Linear Polarization Measurement of Low Lying States in ^{198}Hg

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Introduction

The Hg nuclei around A∼200 mass region, having two proton hole outside the Z=82 shell closer, are the representative of transitional nuclei as they lie in between the well deformed (prolate) rare-earth nuclei and the spherical Pb nuclei. Theoretical calculation also predicts weakly oblate deformation for these nuclei [1–3] and the collective rotational bands built on the ground state and on quasi-neutron excitation were reported $^{188-198}$Hg [4].

Another interesting feature of these nuclei is the existence of semi-decoupled band based on the 5^- level [4, 6], where the energy spacing for the next 7^- state was found to be very less. Single-particle nature arising due to the $i_{13/2}$ neutron coupling with the $p_{3/2}$, $p_{1/2}$, $f_{5/2}$ neutron was suggested for these states. On the other hand, the B(E2) value of the connecting transition from 7^- to 5^- states was found to be 30 s.p.u. [4, 5], indicating collective nature of these states.

Previously, the spin and parity assignments of γ-transitions of ^{198}Hg were determined from the angular distribution [4, 6], where the errors were upto $\sim 50\%$ for the weak transitions.

The aim of the present work is to reconfirm the electric or magnetic nature of various γ-transitions to confirm the parity of the states involved, by an alternate method, i.e., polarization measurements with clover detectors.

Experimental Details

The excited states of ^{198}Hg have been populated via breakup fusion reaction of ^{197}Au with weakly bound stable ^{7}Li [7] projectile of 33 MeV, obtained from the 15UD pelletron accelerator [8, 9] facility at IUAC, New Delhi. A ^{7}Li projectile breaks into ^{3}H and ^{4}He in the vicinity of the Coulomb field of the high Z target as it consists of a cluster structure of triton and α particle. The first fragment is captured by ^{197}Au with high cross section [10].
Indian National Gamma Array (INGA) [11], consists of fifteen Compton suppressed clover detectors was used to detect the de-exciting γ-rays. Offline data analysis was carried out using the INGAsort [12] computer code.

Results and Discussion

A partial level scheme of ^{198}Hg is shown in Fig.1. The typical energy add gated spectra

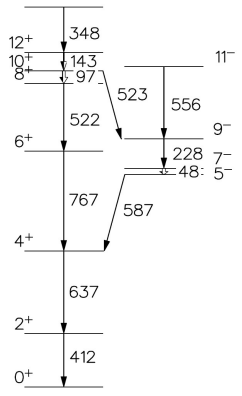

FIG. 1: Partial level scheme of ^{198}Hg.

of 411.8 keV and 636.6 keV γ-rays with a dispersion of 0.5 keV/channel are shown in Fig.2, which confirms the placement of pre-observed [6] γ-transitions belonging to ^{198}Hg.

The linear polarization measurement has

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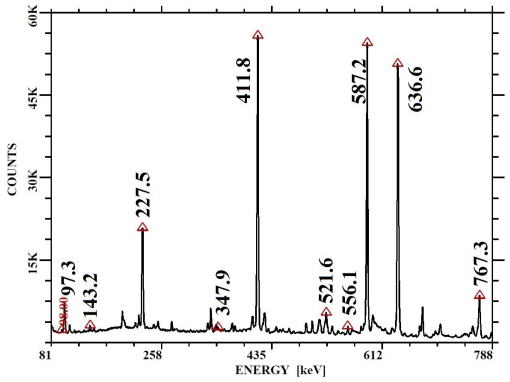

FIG. 2: Sum of the prompt γ-γ coincidence spectra gated by 411.8 keV and 636.6 keV transitions, showing the γ-rays belonging to ^{198}Hg.

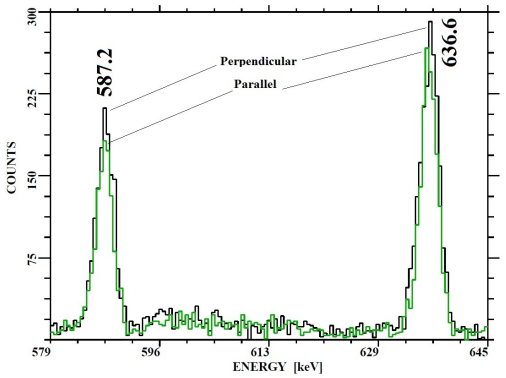

FIG. 3: The perpendicular and parallel counts of 587.2 keV and 636.6 keV γ-rays in ^{198}Hg, obtained from the IPDCO analysis in this work.

been carried out to determine the electric or magnetic nature of the γ-rays in ^{198}Hg.
The polarization asymmetry is defined as:

$$\Delta_{IPDCO} = \frac{a(E_\gamma)N_\perp - N_\parallel}{a(E_\gamma)N_\perp + N_\parallel}$$

$N_\perp$ and $N_\parallel$ are the intensities of the full energy peaks measured from the perpendicular and parallel components respectively. The asymmetry in the response of the four crystals of a clover detector has been taken care of by introducing a correction factor, defined as: $a(E_\gamma) = \frac{N_\parallel(unpolarized)}{N_\perp(unpolarized)}$.
The perpendicular and parallel counts of 587 keV and 636 keV γ-rays are shown in Fig.3.

The multipolarity of the γ-rays are determined from the angular correlation measurements.

$$R_{DCO} = \frac{I_{\gamma_1} \text{ at } \theta_1, \text{ gated by } \gamma_2 \text{ at } \theta_2}{I_{\gamma_1} \text{ at } \theta_2, \text{ gated by } \gamma_2 \text{ at } \theta_1}$$

The values of R_{DCO} and Δ_{IPDCO} have been tabulated in Table I.

TABLE I: Present experimental results on γ-ray energies (E_γ), R_{DCO} and Δ_{IPDCO} for ^{198}Hg.

E_γ (keV)	R_{DCO}	Δ_{IPDCO}
411.8	1.05 (4)	0.08 (6)
587.2	0.77 (3)	0.09 (5)
636.6	0.98 (3)	0.07 (4)

Conclusion

The multipolarities and nature of the several γ-rays in ^{198}Hg have been determined from angular correlation and linear polarization measurements. The positive values of Δ_{IPDCO} directly ensured the electric nature of 411.8 keV, 636.6 keV and 587 keV γ-rays. Also, the electric nature of 587 keV γ-ray confirmed the negative parity of 1636 keV (5^-) level.

Acknowledgment

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