Shape evolution in ^{136}Sm

F. S. Babra[1], R. Palit[1], S. Rajbanshi[2], G.H. Bhat[3], J.A. Sheikh[3], S. Biswas[1], S. Saha[1], Md. S. R. Laskar[1], C. Palshetkar[1], P. Singh[1], U. Garg[4], and A. Goswami[5]
[1]*Department of Nuclear and Atomic Physics, Tata Institute of Fundamental Research, Mumbai - 400 005, INDIA*
[2]*Presidency University, Kolkata 700 073, India*
[3]*Department of Physics, University of Kashmir, Srinagar 190 006, India*
[4]*Physics Department, University of Notre Dame, Notre Dame, Indiana 46556, USA and*
[5]*Saha Institute of Nuclear Physics, 1/AF, Bidhannagar, Kolkata 700 064, India*

Introduction

The evolution of deformation for neutron deficient nuclei in the A$\sim$130 region has attracted considerable interest in the recent years. A number of experimental investigations have been carried out for the even-even Sm isotopes in this region, which showed interesting shape transitions around N=74. For neutron numbers N $\sim$ 74 and below, the Sm isotopes have stable prolate ($\gamma = 0°$) ground state deformations [1]. High spin states in ^{138}Sm isotopes were studied [2] in which significant triaxiality has been observed. Total Routhian Surface (TRS) calculations suggest that ^{136}Sm is a truly transitional γ-soft nucleus between the prolate ^{134}Sm and the triaxial ^{138}Sm isotopes. The transitional nuclei are susceptible to shape changes driven by the rotational alignment of quasiparticle pairs involving high-j orbitals which can polarize the γ-soft cores to specific values of γ. Previous work on the yrast band of ^{136}Sm up to $I^{\pi} = 24^{+}$ has been published in Ref.[1] and the lifetimes of the lower members of the ground-state rotational band have been deduced [3, 4]. The motivation of the present work is to probe the shape evolution in the yrast band of ^{136}Sm beyond the band crossing to see the effect of proton and neutron alignments. Investigation of such shape changes with increasing spin is of contemporary interest, because this can generate various geometries of the core and particle angular momenta which are essential for novel excitation modes. This had been achieved through the measurement of the lifetimes of the levels of ground state rotational band in ^{136}Sm using the technique of Doppler Shift Attenuation method (DSAM). The transitional quadrupole moments extracted from the measured lifetimes have been compared with the cranked shell model and projected shell model calculations.

Experimental Details and Results

High spin excited states of ^{136}Sm were populated using the heavy ion fusion evaporation reaction ^{107}Ag(^{32}S, 1p2n). The reaction involves 145 MeV ^{32}S beam, provided by TIFR-BARC Pelletron facility at TIFR, and 1.2 mg/cm^2 thick ^{107}Ag target foil. Au backing of thickness 12.5 mg/cm^2 was used to stop recoiling nuclei. The de-exciting gamma-rays were detected using the INGA setup consisting of 17 Compton-suppressed HPGe clover detectors Two and higher-fold coincidence events were recorded in a fast digital data acquisition system (DDAQ) based on Pixie-16 modules of XIA-LLC which provides both energy and timing information [5]. The data were sorted using MultipARameter time stamped based COincidence Search (MARCOS) program to generate one-dimensional histograms, E_γ-E_γ and E_γ-E_γ-E_γ coincidence events for offline analysis. Lineshape code was used to extract the lifetimes of the excited states using Doppler shift attenuation method (DSAM).

Results and Discussion

The ground state rotational band in in ^{136}Sm has been extended up to spin $I^{\pi} = 28^{+}$ and excitation energy of 10.52 MeV. The partial level scheme is shown in Fig. 1 which consists of yrast band, gamma-vibrational band built on 2^+ state.

Lifetimes of states with $I^\pi = 8^+$ to $I^\pi = 22^+$ have been measured to study the shape evolution of yrast band. Lineshapes of quadrupole transitions de-exciting from these levels have been observed in the detectors arranged at angles 23° , 90° and 157° in the present geometry. Lineshape plot of lower lying three transitions is shown in Fig. 2. The coincidence spectra were obtained from top gated transitions and were fitted simultaneously. The B(E2) values obtained will be compared with TRS and TPSM (triaxial projected shell model) calculations to probe the collectivity and shape transitions. Slight reduction in the measured transitional quadrupole moment beyond the band crossing is reproduced in the TRS calculations.

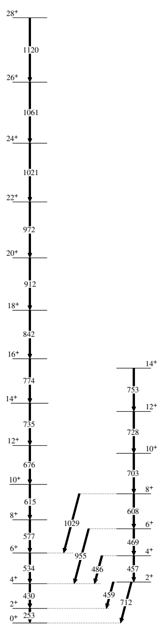

FIG. 1: Partial level scheme of ^{136}Sm depicting the yrast and gamma vibrational band.

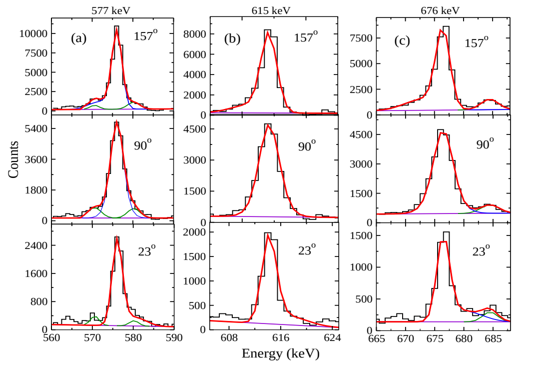

FIG. 2: Lineshape fitting for 577-, 615- and 676-keV transitions obtained from the present work. The coincidence spectra from 23°, 90° and 157° detectors were used.

Acknowledgement

Authors are thankful to the staff at TIFR-BARC Pelletron Linac Facility and all the members of the INGA facility. Support from S. V. Jadhav, R. Donthi, B. S. Naidu and A. Thomas during the experiment is deeply acknowledged. This work was partially funded by the Department of Science and Technology, Government of India (No. IR/S2/PF-03/2003-II).

References

[1] E. S. Paul et al., J. Phys. G: Nucl. Part. Phys. 19, 861 (1993).
[2] E. S. Paul et al., J. Phys. G: Nucl. Part. Phys. 20 1405 (1994).
[3] F. Soramel et al., hys. Rev. C 38, 537 (1988).
[4] R. Wadsworth et al., J. Phys. G 13 (1987) 205.
[5] R. Palit et al, Nucl. Instrum. Methods A 680, 90 (2012).