High Spin Structure In ^{140}Sm

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Introduction

In all even even nuclei with mass A~140 the alignment of proton and neutron quasiparticles in the $h_{11/2}$ orbitals generate low-lying 10^+ states in many cases isomeric. These excitations has been localized in the N=78 ^{140}Sm [1] and ^{142}Gd [2] nuclei and identified as the proton or neutron $(h_{11/2})^2$ configurations through g-factor measurement. Such state couple to the respective core-excitation giving rise to ΔI=2 decoupled bands whose characteristic pattern allow one to identify the involved core and consequently to recognize, in an alternative way, the neutron or proton nature of the aligned $h_{11/2}{}^2$ configuration. For N = 78 nuclei e.g. ^{142}Gd, ^{138}Nd, ^{136}Ce [2-4] the active orbitals are intruder $h_{11/2}$ and normal parity, $d_{5/2}g_{7/2}$. In the rare-earth region, high-j $h_{11/2}$ unique parity orbital is accessible to both neutron and proton excitations. Previously ^{140}Sm was studied by S. Lunardi et al. [1] via ^{114}Cd(^{30}Si,4nγ) reaction at 130 MeV with 4 n type Ge detectors. A cascade of Δl=2 bands based on 10^+ isomer was reported by author.

Experimental Method

In the present work high spin states of ^{140}Sm have been populated through the ^{116}Cd(^{28}Si,4n)^{140}Sm heavy ion fusion evaporation reaction at beam energy of 128.7 MeV provided by Pelletron Linac at TIFR, Mumbai. Target used in experiment was 1 mg/cm^2 ^{116}Cd on 6 mg/cm^2 gold backing. Compound nucleus recoil velocity was 1.9% velocity of light and recoil energy was 25 MeV. Indian National Gamma Array (INGA) consisting of nineteen Compton suppressed Clover detectors at angle of -23°, -40°, -65°, 90°, 65°, 40º, 23º were used to detect de-exciting gamma rays. Two and higher fold gamma-gamma coincidence list mode data were recorded in a fast digital data acquisition system based on Pixie-16 modules of XIA LLC [5]. The data sorting routine MARCOS, developed at TIFR, sorts the time stamped data to generate Eγ – Eγ matrix and Eγ– Eγ – Eγ cube.

Data Analysis and Result

For data analysis we constructed symmetric matrix by placing energy recorded by all detectors on both axis. The level scheme has been established by placing 25 new transitions which include one weakly populated band and modification to previous levels by γ-γ coincidence measurement method and intensity information. Spin and parity has been assigned by R_{DCO} and IPDCO method. Multipolarities of the γ-ray transitions were determined using the R_{DCO} method. An asymmetric matrix was created (using MARCOS) with the events detected at 90˚ clovers on one axis and 157˚ clovers on the other axis. The following relation was used for the calculation of R_{DCO} ratios :

$$R_{DCO} = \frac{I^{\gamma_2}_{157^\circ}\ (Gate^{\gamma_1}_{90^\circ})}{I^{\gamma_2}_{90^\circ}\ (Gate^{\gamma_1}_{157^\circ})}$$

If RDCO is ~1 multipolarity of transition is same as gated transition, otherwise different. In order to obtain information about the level parities linear polarization measurements were done using IPDCO method. In this method the experimental asymmetry, Δ of Compton-scattered polarized photons is defined as:

$$\Delta = \frac{aN_\perp - N_\parallel}{aN_\perp + N_\parallel}$$

where $N_\perp$ and $N_\parallel$ denote the number of coincidence counts between the segments of the clover detectors in perpendicular and parallel direction to the emission plane, respectively. The factor a is asymmetry parameter defined by $N_\parallel / N_\perp$, denotes the correction due to the asymmetry in response to the perpendicular and parallel clover segments. Lifetime of states have been measured by Doppler shift attenuation method. For this asymmetric DCO matrices were constructed by keeping 65˚ detector on one axis and rest of detectors on other axis for forward analysis. For backward lineshape -65˚ (115˚) detectors were kept on one axis and rest of the detectors on another axis. To see the contamination in forward and backward data DCO matrices were constructed for 90° v/s all detectors.

For line-shape analysis of the transitions the LINESHAPE program [6] was used. The program takes into account the energy loss of the beam through the target, the energy loss and angular straggling of the recoils through the target and the backing. For the stopping power option we used the shell-corrected Northcliffe and Schilling stopping powers. The value of the time step and the number of recoil histories were chosen to be 0.001 ps and 5000 respectively. The various level fitted with χ^2 minimization are displayed in Fig. 1. The information of side-feeding intensity, contaminant peaks, normalization and efficiency are taken care of. Lifetime information, quadrupole moment and B(E2) values are listed in Table 1.

Table 1: Lifetime and B(E2) information of levels in ^{140}Sm.

Energy (keV)		τ (ps)	Q_t	B(E2) (e^2b^2)
994	6+	2.47	1.69	0.064
1151	8+	1.32	1.6	0.016
782	8+	1.4	3.5	0.19

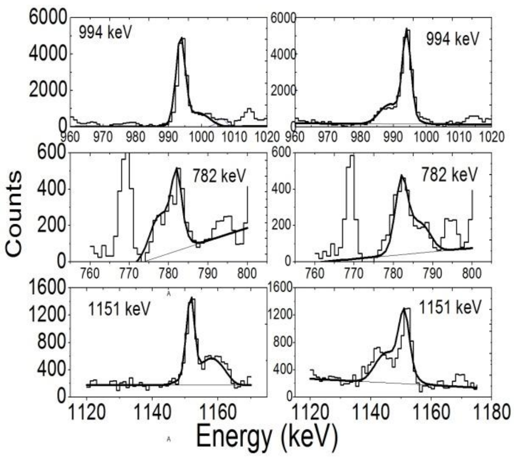

Fig. 1 DSAM fitting of transitions in ^{140}Sm

Experimental alignments ix = Ix − Ixref are plotted in Fig. 2 as a function of rotational frequency. Here Ix [7] was estimated as $I_x = [(I+1/2)^2-K^2]^{1/2}$. Ixref is based on frequency-dependent variable moment of inertia reference, $\Im_{ref} = \Im_0 + \Im_1 \omega^2$ where Harris parameters $\Im_0$=8.9$\hbar^2$ MeV^{-1}, $\Im_1$= 14.8 MeV^{-3} are used [8]. A ΔI=1 band based on 14^-, proposed 4-quasiparticle configuration $\pi[g_{7/2}h_{11/2}] \otimes \nu[h11/2]^{-2}$ and ΔI=2 band based on 5^- proposed to two neutron configuration, $\nu[h_{11/2} \otimes s_{1/2}/ d_{3/2}]$ on the basis of systematic.

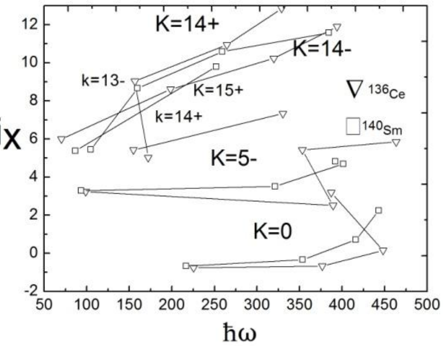

Fig. 2 Experimental alignment of ^{136}Ce and ^{140}Sm nuclei

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