Study Of High Spin State Of ^{50}Ti using DHF Model

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Introduction

Studies of shell structures of neutron rich A~50 are gaining much attention from both the theoretical and experimental point of view. One example of N=32 and/or 34 sub shell closer by changing the single particles orbit in this mass region [1]. A spectroscopic study of the yrast high spin state provides important information on the presence of shell gap, since large jumps in transition energies at high spin values are often assessed as an indicator for excitation that involves breaking of core i.e. state with higher angular momentum are generated from excitation across a shell gap. In yrast level of ^{50}Ti, a large gap in excitation energy between 6^+ and 7^+ states is explained as a one-particles one-hole (1p1h) excitation across the N=28 shell gap and high spin level up to 11^+ are reported [2]. Shell model predict that the N=28 gap persists in neighboring nuclei of ^{50}Ti. Again recently a isomeric state has been reported in ^{49}Ti at 7.076 MeV and is explained as a neutron 1p2h configuration. Two new high spin state has been reported in ^{51}Ti at 4.406 MeV and 5.246 MeV with J^{π} at (15/2-)and (17/2$^-$) respectively [2, 3,4]. To understand rotational band, the properties ground band and K-isomeric band of Titanium nuclei one need a theoretical model, which takes into account the residual interaction among the nucleons and give the proper single particle wave function as well as multi-nucleon configuration for this nuclei.

For this, we have adopted the Deformed Hartree-Fock (DHF) model to get the single particles state and deformed multinucleon configuration [5] and states of good angular momentum are obtained by Angular momentum projection technique.

Outline of the Model

Deformed HF model is a quantum mechanical model to describe nuclear properties. This formalism is a sound technique to obtain mean field from two body nuclear interaction to construct appropriate ground state single particle wave function. The theory is based on variational principle. The nuclear Hamiltonian in a given model space consists of single particle term and a term for two body residual interaction among active nucleons, given by

$$H = \sum_{jm} \epsilon_j \, a^{\dagger}_{jm}$$

$$+ \sum V\,(j_3 m_3\, j_4 m_4; jm j_2 m_2)\, a^{\dagger}_{j_3\, m_3} a^{\dagger}_{j_4\, m_4} a_{j_2 m_2}$$

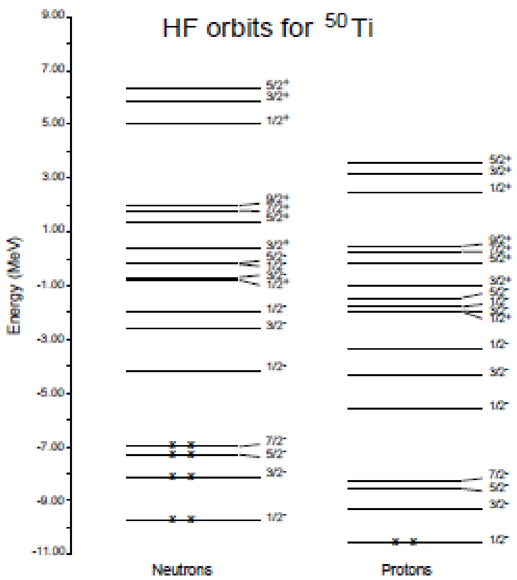

Fig.1 The deformed HF orbit for ^{50}Ti.

A deformed shaped one described by slater determinant of deformed orbit$|\Phi_K\rangle$ is localized in angle and, by the uncertainty Principle is not a state of good angular momentum (J). Thus $|\Phi_K\rangle$ does not have a unique angular momentum (J) and is a superposition of various J states [5].

$$|\Phi_K\rangle = \sum_I C_{IK} |\Psi_{IK}\rangle \quad (2)$$

One need to project out the state of good angular momentum of intrinsic state using the angular momentum projection operator [3, 4].

$$P_K^{IM} = \frac{2I+1}{8\pi^2} \int d\Omega D_{MK}^{I\ *}(\Omega) R(\Omega) \quad (3)$$

Results and Discussion

The deformed HF orbits are calculated with a spherical core of ^{40}Ca with eight active neutron and two active proton above the core. The model space span the proton orbits $1p_{1/2}$, $1p_{3/2}$, $0f_{5/2}$, $1d_{5/2}$, $0f_{7/2}$, $0g_{9/2}$ having energies 2.353, 0, 2.770, 7.775, -4.081, 4.616 MeV and neutron orbits $1p_{1/2}$, $1p_{3/2}$, $0f_{5/2}$, $1d_{5/2}$, $0f_{7/2}$, $0g_{9/2}$ having energies 2.323, 0, 2.306, 8.794, -4.559. 4.381 MeV respectively. We use the surface Delta [5] interaction as the residual interaction among the active nucleons to obtain deformed single particles orbit. The deformed orbits obtained after successful iteration are shown in **Fig.**1 with β=0.17.

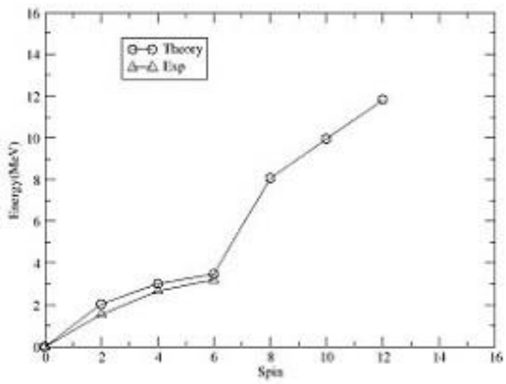

Fig.2 Comparisons of calculated band energies with experimental data for ^{50}Ti (Experimental value taken from Ref. [1,6]).

We use Angular momentum technique to obtain the energy spectra of ground and excited K-band of ^{50}Ti. The spectra of ground band are presented in **Fig.**2. The experimental ground band is fairly well explained in our calculation. Our model predicts the ground state band up to spin 12^+ where experimentally observed up to spin 6^+.

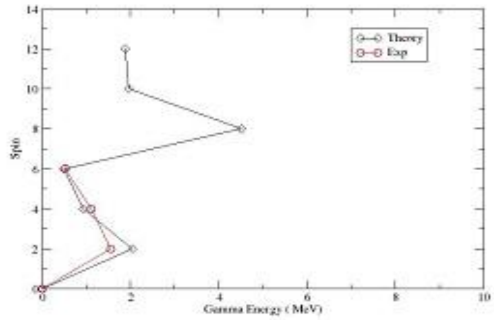

Fig.3 Comparison of theoretical and experimental back band of ^{50}Ti

We have compared Gamma energy versus spin in Fig.3. Our calculation gives two back bending one at spin 2^+ and other at spin 8^+.

Also we have made calculation for several excited configuration of 0qp, 2qp and 4qp nature for future reference. B(E2) and B(M1) values of these bands are also calculated.

Conclusion

We have tried to explain theoretically the different high spin state, rotational band and K-isomeric state of neighboring Ti nuclei using DHF and AMP microscopic Model. We have also calculated their energy spectra electromagnetic properties for future references.

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