Shape coexistence picture in ^{152}Sm: Observation of $K^\pi = 0^+_4$, 0^+_5 and 2^-_1 bands

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Introduction

Until very recently, shape co-existence was limited to connection between spherical and quadrupole deformed shapes [1, 2]. In few recent works around N = 90, it is observed that Sm (N = 88, 90) and its neighbor Gd (N = 88) display coexistence not only of quadrupole shapes but also that among two different degrees of deformation. In these nuclei, significant overlap between bands with quadrupole and octupole shapes have been found [3, 4].

Four excited 0^+ levels are known in ^{152}Sm [5, 6]. However, no excited quadrupole bands are known to be built on the 0^+_4 and 0^+_5 levels. Neither their connection is known to the yrast octupole band. It is important to study the band structures developed on the excited 0^+ levels to understand their coexistence with octupole shapes.

In the present work, we report the excited levels in ^{152}Sm developed on the $K^\pi = 0^-$ octupole band. In total three new band structures have been proposed among which, two even spin positive parity sequences are placed on the 0^+_4 and 0^+_5 levels of this nucleus. The third set of even spin negative parity levels forms a band similar to an higher lying $K^\pi = 2^-_1$ octupole excitation. The structural properties of these proposed band structures have been studied to understand their shapes and their co-existence with the $K^\pi = 0^-$ octupole band. A very preliminary account of this observation was also reported earlier [7].

Experimental Details

The experiment was performed with 26 MeV α beam delivered from K 130 cyclotron at VECC, Kolkata. Enriched ^{150}Nd target was used and the prompt γ transitions from excited ^{152}Sm were detected with an array of twelve Clover HPGe detectors. The details of setup, data acquisition and analysis

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can be found in Ref. [8].

Results and Discussions

The newly found excited levels form well defined structures following E ∼ I(I+1) criteria as shown in Fig. 1. These levels decay most strongly to the octupole band having weak or no connection to the ground band, β band and γ band of the nucleus, except for few low lying levels.

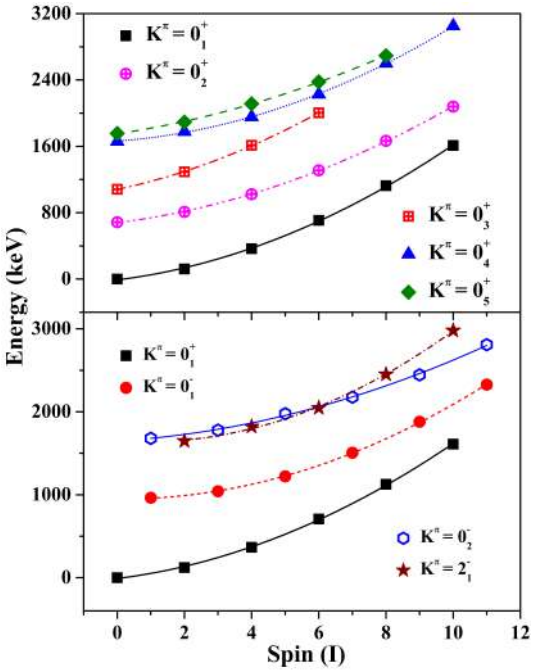

FIG. 1: The excitation energy vs spin has been plotted for the newly observed bands developed on the $K^\pi = 0^-$ octupole band. See text for details.

Negative parity even spin levels show parallel trajectories to that of the lowest odd spin $K^\pi = 0^-$ octupole band in ^{152}Sm and is interpreted as another higher lying octupole, $K^\pi = 2^-$ structure. The M1 decays to the $K^\pi = 0_1^-$ octupole band indicates the excitation of a neutron pair to the unique parity $i_{13/2}$ orbital retaining the underlying octupole correlation.

Energy ratios were studied for the 0_4^+ and 0_5^+ bands and compared with the lower lying 0^+ bands in ^{152}Sm (Fig. 2). It is apparent that the level structure proposed on 0_4^+ and 0_5^+ level follows the X(5) symmetry criteria of ^{152}Sm [9].

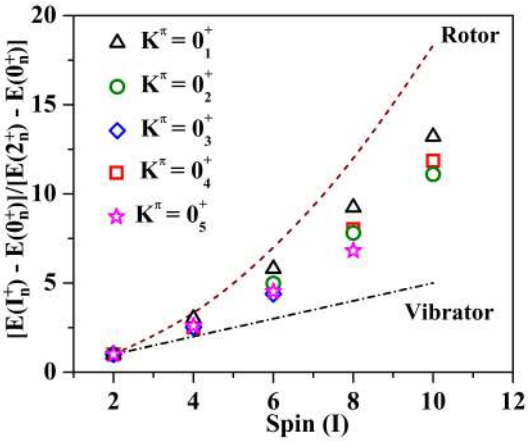

FIG. 2: The characteristic energy ratios are plotted as a function of spin for the excited 0^+ sequences proposed in the present work along with the known ones. See text for details.

The present work confirms the coexistence of two different octupole shapes and those with two different degrees of deformation ($\lambda = 2$ *and* 3) in N = 90 Sm, where higher lying quadrupole vibrations are built on the lowest octupole excitation in the nucleus.

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