High spin structure of ^{80}Kr using Triaxial Projected Shell Model

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Introduction

Study of A∼80 nuclei is interesting because of various shape evolutions and shape coexistences[1]. High spin structure in these nuclei is dominated by the $g_{9/2}$ orbitals and level density is smaller compared to the rare-earth nuclei. This leads to significant variations in nuclear configurations and quasiparticle alignment when going from one nucleus to another [2-4]. Thus, unlike the rare earths which have stable deformations, nuclei in mass∼80 region show pronounced structure changes. Again in these medium mass proton rich nuclei, neutrons and protons occupy the same single particle orbits. So, the pair alignments of neutrons and protons compete with each other as the nucleus rotates and under certain conditions they may align simultaneously.

The study of neutron-deficient Kr isotopes in the mass range A=70-80 which is in the transitional region is quite interesting because the ground states of these nuclei exhibit a rich variety of shapes as a function of neutron number [5, 6]. The purpose of present work is to carry out a study of the yrast-band and gamma-band structure for the ^{80}Kr nucleus using Triaxial Projected Shell Model(TPSM) approach [7].

Outline Of The Model

The extended TPSM quasi-particle(qp) basis consists of angular momentum projected qp vacuum(0-qp) state, two -proton(2p), two neutron(2n) and 4-qp state i.e.,

$$\{ \quad \hat{P}^I_{MK} \mid \phi\rangle; \hat{P}^I_{MK}\ a^\dagger_{p1} a^\dagger_{p2} \mid \phi\rangle; \hat{P}^I_{MK}\ a^\dagger_{n1} a^\dagger_{n2} \mid \phi\rangle; \hat{P}^I_{MK} a^\dagger_{p1} a^\dagger_{p2} a^\dagger_{n1} a^\dagger_{n2} \mid \phi\rangle\} \quad (1)$$

In Triaxial Projected Shell model calculations, the pairing plus quadrupole-qudrupole Hamiltonian is used including quadrupole-pairing term:

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

The Triaxially deformed single particle basis is obtained from the Nilsson model. The corresponding triaxial Nilsson mean-field Hamiltonian is given by,

$$\hat{H}_N = \hat{H}_0 - \frac{2}{3}\hbar\omega\{\epsilon\hat{Q}_0 + \epsilon' \frac{\hat{Q}_{+2} + \hat{Q}_{-2}}{\sqrt{2}}\} \quad (3)$$

Where ϵ and ϵ' specify the axial and triaxial deformation respectively. ϵ and ϵ' are related to conventional triaxiality parameter as $\gamma = tan^{-1}(\epsilon'/\epsilon)$ [8]. In (3),$\hat{H}_0$ is the spherical single particle Hamiltonian containing a proper spin-orbit force. The monopole pairing strength G_M is of the standard form $G_M = [G_1 - G_2(N-Z)/A]A^{-1}$ for neutrons and $G_M = G_1/A$ for protons.

In the present calculation, we have taken $G_1 = 20.25$ and $G_2 = 16.20$ which is appropriate for the single-particle space employed in the model, where three major shells are used for each type of nucleons (N=2,3,4 for both neutrons and protons). The quadrupole pairing strength G_Q is proportional to G_M, and the proportionality constant is 0.20. This interaction strength is consistent with those used earlier for the same mass region[4, 9].

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Results and Discussion

TPSM calculations have been performed for ^{80}Kr. We have employed $\epsilon = 0.29$ and $\epsilon^{'} = 0.107$ in the Nilsson potential to generate the deformed basis for ^{80}Kr. The value of ϵ and $\epsilon^{'}$ has been chosen so that the behaviour of the yrast band and γ band is properly described. The results obtained for yrast state band and γ band are compared with experimental values which is represented in Fig.1. For the yrast band, theoretical results are in good agreement upto spin I=16 available experimentally and is predicted upto spin I=22.

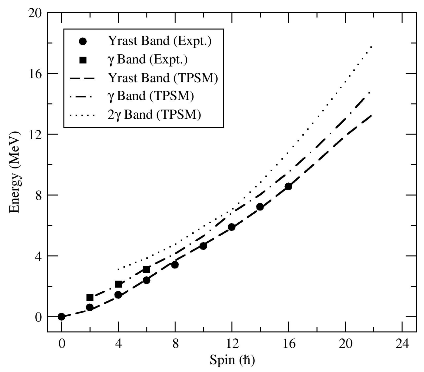

FIG. 1: Comparison of the calculated Yrast band energies with experimental data for ^{80}Kr. Experimental data taken from ref. [10].

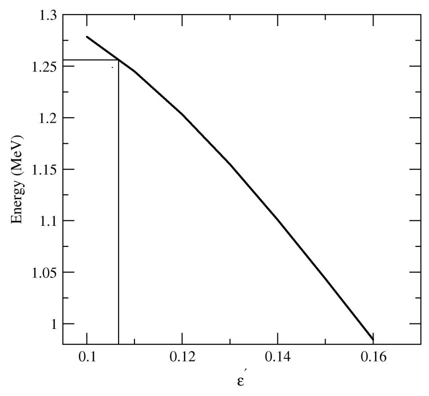

FIG. 2: Variation of γ band head energies with triaxial deformation parameter $\epsilon^{'}$ for ^{80}Kr.

The band head energies of γ band is plotted with triaxial deformation parameter $\epsilon^{'}$ in Fig. 2. The experimental γ band is well reproduced with $\epsilon^{'} = 0.107$. Experimental values are available upto spin I=3. However, with TPSM calculations it is produced upto spin I=22 with a difference of 0.011 MeV between experimental and theoretical band head energies. The theoretical 2γ band is also predicted with excitation energy of 3.1127 MeV which may be populated in future experiments.

The comparison of results shows that the calculated band spectra using TPSM are in good agreement with the experimental ones and prolate shape is predicted at high spins.

Acknowledgement

One of the authors, Dr. Z. Naik would like to acknowledge DST-FIST, India and Ms. N. Behera acknowledges Department of science and technology(DST), Odisha for the financial support.

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