DCO ratio analysis of high spin states in ^{67}Ga

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Introduction

With three proton above the magic N=Z=28 shell closure, Ga isotopes are ideal for studying the interplay of the single particle and collective behavior. For odd-A Ga isotopes, the valence particle occupies the negative parity $2p_{1/2}$, $2p_{3/2}$ and $1f_{5/2}$ orbitals outside the N=Z=28 Ni core. As a result of which the ^{63,65,67}Ga have $I^{\pi} = 3/2^-$ as ground state and $I^{\pi} = 5/2^-$ as first excited state[3, 4]. On the other hand, for higher excited states, occupation of positive parity $g_{9/2}$ intruder orbital plays an important role. In these nuclei the $9/2^+$ state, whose configuration may be understood as due to the promotion of the unpaired proton into $g_{9/2}$ orbital, is the lowest positive parity state and lies at about 2 MeV excitation energy. Alignment of neutron pair may be expected at higher rotational frequency. In heavier ^{71,73,75}Ga, addition of $g_{9/2}$ neutrons is expected to bring in more deformation and pronounced rotational band structure built on single proton level[5]. Here we aim to study the level structure of ^{67}Ga, particularly it's rotational-like band structure based on $9/2^+$ state. Previous spectroscopic data on high spins states of ^{67}Ga are available from ^{53}Cr(^{16}O,pnγ)[1],^{57}Fe(^{12}C,pnγ)[2] and from ^{12}C(^{58}Ni,3pγ) [3] reactions.

Experimental Details

Fusion evaporation reaction ^{52}Cr(^{19}F,2p2n) was used to populate high spin states in ^{67}Ga at beam energy of 70MeV provided by the 15UD pelletron accelerator of the Inter University Accelerator Center(IUAC), New Delhi. A 1 mg/cm^2 thin natural Cr(84% natural abundance) was evaporated onto 7mg/cm^2 Gold backing. Prompt γ rays were detected using the Gamma Detector Array(GDA)[6] consisting of 12 compton suppressed germanium(HpGe) detector in coincidence with the evaporated light charged particle for better channel selection. The HPGe detector in GDA were arranged in three rings, four each at 53°, 99°, and 153°. The 4π charged particle detector array(CPDA)[7] comprised of 14 ΔE-E phoswich plastic scintillator(BC400 and BC444). More details on the experimental setup can be found in [7, 10]. Offline analysis of the data was done using INGASORT [8] and RADWARE [9] suites of programs.

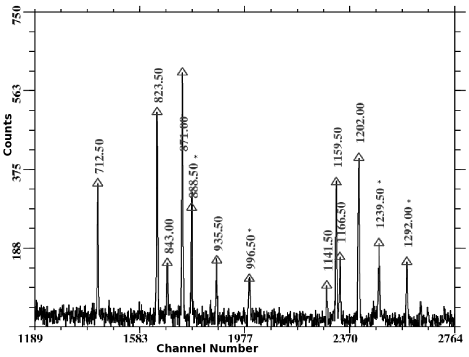

FIG. 1: Projected spectrum gated by 958 keV of ^{67}Ga

Results and Discussion

The level scheme obtained in this work is consistent with the previous work of Zobel *et.al.*[2] and Danko *et.al.*[3]. Due to the weak population of the negative parity states, we were unable to observe some of the transitions

*Electronic address: siddarthrai.rs@visva-bharati.ac.in as quoted in [3]. The rotational-like structure based on $9/2^+$ level was strongly populated in the fusion evaporation reaction. To confirm the quadrupole nature of the gammas belonging to the band we have performed DCO analysis. A $\gamma\gamma$ coincidence matrix was constructed with events detected at $153°(\theta 1)$ versus those at $99°(\theta 2)$. By gating a transition of known multipolarity, DCO ratio was obtained,

$$R_{DCO} = \frac{I_{\gamma 1}(\theta 1), \text{ gated by } \gamma_2(\theta 2)}{I_{\gamma_1}(\theta 2), \text{ gated by } \gamma_2(\theta 1)}. \quad (1)$$

Gating with a known quadrupole transition, the value of R_{DCO} is expected to approximately unity for quadrupole transition. A stretched dipole is expected to have R_{DCO} between 0.4 and 0.6, while a value between 0.6 and 0.8 implies a mixed transition. For pure nonstretched dipole($L = 1, \Delta J = 0$)transitions, R_{DCO} value is also expected to be close to unity.

In our case, DCO ratio was obtained by putting gate on known quadrupole transition, 958 keV($13/2^+\hbar \rightarrow 9/2^+\hbar$). The values obtained for the transition belonging to the band confirms the quadrupole nature of the transitions. The plot of DCO ratio for different transitions are shown in Fig.2(DCO ratio of 958 keV obtained by gate on 1160 keV). Also the multipolarity of 935 keV transition originating from 5225 keV has been confirmed as ΔI=1 transition, which was previously assigned as ΔI=2 transition by Zobel *et.al.* [2] prior to that of [1].

Conclusion

We have revisited the level structure of the ^{67}Ga and studied the nature of band structure using DCO analysis. Level scheme obtained is consistent with the previous works [2, 3]. It is further suggested that polarization and lifetime measurement of the band in ^{67}Ga and its other isotopes are necessary in order to understand the evolution of the collectivity of the π $g_{9/2}$ band. Further analysis of the data and study of the band structure using cranked shell model is in progress.

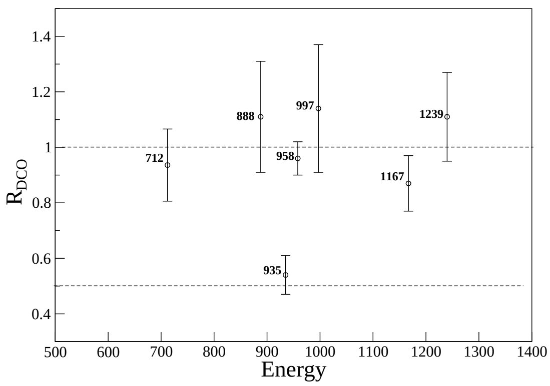

FIG. 2: DCO Ratio of the transitions belonging to the band gated by 958 keV transition

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