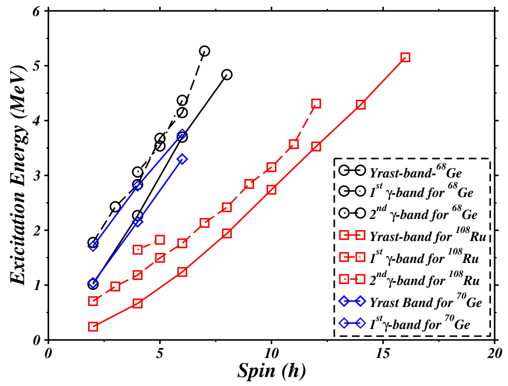

FIG. 1: Variation of excitation energy as a function of spin for yrast band with quasi- γ vibration band and second phonon band for ^{68}Ge and ^{108}Ru nuclei.

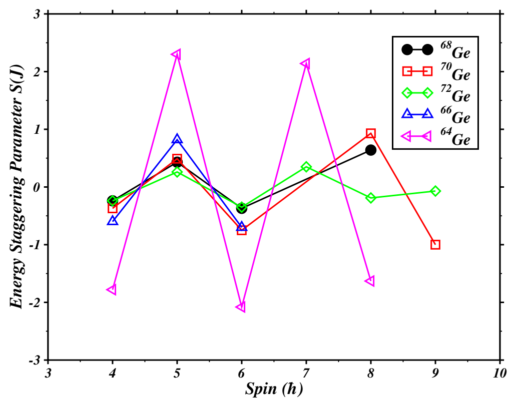

FIG. 2: Calculated odd-even energy staggering S(I) plotted against spin (I) for ^{68}Ge and compared with its neighboring nucleus in 70 mass region.

tensity (I_γ) measurements, Directional Correlation oriented nuclei (R_{DCO}) ratios, angular correlation oriented nuclei ratios (R_θ) and integrated polarization directional oriented nuclei (IPDCO) measurement values [5]. In the present study, the R_{DCO} and & R_{ADO} values for 762 and 564 keV transitions have been measured as a $\Delta I = 0$ (mixed with E2/M1) transitions, which confirms the γ- vibration band in ^{68}Ge nucleus. We have also extended the one phonon quasi γ vibration band upto 8^+ state with the addition of two 1312 keV and 1224 keV γ- transitions. Further, a second phonon band have been identified and extended upto 6^+ state with an addition of two 1266 keV and 1268 keV γ- transitions in the level scheme.

In order to probe the γ- soft nature of ^{68}Ge nucleus, we have measured the S(4) value of the γ band, to be -0.24. These characteristics are also displayed in the variation of excitation energy as a function of spin for one quasi- γ band and second phonon bands (shown in Fig. 1.). Further, the calculated values of $R_{4^+/2^+}$ and $R_{2^+_\gamma/2^+}$ ratios have been observed 2.23 and 1.77, respectively. The variation of staggering parameter S(J) as a function of spin for quasi- γ -bands have been compared with neighboring Ge isotopes and are shown in Fig 2. The slow variation of staggering parameter S(J) provides the evidence for Z(4) symmetry structure at low excitation states in ^{68}Ge, which lies in between the vibrator and γ- soft nature of the nucleus. The experimental results of low lying bands have been investigated using the total Routhian surface (TRS) calculations in the framework of the cranked shell model. In these calculations, we have included Strutinsky shell correction and measured TRS in a β_2 -γ mesh for the ground state bands in ^{68}Ge where the total energy have been minimized with respect to the hexadecouple deformation β_4 . The results suggest ground state configuration as a γ- soft shape ($\gamma \sim 87°$) with $\beta_2 = 0.26$ at $\hbar\omega = 0.05$ MeV.

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