Study of band structure in $^{78,80}Sr$ using Triaxial Projected Shell Model

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Introduction

Study of the A∼80 nuclei is much interesting due to the presence of abundant nuclear structure phenomena and these nuclei are usually characterised by shape co-existence [1]. Unlike in the rare-earth region where nuclei have stable deformation, the structure of the proton-rich mass-80 nuclei shows significant variations among the neighbouring nuclei when going from one nucleus to another. This is because of the much smaller shell model configuration space in this mass region than for the rare-earth nuclei. Again in these 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 purpose of present work is to carry out a systematic study of the yrast-band and gamma-band structure for the even-even $^{78-80}Sr$ nuclei using Triaxial Projected Shell Model(TPSM) approach [2]. These nuclei were chosen because ^{78}Sr has well developed side band(unassigned configuration) and ^{80}Sr has well developed γ band observed experimentally.

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 $\epsilon^{'}$ specify the axial and triaxial deformation respectively. ϵ and $\epsilon^{'}$ are related to conventional triaxiality parameter as $\gamma = tan^{-1}(\epsilon^{'}/\epsilon)$ [3]. 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 0.24 for ^{78}Sr

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and 0.16 for ^{80}Sr. These interaction strengths are consistent with those used earlier for the same mass region except G_Q=0.24 for ^{78}Sr [4, 5].

Results and Discussion

TPSM calculations have been performed for ^{78}Sr and ^{80}Sr. We have employed ϵ = 0.360 and $\epsilon^{'}$ = 0.160 for ^{78}Sr and ϵ = 0.340 and $\epsilon^{'}$ = 0.157 for ^{80}Sr in the Nilsson potential to generate the deformed basis. The results obtained for yrast state band and γ band are compared with experimental values which is represented in figures-1,2 respectively for ^{78}Sr and ^{80}Sr.

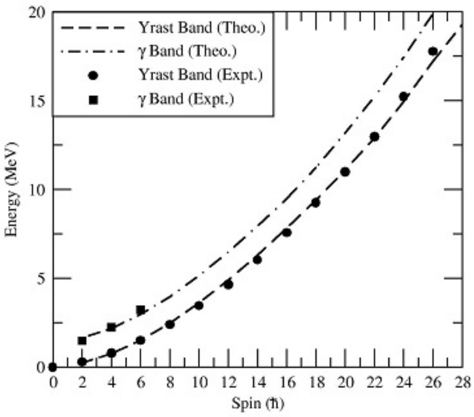

FIG. 1: Comparison of the calculated spectra with experimental data for ^{78}Sr. Experimental data taken from ref. [6].

From Fig.-1, it is noted that the energy states of the yrast band and K=2 γ band are well reproduced for ^{78}Sr. For the yrast state band, the energy difference between experimental and calculated values at highest spin 26^+ is 0.589 Mev and for the γ band the difference between experimental and theoretical band head energies is 0.143 Mev and for the highest observed spin 6^+ it is 0.299 Mev.

Fig.-2 shows the comparison between experimental and calculated band spectra for ^{80}Sr. For the yrast state band the energy difference between observed and calculated values at highest available spin 24^+ is 0.265 Mev.

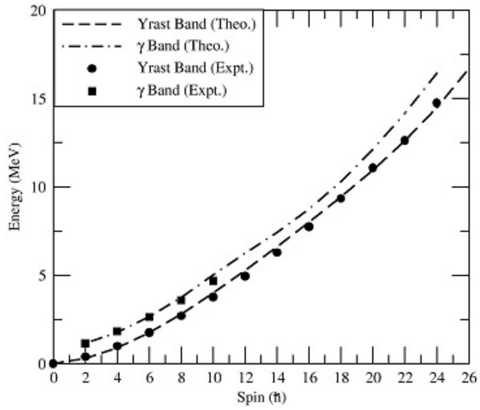

FIG. 2: Comparison of the calculated band energies with experimental data for ^{80}Sr. Experimental data taken from ref. [6].

For the γ band the difference in experimental and calculated band head energies is 0.007 Mev and for highest observed spin 10^+ this difference is 0.32 Mev.

The comparison of results shows that the calculated band spectra using TPSM are resonably in good agreement with the experimental ones.

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