Rotational particle coupling in ^{134}Cs

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Introduction

The light mass odd-odd transitional nuclei in the A ~ 130 region exhibit a variety of features depicting nuclear collectivity that originates due to interplay between deformation driving high-j proton and neutron orbits. Band structures have been systematically observed in several nuclei in this mass region [1], arising primarily due to $\pi h_{11/2} \otimes \nu h_{11/2}$ configuration. The Particle Rotor Model (PRM) [2] has been successfully employed to explain the observed features of those bands in which the two odd quasi-particles are coupled to the underlying even-even core, described by a Nilsson Hamiltonian. The position of Fermi levels of protons and neutrons in these nuclei results in semi-decoupled bands, characterized by small staggering, which is dependent on the γ deformation parameter of the equilibrium shape. The shape of these bands and the associated signature splitting reveals information regarding the competition among the shape driving orbits as one moves towards the N = 82 shell closure. Earlier, Datta Pramanik *et al.* [3] have predicted shape change from prolate to oblate for the $\pi h_{11/2} \otimes \nu h_{11/2}$ band at N = 75 in odd-odd La nuclei (Z = 57) using a particle-rotor coupling model (PRM). Similar observation and interpretation for the shape transition has been reported for the neighboring Z = 59, 61 nuclei as well [4]. The bands in the N =77 candidates of La[5] and Cs[6] has been established to be the possible chiral partners, whereas, in N =79 La isotope the band is of oblate deformation [1]. Until recently, the experimental data on band structures in Cs nuclei (Z =55) were rather incomplete. Very recently, band structures have been confirmed in N =79 ^{134}Cs nucleus by our group, using two different production routes and employing the high spin gamma spectroscopy technique [7]. In this work, we report the results on the characterization of one of the bands as a candidate $\pi h_{11/2} \otimes \nu h_{11/2}$ band by a detailed PRM calculation.

Calculation

The calculation has been performed by using the deformation parameter, ε_2, and the intrinsic quadrupole moment, Q_0, of the neighboring even-even ^{132}Xe core which has been taken from the existing experimental data [8]. The μ, κ values for the deformed modified oscillator potential in this mass region for N=5 shell were taken from literature. The pairing gaps δ_p, δ_n and the Fermi levels λ_p, λ_n were calculated by solving the inverse gap equation. The effective charges for neutron and proton e_p^{eff}, e_n^{eff} have been taken as 1.0, 1.0. The variation of these values rarely affects the transition rates as the major part is contributed by the collective part. The final parameters used in this calculation are tabulated in table I.

Table 1: Parameters used for the calculation

Parameter	Value	Parameter	value
Core	^{132}Xe	λ(neutron)	47.33 MeV
ε_2	0.14	δ (proton)	0.35 MeV
Q_0, g_s	2.15, 2.8	δ(neutron)	1.49 MeV
μ(proton) μ(neutron)	0.5 0.35	Variable Moment of Inertia C	2.3
κ(proton) κ(neutron)	0.0637 0.0637	Residual interaction strength G	0.6
λ(proton)	40.61MeV	e_p^{eff}, e_n^{eff}	1.0, 1.0

Results

The calculation has been successfully able to interpret the positive parity band developed on a 9^+, 1394 keV state as a candidate for the

$\pi h_{11/2}\otimes\nu h_{11/2}$ structure. The calculation with a prolate deformation of 0.14 fits the experimental data, both for the excitation energy and transition probability. The theoretical results have been compared with the experimental data in Fig. 1-4. The experimental branching ratio has been plotted by taking the upper limit of the intensity of the unobserved crossover E2 transitions.

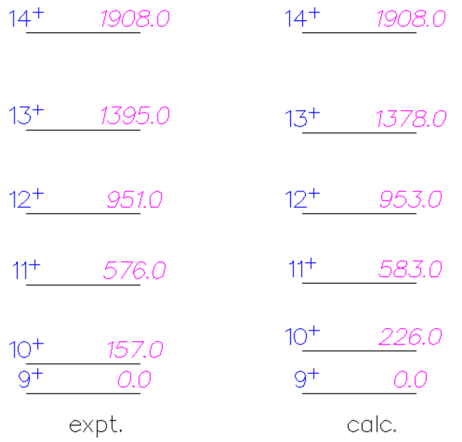

Fig. 1 Excitation energy vs spin for the $\pi h_{11/2}\otimes\nu h_{11/2}$ band in ^{134}Cs. Level energies are given w.r.t the band head.

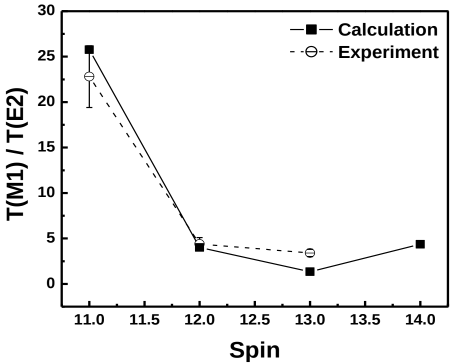

Fig. 2 Branching ratio vs spin plot

Discussion

The excitation energy and electromagnetic properties of one of the positive parity band have been excellently reproduced in the framework of particle rotor coupling calculations, establishing the candidate of $\pi h_{11/2}\otimes\nu h_{11/2}$ structure in N=79 Cs nucleus. A prolate deformation of ε_2 = 0.14 has been interpreted for the rotational even even core and the calculation has been able to infer the observed signature splitting both in energy and transition probability. From the present work, the systematics of $\pi h_{11/2}\otimes\nu h_{11/2}$ structure in N =79 isotones has been extended up to Z =55 nucleus.

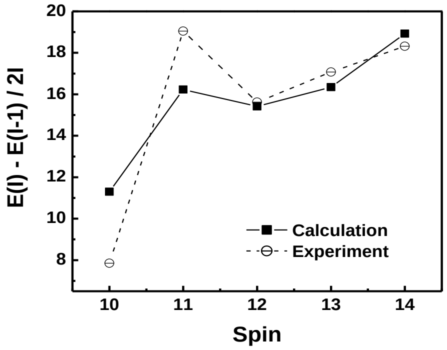

Fig. 3 Prediction of calculation for the observed signature splitting in the excitation energy.

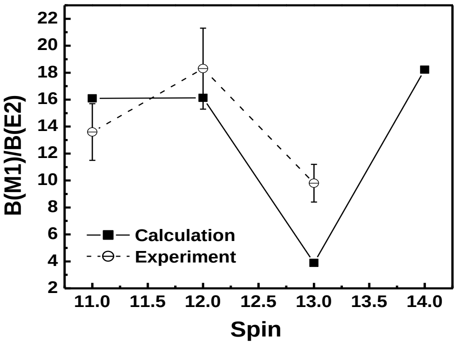

Fig. 4 Prediction of the calculation for the signature splitting in the transition probability.

Acknowledgement

T. B. gratefully acknowledges the useful suggestions obtained from Dr. S. K. Basu at different stages of this work.

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