Lifetime measurements in ^{140}Sm using DSAM

Diwanshu[1],* Navneet Kaur[2], Bharti Rohila[1], Ashok Kumar[1], Amandeep Singh[1], Rajbir Kaur[1], Kushal Kapoor[1], H.P. Sharma[3], Saikat Chakraborty[3], S. K. Chamoli[4], Suresh kumar[4], R. Palit[5], Sudipta Saha[5], Jasmine Sethi[5], Shital K. Jadhav[5], Rajnish Dhonti[5], and Bala ji S. Naidu[5]
[1]*Department of Physics, Panjab University, Chandigarh,160014, India*
[2]*Department of Physics, S.D. College Ambala Cantt., Haryana,133001, India*
[3]*Department of Physics, Banaras Hindu University, Varanasi,221005, India*
[4]*Department of Physics and Astrophysics, University of Delhi,110007, India and*
[5]*Tata Institute of Fundamental Research, Mumbai,400005, India*

Introduction

Samarium isotopes are well known for the prolate-oblate shape coexistence in their structure. They show a transition from a spherical shape at N=82 shell closure to a deformed prolate shape in neutron-deficient nuclei with the exception of oblate shape in ^{140}Sm (N=78) [1]. The magnitude of prolate deformation increases as the neutron number decreases. Oblate shape in ^{140}Sm and other rare earth nuclei is also confirmed in the framework of Relativistic Mean Field(RMF) theory [2]. Shape coexistence has been found above 3 MeV due to the presence of two isomeric states, interpreted as $(\pi h_{11/2})^2$ due to two proton particles and $(\nu h_{11/2})^{-2}$ due to two neutron holes [3].The g-factor measurements confirmed $(\pi h_{11/2})^2$ state as prolate and $(\nu h_{11/2})^{-2}$ as oblate respectively [4]. Lifetime measurements in the rotational bands built on these isomeric states can give a definite answer to the question of deformation via measurements of transition probabilities and deformation parameter.

Experimental Details

The high spin states of ^{140}Sm have been populated by using heavy ion fusion evaporation reaction ^{116}Cd(^{28}Si, 4n)^{140}Sm at beam energy of 128.7 MeV provided by Pelletron Linac at TIFR, Mumbai. Thin ^{116}Cd target of thickness 1 mg/cm^2 has been fabricated with 6 mg/cm^2 Gold foil as backing. The recoiling nuclei in excited states were stopped within the backing material and the de-exciting gamma rays were detected by INGA consisting of nineteen compton supressed Clover detectors at angle of -23^o, -40^o, -65^o, 90^o, 65^o, 40^o and 23^o. Two and higher fold γ-γ coincidence events were recorded in a fast digital data aquisition system based on Pixie-16 modules of XIA-LLC [5]. The data were sorted using 'Multi pARameter time stamped based COincidence Search program' (MARCOS), developed at TIFR, that sorts the time-stamped data to generate Eγ-Eγ matrices and Eγ-Eγ-Eγ cubes compatible with RADWARE [6] format.

Data Analysis and Results

DSAM method has been used to determine the lifetimes of excited nuclear levels. The γ-γ coincidence events were sorted into three angle dependent asymmetric matrices with y-axis corresponding to γ-rays in the respective detectors at 140^o, 90^o, 40^o while the x-axis corresponds to γ-rays at any other position. The energy gated spectrum for analysis was obtained by gating on the γ-rays recorded on the x-axis and projected on the y-axis, corresponding to a specific angle of a respective matrix. The basic procedure is to calculate the Doppler broadened shapes of the transitions of interest and then least square fit the calculated shapes using LINESHAPE [7] code to extract the level lifetime. The program takes into account the energy loss of the beam

*Electronic address: diwanshusharma96@gmail.com

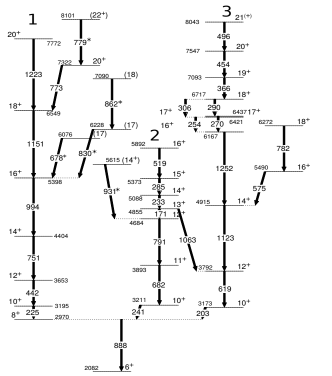

FIG. 1: Partial level scheme of ^{140}Sm

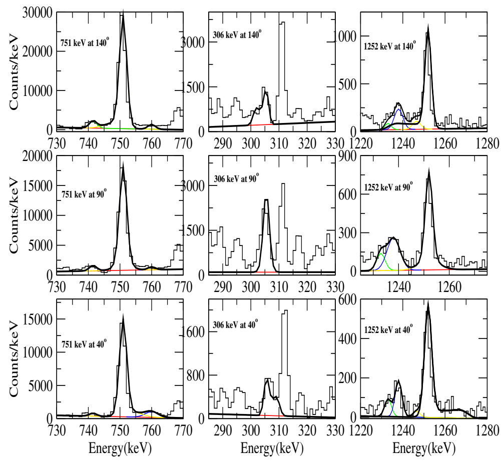

FIG. 2: Fitted lineshape for the 751 keV, 306 keV and 1252 keV γ-rays in ^{140}Sm at 140^o, 90^0 and 40^o.

through the target and the energy loss and angular straggling of recoils through the target and the backing. For energy loss calculations, Shell-corrected Northcliffe and Schilling electronic stopping powers were used. The value of time step and number of recoil histories were 0.001ps and 5000 respectively. Velocity profiles for different angles were generated using the geometry of the detector and input parameters. For individual transition energies, simulation was carried out by varying the background parameters, intensity of contaminant peaks and side-feeding quadrupole moments. Three χ^2 minimization routines SEEK, SIMPLEX and MIGRAD were used to obtain the best fit.

TABLE I: Results of lineshape analysis for γ-transitions in ^{140}Sm.

Eγ (keV)	I$^\pi$	τ (ps)^a	τ (ps)^b
751	14^+	1.72(2)	1.7
306	18^+	1.98(1)	
1252	16^+	0.93(18)	

^{a}Calculated in the present work.
^{b}By M. A. Cardona et al.[3].

Fig.2 displays the backward, 90^0 and forward Doppler shifted lineshapes and χ^2 fit for 751 keV, 306 keV and 1252 keV. The deduced lifetimes(τ) are shown in Table 1.

Earlier lifetime in ^{140}Sm were reported by M. A. Cardona et al. by using RDM technique for 14^+ level (751 keV) which is found to be in well agreement with the value determined in the present work. The analysis is in progress for lifetimes of more states and will be presented at the symposium.

Acknowledgments

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