Evidence of Antimagnetic Rotation in ^{141}Sm

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Introduction

Existence of the rotational band-like structure formed by electric quadrupole transitions (E2) in near spherical nuclei have the special research interest in last decade. These structures, known as antimagnetic rotation (AMR), have been interpreted within the framework of the shear mechanism [1]. In this description the angular momentum is generated by the closing of the two blades of conjugate shears, produced by the valence particles (holes). These valence particles (holes) are initially aligned in time reversed orbits at the bandhead. There is no net perpendicular component of the magnetic dipole moment for this configuration and it is symmetric with respect to a rotation by π about the total angular momentum axis (rotational axis). The resulting quadrupole transition strength will decrease with the increase in spin along the band due to the gradual closing of the angular momentum blades.

The AMR bands are also been interpreted in the framework of a fully self-consistent microscopic tilted axis cranking method based on covariant density functional theory [1]. The observation of a conjugate shear structure responsible for the generation of angular momentum in near spherical systems in the form of AMR have been found in the A $\sim$ 100 and 140 mass regions. It is expected to observe the double shear structure in nuclei where firm experimental evidence of the single shear structure has been reported [2] since both of the shear structures (single and double shear structure) are the consequence of the shears mechanism.

It is noteworthy that the configurations of the AMR bands, in the Pd, Cd, and Eu nuclei, observed until today have different orbitals for valence protons and neutrons. However until today, the AMR bands are yet not explored in Sm nuclei though single shears structures are observed in ^{141,142,143}Sm nuclei. Present work narrates a quest of such an AMR band originating from the valence protons and neutrons in the same orbital in ^{141}Sm. Previous work on ^{141}Sm by M. A. Cardona *et al.* established a quadrupole band-structure above the 27/2, 3580-keV excited state [3]. The present investigation is primarily aimed at observation of the AMR bands in the ^{141}Sm nucleus and confirmation of its characteristics through the deduced B(E2) values from the lifetime measurements and theoretical calculations within the framework of the semiclassical particles-plus-rotor model (SPRM).

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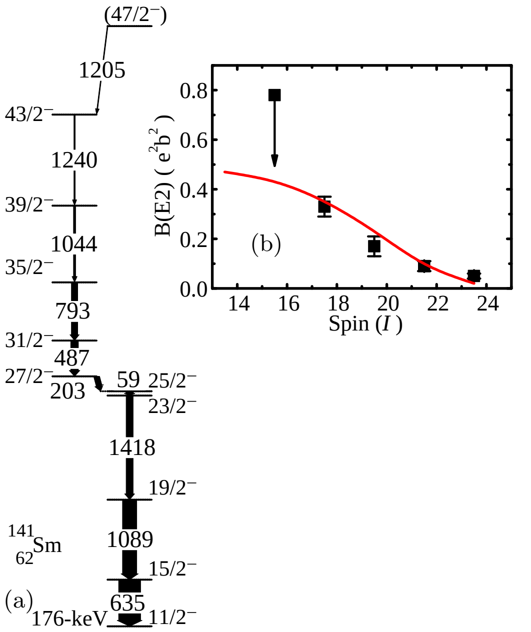

FIG. 1: (a) Level structure of ^{141}Sm obtained from the present experiment. (b) experimental B(E2) values (solid black squares) against spin along with the theoretical calculations within the framework of the SPRM model (red solid line).

Results and Discussions

High-spin states of ^{141}Sm were populated using ^{116}Cd(^{30}Si,5n) reaction at E_{lab} = 149 MeV. The target was 2.4 mg/cm^2 ^{116}Cd (99% enriched) on a 14.5 mg/cm^2 thick lead backing. The de-exciting γ-ray transitions were detected by the Indian National Gamma Array (INGA) which was consisted of seventeen Compton-suppressed clover detectors at the time of experiment [4].

The structure of interest obtained from the present work is shown in Fig. 1(a). Level lifetimes of the states have been determined by analyzing the Doppler-broadened lineshape of the γ-rays using the Doppler Shift Attenuation Method (DSAM) [5]. The uncertainties on the lifetimes, derived from the χ^2-minimization analysis, do not include the systematic contribution of the stopping powers from the SRIM database that was expected to be $\sim$ 10%.

The measured B(E2) values show decreasing trend with spin which is a characteristic signature of the AMR band (Fig. 1(b)). The ratio $J^{(2)}/B(E2)$ increases sharply along the band. Thus it may be concluded that the AMR band exists in ^{141}Sm. In order to explore the underlying structure of the AMR band in ^{141}Sm, an analysis is carried out using the SPRM model [6] based on the configuration $\pi h^2_{11/2} \otimes \nu h^{-3}_{11/2}$. This calculation well reproduce the experimental B(E2) rates as shown in Fig. 1(b).

Therefore, the theoretical calculations within the SPRM model support the interpretation of the band in the ^{141}Sm nucleus being associated with the AMR phenomenon. This is the first observation of this phenomenon in the $Z = 62$, Sm nuclei.

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