Study of chiral rotations in ^{126}Cs nucleus

*G. H. Bhat[1], J. A. Sheikh[1,2], R. Palit[3], and P. A. Ganai[4,1],
[1] *Department of Physics, University of Kashmir, Srinagar,190 006, India*
[2] *Department of Physics and Astronomy, University of Tennessee, Knoxville, TN 37996, USA*
[3] *Department of Nuclear and Atomic Physics, Tata Institute of Fundamental Research, Colaba, Mumbai, 400 005,India*
[4] *Department of Physics, National Institute of Technology, Srinagar, 190 006, India**

The classification of band structures from symmetry considerations has played a central role in our understanding of nuclear structure physics. Most of the rotational nuclei are axially symmetric with conserved angular-momentum projection along the symmetry axis. This symmetry has allowed to classify a multitude of rotational bands using Nilsson scheme and has been instrumental to unravel the intrinsic structures of deformed nuclei [1].

Recently, the observation of chiral symmetry in some odd-odd nuclei in $A \simeq 130$ region is considered a manifestation of γ-degree of freedom [2]. It has been shown that rotational motion of a triaxial deformed mean-field can also exhibit chiral symmetry with angular-momenta of valence protons, valence neutrons and the triaxial core directed along the three principle axes of the triaxial field. For substantial triaxiality, the orientation of the rotational axis determines the geometry of the system. For well deformed nuclei, the rotational bands are built through rotation about an axis that is perpendicular to the symmetry axis. While the tilted bands are obtained by rotation about an axis which is tilted with respect to the principle axis and is rotation is still planaar. However, the chiral bands are obtained by rotating about an axis which does not lie in a plane and is therefore, known as aplanar rotation. The three mutually perpendicular angular momenta, formed by short, intermediate and long semi-axis, can be arranged to form two systems with opposite chirality, namely left and right handness. They are transformed into each other by the chiral operator that combines time-reversal and spatial rotation of angle π. Thus planer geometry is "achiral" and aplaner geometry is "chiral" [3]. possible fingerprints. Besides, energy spectra the life-time measurements play a centre role for identification of the chiral bands. For the ideal chiral critria, the intra-band B(E2) transitions at higher angular momenta should increase with increase in spin while as inter-band B(E2) transitions should decrease with increase in spin. This is due to the reason that chiral doublet bands have strong M1 and E2 intra-band transition but weak inter-band transitions [4]. It has been found in ^{128}Cs and ^{135}Nd isotopes that B(M1) staggering is associated with the characteristics of nuclear chirality [2]. Like the energy spectra, the electromagnetic transitions are very sensitive to the deformation. The dependence of the electromagnetic transitions on triaxilaity have been investigated in Particle Rotor Model (PRM) [3]. Since the original work of Frauendof and Meng [3], a lot of the experimental [4] as well as theoretical effort [5], has been devoted to investigate the nuclear chiral symmetry. Till date, candidate chiral doublet bands have been proposed in a number of odd-odd, odd-A and even-even nuclei in the A ∼ 100, 130, 190 mass regions. Recent development of triaxial projected shell model (TPSM) has been applied to study the detailed investigation of chiral bands in ^{128}Cs [6].

The basis space of the TPSM approach for odd-odd nuclei, developed in the present work, is composed of one-neutron and one-proton

*Electronic address: gwhr.bhat@gmail.com

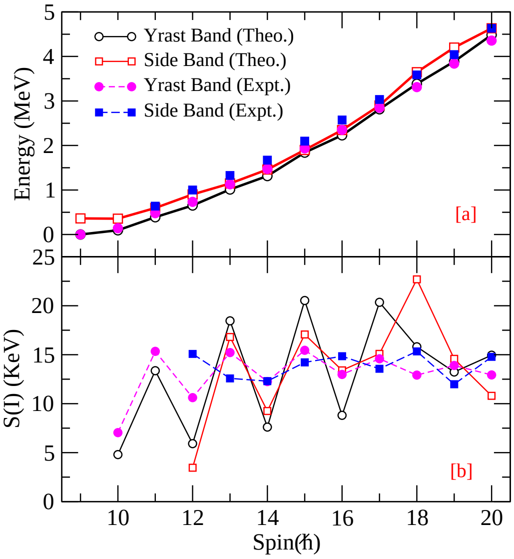

FIG. 1: Comparison of the TPSM energies after configuration mixing with the available experimental data for the yrast and side bands of the studied ^{128}Cs nucleus in pannel [a]. Calculated staggering parameter $S(I) = [E(I) - E(I-1)]/2I$ is plotted along with the measured values in pannel [b].

quasiparticle configurations:

$$\{|\phi_\kappa = {a_\nu}^\dagger {a_\pi}^\dagger |0\}. \tag{1}$$

The above basis space is adequate to describe the ground-state configuration of odd-odd nuclei. The Hamiltonian used in the present work is

$$\hat{H} = \hat{H}_0 - \frac{1}{2}\chi \sum_\mu \hat{Q}^\dagger_\mu \hat{Q}_\mu - G_M \hat{P}^\dagger \hat{P} - G_Q \sum_\mu \hat{P}^\dagger_\mu \hat{P}_\mu, \tag{2}$$

with the last term being the quadrupole-pairing force. The monopole-pairing force constants G_M used in the calculations are $G_M^\nu = [20.12 - 13.13\frac{N-Z}{A}]A^{-1}, G_M^\pi = 20.12A^{-1}$. Finally, $G_Q = 0.16\ G_M$.

In the present study, a detailed investigation of the chiral band structures observed in ^{126}Cs has been performed using the TPSM approach. In the calculations, the quadrupole deformation $\epsilon = 0.260$ and triaxial deformation $\epsilon' = 0.150$ is used to achieve better agreement with the experimental energy spectra. The axial deformation value has been adopted from particle-rotor model and other studies and the chosen value of non-axial deformation corresponds to $\gamma \sim 30^o$. In the second stage of the calculations, projected bands obtained above are used to diagonalize the shell model Hamiltonian, Eq. (2). Bands after diagonalization have dominant compenents from several angular-momentum projected basis configurations and the lowest two bands obtained are displayed in the top panel of Fig. 1 along with the corresponding experimental chiral bands known for ^{126}Cs. It is evident from Fig. 1(a) that TPSM calculations reproduce the known experimental energies of the chiral bands quite well. It is noted from the figure that the two bands are very close to each other i.e., degenrate, which forms the essential bench mark for chiral rotation. In Fig. 1(b), the staggering parameter, $S(I) = [E(I) - E(I-1)]/2I$ for the two calculated chiral bands are plotted and compared with the corresponding experimental numbers. It is noted that for low angular-momenta, the calculated quantity deviates considerably from the experimental values, but for higher angular-momenta a reasonable agreement is obtained. Particle-rotor model results depict a similar discrepancy at lower angular-momenta (in Fig. 1 of Ref. [7]).

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