TPSM Study of even-even $^{144\text{-}148}$Ce Isotopes

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Introduction

Neutron rich nuclei lying in the vicinity of doubly magic core ^{132}Sn are becoming one of the interesting research areas to study the nuclear structure. One such example is Cerium. The neutron rich isotopes of cerium provide information about the transition region from spherical to deformed nuclei. From earlier studies it has been observed that in cerium isotopes the nuclear deformation begins to occur between N = 86 and N = 88. Also, the shape transition in the even Ce isotopes from being spherical nuclei to deformed has been observed.

The Skyrme-Hartree-Fock and Bardeen-Cooper-Schrieffer (BCS) approaches(microscopic), and an algebraic collective model (macroscopic approach) were recently used to investigate cerium isotopes, which suggested that the phase transition from spherical to deformed occurs between ^{146}Ce and ^{148}Ce [1]. It has also been found that ^{142}Ce with two valence neutrons exhibits a vibrational spectrum, but with the addition of more neutrons, ^{148}Ce begins to exhibit rotational behavior. [2].

Theory of Applied Model

The aim of this work is to study the nuclear structure of neutron rich isotopes of cerium with mass number 144, 146 and 148 by applying Triaxial Projected Shell Model (TPSM) technique. This model has proven to be very successful in explaining the structure of various nuclear isotopic chains. In TPSM approach the intrinsic basis are triaxially deformed which are constructed using triaxial Nilsson potential. This basis set consists of 0-qp(quasiparticle) state, two proton (pp) qp, two neutron (nn) qp, two proton and two neutron (2p2n) qp configurations. The good angular momentum states are subsequently obtained by applying three-dimensional angular momentum projection technique. Finally, in the projected basis the configuration mixing is carried out and the Hamiltonian gets diagonalized. The Hamiltonian used is given by [3],

$$\hat{H} = \hat{H}_0 - \frac{\chi}{2}\sum_{\mu}\hat{Q}^{\dagger}_{\mu}\hat{Q}_{\mu} - G_M\hat{P}^{\dagger}\hat{P} - G_Q\sum_{\mu}\hat{P}^{\dagger}_{\mu}\hat{P}_{\mu}$$

where H_0 is the single-particle spherical Hamiltonian, G_M is the monopole pairing strength and G_Q is the quadrupole pairing strength.

For the even-even system, triaxial quasiparticle configuration is composed of different K states which are projected along the symmetry axis, while the vacuum configuration comprises of K = 0,2, 4... states.

Results and Discussions

The yrast energies obtained after the diagonalization of the Hamiltonian are shown in Fig. 1. This is the lowest energy band that we get after configuration mixing of various basis states. The figure shows that the calculated results are in good agreement with the experimental values

In Fig. 2, the backbending plots are obtained for ^{144}Ce, ^{146}Ce and ^{148}Ce isotopes. The backbending (S-shaped) curves signify the increase in the moment of inertia which results in sudden decrease of rotational frequency. For ^{144}Ce, by TPSM results the backbending is observed at 6ħ and this is in accordance with the available experimental results. Further, for ^{146}Ce TPSM predicts the backbends at 8ħ and 18ħ but there are no bends obtained in the plots of experimental data. Also, for^{148}Ce, TPSM plots show the bends at 8ħ and 20ħ whereas experimentally the backbend is only at 20ħ.

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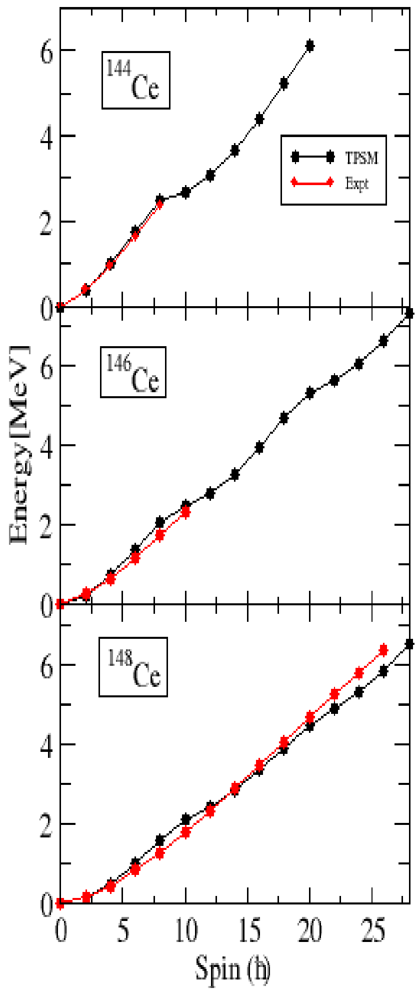

Fig. 1 Comparison of theoretically calculated (TPSM) and experimental yrast band energies for $^{144-148}$Ce isotopes

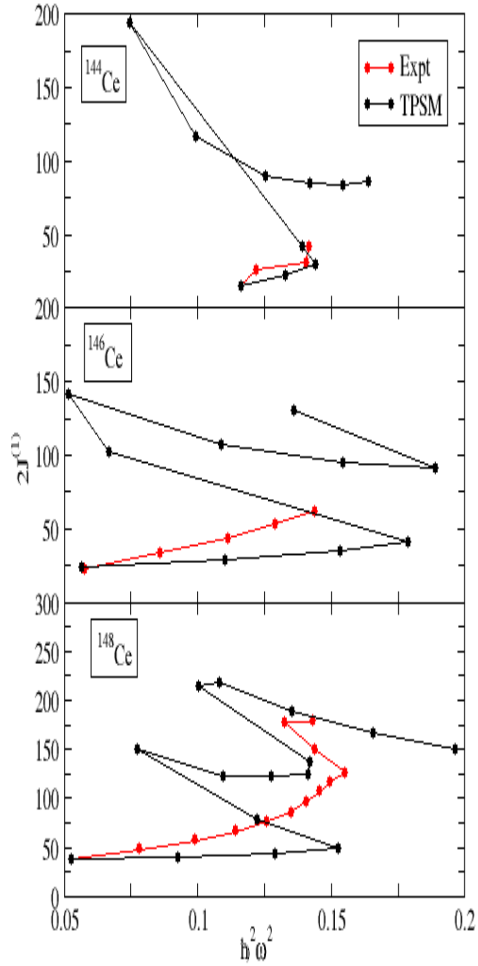

Fig. 2 Backbending plots for $^{144\text{-}148}$Ce in which twice of the kinematic moment of inertia i.e., $2J^{(1)}(\hbar^2\mathrm{MeV}^{-1})$ is plotted against square of rotational frequency $(\hbar\omega)^2$

Summary

The yrast band and the backbending plots are obtained using the TPSM techmnique for the even-even $^{144\text{-}148}$Ce isotopes. The results are compared with the available experimental data and it has been observed that they are in agreement with each other.

References

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