New scenario of shape co-existence in ^{152}Sm

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Introduction

The structure of ^{152}Sm has always intrigued scientists because of its complex behaviour in shape degree of freedom. Nuclear structure studies in N=90 shape transitional region have always been interesting since it exhibits exotic phenomenon like quantum shape phase transition (QPT) and shape co-existence.

The nucleus ^{152}Sm has been characterized by a variety of low-energy collective modes, mainly as rotations, β vibrations and γ vibrations. The N = 90 nuclei in Sm-Gd region are also very well known for the observation of quantum shape phase transition from spherical (vibrator) to well deformed (rotor) [1]. It has already been established that these nuclei, especially ^{150}Nd, ^{152}Sm & ^{154}Gd, show signatures of shape coexistence, with excited 'spherical' structures coexisting with more deformed ground states. ^{150}Nd and ^{152}Sm are actually considered as the best empirical example known today of X(5) symmetry . Realistic mean-field calculations with group theoretical models also suggest that ^{152}Sm could be a suitable candidate for tetrahedral deformation [2].

Octupole correlation has been observed in β vibrational band in ^{150}Sm [3] and stable octupole band is seen to be developed on be β vibrational structure in ^{152}Sm [4]. With the motivation of exploring the mixing and co-existence of two different degrees of shapes, the spectroscopy of N = 90 ^{152}Sm was performed [5]. The present work reports an unique feature of shape coexistence found for the first time in N = 90 Sm nucleus.

Experiment

The excited states of ^{152}Sm have been populated using fusion evaporation reaction. Out of few possible stable beam-target combinations, the ^{150}Nd (α, 2nγ) reaction was used. The α-beam was delivered at 40 MeV from K-130 cyclotron facility at VECC, Kolkata. A 10 mg/cm^2 thick enriched ^{150}Nd target was prepared on a Mylar backing. The decaying γ-rays from the excited states were detected using multi-detector array comprising of twelve Compton suppressed clover [125°(3), 90°(6), 40°(3)] HPGe detectors. The data were recorded in list mode using PIXIE-16 digitizers. The raw data were sorted using the program IUCPIX [6] to generate different symmetric and asymmetric γ–γ matrix, triple γ cube which were subsequently analyzed using the program INGASORT [7] and RADWARE [8].

Analysis and Results

Two new band structures were observed to be developed on $K^{\pi} = 1^-$ octupole band in ^{152}Sm at much higher excitation compared to the β and γ vibrational bands in this nucleus. The new level structure is shown in Figure 1. The gamma rays were placed based on the analysis of γ–γ matrix and triple γ cubes as shown in Figure 2.

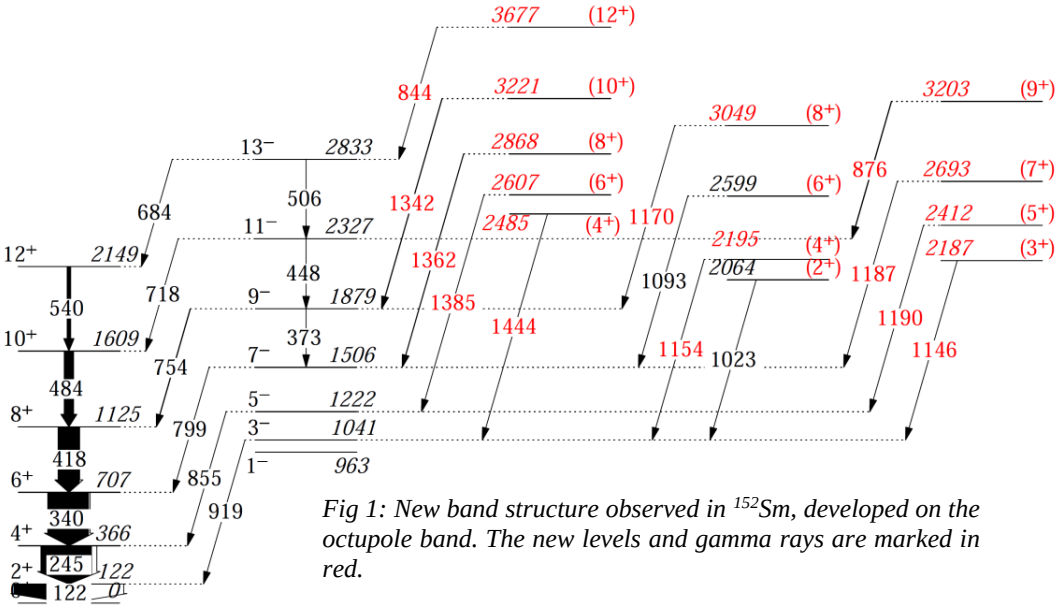

Fig 1: New band structure observed in ^{152}Sm, developed on the octupole band. The new levels and gamma rays are marked in red.

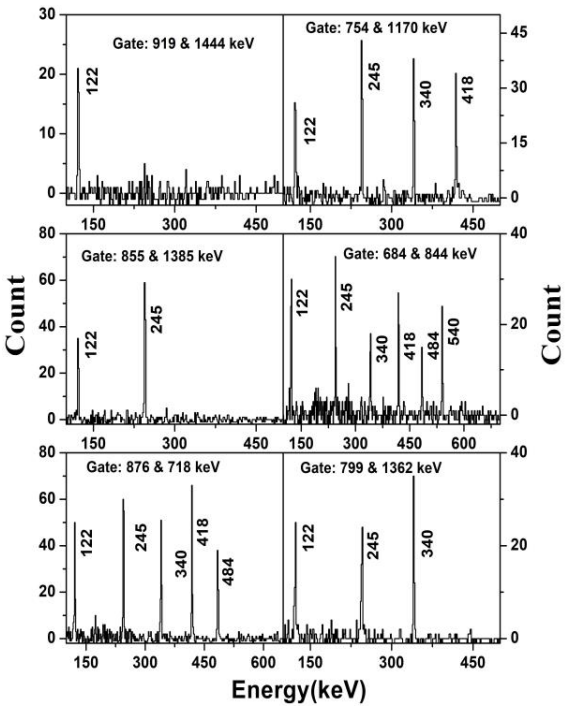

Fig. 2: The gated projections from triple gamma cube, relevant to the new levels placed in ^{152}Sm.

The spin – parity assignments have been made based on the DCO and IPDCO analysis and it is found that the new structures resembles rotational structure developed on the negative parity levels of the octupole band.

Summary

The new band structure developed on the octupole band could be correlated with the similar mixing of β vibrational band with octupole structure in ^{150}Sm [3]. Accordingly, the newly observed positive parity sequences represents a vibrational structures based on the lowest $K^{\pi} = 1^{-}$ sequence and represents a new kind of phenomenon in shape co-existence in ^{152}Sm.

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