Excited states of ^{145}Eu

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Introduction

The $^{145}_{63}Eu_{82}$ has one proton-hole inside the doubly magic nucleus $^{146}_{64}Gd_{82}$, therefore, it is a good candidate to study non-collective excitation in nuclei. The Fermi surface is located near $2f_{7/2}$, $1h_{9/2}$, $1i_{13/2}$ and $1h_{11/2}$ orbitals. The low spin states are originated mainly due to single-particle excitation and the high spin states are proposed in terms of weak coupling: one proton hole to the ^{146}Gd core or one proton particle to the ^{144}Sm core (core-coupling) or multi-quasiparticle excitation as reported by Bazzacco *et.al.* and Piiparinen *et.al.* in ^{145}Eu [1, 2]. However, most of the high spin states in ^{145}Eu have tentative spin/parity assignment. Thus, the aim of this work is to assign the spin/parity of the high spin states in ^{145}Eu on the basis of angular distribution/correlation and linear polarization results.

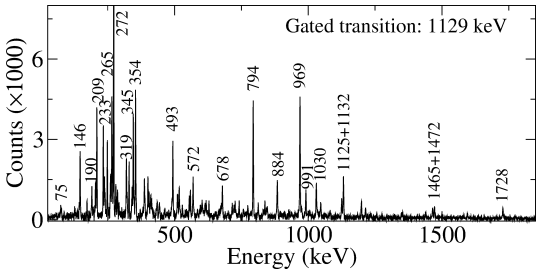

FIG. 1: The γ-rays (as marked) have been observed in coincidence with the 1129 keV transition of ^{145}Eu [2].

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Experimental details

High spin states in ^{145}Eu were populated via ^{122}Sn(^{28}Si, 5nγ) reaction at 146 MeV, delivered by the 15UD Palletron accelerator of Inter-University Accelerator Centre, New Delhi. The γ-rays were detected by 16 Compton suppressed clover detectors and 2 LEPs of Indian National Gamma Array [3, 4]. 2 mg/cm^2 thick ^{122}Sn foil was rolled on 10 mg/cm^2 Au to form the target. The offline data analysis was carried out using INGAsort software.

Results and Discussions

Most of the excited states in ^{145}Eu were reported with tentative spin/parity above $I^\pi = 29/2^+$ state at 5852 keV [2]. The angular distribution from oriented nuclei (ADO) ratio (R_θ) and linear polarization asymmetry ($\Delta asym$) have been determined for several γ-rays to fix the spin/parity of these states. The R_θ of the γ-rays is defined as [5]:

$$R_\theta = \frac{I_{\gamma_1} \text{ at } 148^\circ \text{ gated by all angles}}{I_{\gamma_1} \text{ at } 90^\circ \text{ gated by all angles}}$$

The Δ_{asym} of a transition is defined as:

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

Where, $N_\parallel$ ($N_\perp$) is the count of γ-rays scattered in perpendicular (parallel) direction with respect to the beam direction. The correction factor a(E_γ) is the ratio of perpendicular to parallel scattering asymmetry within the crystals of the detector.

In the present work, the DCO and ADO ratios and Δ_{asym} values are presented (TABLE I).

TABLE I: Energies (E_γ, E_i, E_f, E_{Gate}), DCO ratio (R_{DCO}), ADO ratio (R_θ), linear polarization asymmetry (Δ_{asym}), spin/parity, multipolarity (λ) and electric/magnetic (E/M) nature of the γ-rays/states of ^{145}Eu. First four rows reproduced the previously reported results and rest eight rows report the newly obtained results.

E_i	E_f	E_γ	R_{DCO}			R_θ	Δ_{asym}	I_i^π	I_f^π	λ	E/M
(keV)	(keV)	(keV)	$\theta = 148^\circ$	$\theta = 32^\circ$	E_{Gate}	(err)	(err)				
2814	1845	968.7	0.92	0.92	1129	1.00(5)	+0.098(17)	$17/2^-$	$13/2^-$	Q	E
3977	3183	793.5	1.56	1.68	272	0.61(2)	+0.242(10)	$25/2^+$	$23/2^-$	D	E
4123	3977	146.1	1.22	2.05	794	0.77(5)	−0.032(5)	$27/2^+$	$25/2^+$	D	M
5852	4123	1727.6	1.51	1.14	146	1.16(19)		$29/2^+$	$27/2^+$	D	
6197	5852	345.0	0.48	0.41	1728	0.49(5)	+0.065(15)	$31/2^+$	$29/2^+$	D	M
6461	6197	264.7	1.19	1.45	345	0.65(3)	+0.050(9)	$33/2^+$	$31/2^+$	D	M
7593	6461	1131.2	1.59	1.51	265	1.09(6)		$37/2^+$	$33/2^+$	Q	
7802	7593	208.7	0.89	0.92	1132	0.79(4)	+0.035(7)	$39/2^+$	$37/2^+$	D	M
8035	7802	232.9	0.99	1.09	209	0.92(8)	+0.086(16)	$39/2^+$	$39/2^+$		
8528	8035	493.0	0.71	0.62	233	0.56(2)	−0.195(72)	$41/2^+$	$39/2^+$	D	M
8881	8528	353.5	1.07	1.28	493	0.63(4)	−0.135(38)	$43/2^+$	$41/2^+$	D	M
9129	8881	247.9	1.14	0.99	354	0.69(3)	−0.051(9)	$45/2^+$	$43/2^+$	D	M

The ADO value for stretch dipole and quadrupole transitions are found to be 0.6 and 1.0 respectively, derived from stretched transition of ^{142}Sm. The spin/parity of eight states have been confirmed/assigned in the present work on the basis of Δ_{asym} values of decaying transitions. The plot of Δ_{asym} versus ADO ratio (R_θ) of different transitions has been shown in Fig. 2.

The previously reported spin and parity of 2814, 3977, 4123 and 5852 keV states have been verified on the basis of R_{DCO}, R_θ and Δ_{asym} values of corresponding depopulating γ-rays (Table I) and found in agreement with the previous assignments. The spin and parity of eight high spin states, *viz.*, 6197, 6461, 7593, 7802, 8035, 8528, 8881 and 9129 keV states have been confirmed in this work on the basis of multipolarity (λ) and electromagnetic nature (E/M) of the decaying γ-transitions, as listed in the Table I. The dipole nature of 345, 265, 209, 493, 354 and 248 keV γ-rays and quadrupole nature of 1131 keV γ-ray have been confirmed from both R_{DCO} and R_θ values. The magnetic nature of these dipole transitions has also been determined from the Δ_{asym} values. Further data analysis is underway. Detail results will be presented during the symposium.

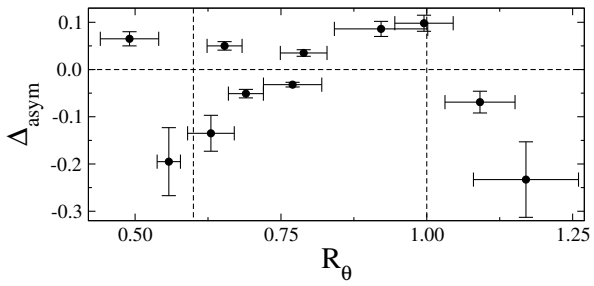

FIG. 2: Plot of experimental polarization asymmetry (Δ_{asym}) vs angular distribution ratio (R_θ).

Conclusion

Non-collective states in ^{145}Eu have been studied via ^{122}Sn(^{28}Si, 5nγ) at 146 MeV. The DCO/ADO ratio and Δ_{asym} values have been extracted for γ-rays to confirm spin/parity of eight high spin states.

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