Magnetic Rotational band in ^{141}Sm nucleus

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Introduction

The existence of the magnetic rotational (MR) bands, consisting of strong magnetic dipole ($M1$) transitions, in nearly spherical weakly deformed nuclei is well established [1]. The experimental signature these bands is the characteristic decrease of the $B(M1)$ values with spin along the band. Nuclei in the vicinity of the ^{146}Gd ($Z = 64, N = 82$) core have been subjects of many spectroscopic investigations over the last two decades. In particular, several studies on the observation of dipole bands in these nuclei were reported in the literature [2], of which the bands in ^{139,142}Sm, ^{141,143}Eu, ^{142}Gd were interpreted as MR bands. The earlier studies on ^{141}Sm [3] have been reported a dipole cascade at an excitation energy of 3.4 MeV. In the present investigation, the lifetimes of these states in the dipole band have been determined using the Doppler shift attenuation method (DSAM) and have been interpreted as MR band in the framework of the shears mechanism with the principal axis cranking (SPAC) model calculations.

Experimental details

High spin states in ^{141}Sm have been populated using the reaction ^{116}Cd (^{31}P, p5n) at E_{lab} = 148 MeV. The ^{31}P beam has been obtained from the Pelletron Linac Facility at Tata Institute of Fundamental Research (TIFR), Mumbai. The beam was incident on 2.4 mg/cm^2 of ^{116}Cd (99% enriched) target on a 14.5 mg/cm^2 thick Pb backing. The de-exciting γ-rays were detected by the Indian National Gamma Array (INGA) array [4] which consisted of nineteen Compton suppressed clover detectors placed at six different angles. About $4{\times}10^9$ two and higher fold γ-γ coincidence events have been recorded with the fast digital data acquisition system based on Pixie-16 modules from XIA LLC [4, 5].

Results and discussion

Doppler-broadened line shapes have been observed for the 309.4, 446.4, 527.8, 548.0, 253.7 keV transitions of the dipole band above the $I^\pi = 27/2^-$ state. The level lifetimes have been extracted using the LINESHAPE code [6]. The process of the lineshape analysis has been described in detail in Ref. [7]. The background subtracted gated spectra at 65°, 90° and 140° have been fitted simultaneously to extract the level lifetimes. Typical line shapes for the transitions in the dipole band are shown in Fig. 1. The level lifetimes and corresponding $B(M1)$ values for the respective levels are given in Table I. The evaluated $B(M1)$ values for the transitions of the dipole band in ^{141}Sm, as shown in Fig. 2, are comparable to those for the dipole bands in ^{139,142}Sm, ^{141,143}Eu and ^{142}Gd [7] and the values have also been found to decrease with increase in excitation energy and spin (Table

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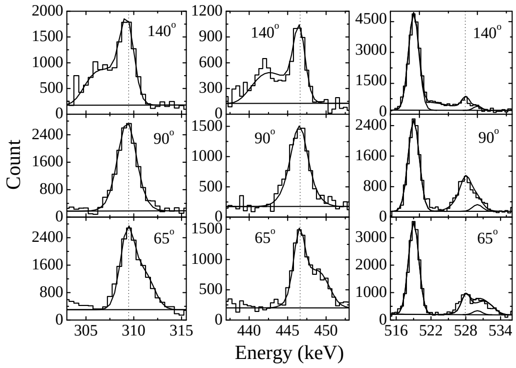

FIG. 1: Representative spectra along with the fitted line shapes for (a) 309.4 (b) 446.4 and (c) 527.8 keV transitions in the dipole band of ^{141}Sm.

I). This characteristic decrease of $B(M1)$ values (Fig. 2) may be ascribed to the fact that these dipole transitions have been emanated from the shears mechanism.

Calculations have been carried out in the frame work of a semi-classical SPAC model with the configuration $\pi h^2_{11/2} \otimes \nu h^{-1}_{11/2}$ for the dipole band in ^{141}Sm. The prolate deformation and the normal initial alignment have been envisaged for the calculations assuming unstretched condition of the angular momenta with $j_1 = 5.5\hbar$, $j_2 = 9\hbar$, g_1 = -0.21 and g_2 = +1.21 [7]. The experimental $B(M1)$ values have been well reproduced within the framework of the SPAC model for the dipole band in ^{141}Sm (Fig. 2). This calculations debunk the fact that the dipole band in ^{141}Sm has been germinated due to the magnetic rotation.

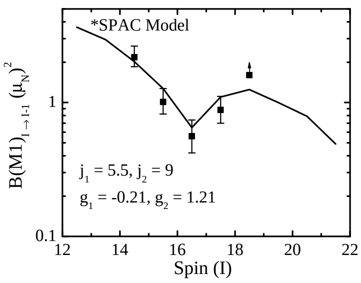

FIG. 2: The comparison of the experimental $B(M1)$ values for the dipole band of ^{141}Sm with the SPAC model calculations.

TABLE I: Measured level lifetimes and $B(M1)$ values for the dipole band in ^{141}Sm.

I_i^π	$E_\gamma(keV)$	τ(ps)	$B(M1)\mu_N^2$
$29/2^-$	309.4	$0.82^{+0.17}_{-0.14}$	$2.18^{+0.37}_{-0.46}$
$31/2^-$	446.4	$0.62^{+0.16}_{-0.12}$	$1.01^{+0.19}_{-0.26}$
$33/2^-$	527.8	$0.68^{+0.22}_{-0.17}$	$0.56^{+0.18}_{-0.14}$
$35/2^-$	548.0	$0.50^{+0.13}_{-0.10}$	$0.88^{+0.23}_{-0.18}$
$37/2^{(-)}$	253.7	1.86↓	1.65↑

tion. The detailed calculations will be present to fathom the intrinsic stucture of this band at this spin region. The SPAC calculations reveal the fact that the magnetic rotational bands in odd mass ^{139,141}Sm nuclei have been based on small prolate deformation whereas oblate deformation has been deduced for the shears band in ^{142}Sm. These espials hint the existance of the shears bands in Sm nuclei has large impact on the neutron number of the isotopes.

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