Nuclear structure study of $^{66}_{31}Ga_{35}$ at high spin

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Introduction

The neutron deficient ^{66}Ga nucleus lies close to $N = Z$ line and it is in-between doubly magic spherical ^{56}Ni nucleus and deformed ^{76}Sr. The energy levels of ^{56}Ni and its nearby neighbours exhibit single particle excitations [1] and it can be well explained by spherical shell model calculations. Low mass Sr isotopes show collective behaviour which has strong dependence on deformation parameters. The ^{66}Ga nucleus lies in-between these two regions and the energy levels exhibit both single particle as well as collective nature. This nucleus has three protons and seven neutrons outside the $N = Z = 28$ core. The valence protons and neutrons lies in $2p_{3/2}$ and $1f_{5/2}$ orbitals respectively. The low lying states of ^{66}Ga is explained by these orbitals. For higher lying states, $1g_{9/2}$ orbital plays an important role in this mass region as occupancy in this orbital exhibits a deformation character in this nucleus.

In this paper we report nuclear structure study of ^{66}Ga by using heavy ion induced fusion evaporation reaction. All the previous study on this nucleus is based on light ion induced reaction and β decay study. The level structure study of ^{66}Ga nucleus was based on ^{66}Ga(α,pnγ) and ^{63}Cu(α,nγ) reaction at 30 and 18 MeV incident beam energy [2] and they used Ge(Li) detectors as their detection system. The level scheme was extended upto $\sim$ 5 MeV excitation energy. The structure of this nucleus was explained by weak coupling of ^{65}Ga core to a neutron in $1g_{9/2}$ orbital. Detail study of its structural characteristics is warranted and it is very useful for theoretical model calculations. This nucleus was studied long back using modest detector set up and in some cases low resolution (NaI) detection system was used. A heavy-ion-induced fusion-evaporation reaction and a large array of high-resolution γ -ray spectroscopy work is needed to get detailed information. In our present work we used the facility of large array of Compton suppressed Clover detectors and digital data acquisition system. Using this facility it has scope to extend level scheme and unambiguously assign spin parity.

Experimental Details

The ^{66}Ga nucleus was populated by using ^{56}Fe(^{12}C,pn) reaction at $E_{lab} = 62$ MeV. The ^{12}C beam was provided by the 14UD Pelletron Accelerator at Pelletron Linac Facility, Mumbai. The target was a thick natural Iron foil. The de-exciting γ - rays were detected using the Indian National Gamma Array (INGA), at the Pelletron Linac Facility, Mumbai. During the experiment, INGA consisted of 15 Compton suppressed Clover detectors, 2 at 40^o, 2 at 65^o, 4 at 90^o, 2 at -65^o, 2 at -40^o and 3 at -23^o. Distance of the front face of the detector to the target was $\sim$ 25 cm. Two and higher fold Clover coincidence events were recorded with digital data acquisition system based on the Pixie-16 modules by XIA LLC. Energy calibration was carried out using radioactive (^{152}Eu and ^{133}Ba) source. The level scheme is

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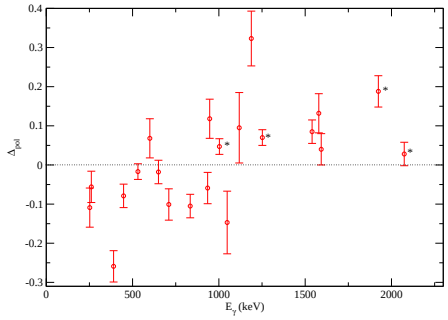

FIG. 1: Plot of Δ_{Pol} with energy for ^{66}Ga nucleus and new transitions are indicated by asterisk.

built up from the observed $\gamma - \gamma$ coincidence relationship. The conventional symmetric, angle dependent and polarization matrices are constructed using MARCOS [3] and analyzed using the RADWARE software package. In total about 5.1 billion coincident events of fold 2 and higher were recorded. The angle dependent matrices are used for spin difference assignment and polarization matrices are used for parity assignment. The singles data can be used for angular distribution measurement and from this we can extract the mixing ratio of a particular transition after χ^2 minimization.

Experimental Results

Spin parity assignment was done from the conventional R_{DCO} and the observed asymmetry between the number of perpendicular and parallel scattered events with respect to the reaction plane (Δ_{Pol}). Fig. 1 shows the value of Δ_{Pol} at different γ -ray energies observed in the present work. Level scheme of ^{66}Ga nucleus is presented in Fig. 2 based on present experiment. Level scheme is built up by using $\gamma-\gamma$ coincidence measurement. Most of the previously observed levels and transitions are confirmed in this present effort. Few new transitions (levels) are observed in this present experiment and they are placed in the level scheme. Few new assignments (spin and

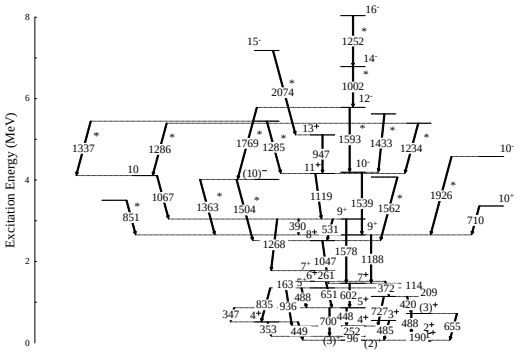

FIG. 2: Proposed level scheme of ^{66}Ga nucleus and new transitions are indicated by asterisk.

parity) were tentatively done in our present work. In the present work detailed analysis to understand the high spin structure of ^{66}Ga is in progress and will be reported in the symposium.

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References

[1] M. Weiszflog *et. al.* Eur. Phys.J. A. 11, 25 (2001).
[2] C. Morand *et. al.* Nucl. Phys. A. 308, 103 (1978).
[3] S. Saha *et. al.* Phys. Rev. C 86, 034315 (2012).