Structure of ^{150}Nd in Deformed Hartree Fock (DHF) Model

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Introduction

One of current problems of interest in context with nuclear structure is the calculation of neutrinoless double beta decay nuclear matrix elements (NME). From the nuclear physics point of view, the study of two neutrino double beta decay can help us to test the validity of different nuclear models employed for nuclear structure calculation of NME. The basic philosophy of nuclear many body theory is to exlplain all the observed nuclear properties. The reliability of a model can be judged from the sucessful explaination of various observed properties of nuclei e.g., transition energy, static quadrupole moments, reduced transition probabilities like BE and BM.

^{150}Nd is one of potential candidates for double beta decay study being carried out at SuperNemo[1] and SNO [2]. Here the Deformed Hartree Fock (DHF) model along with Surface-delta interaction (SDI) has been applied to study the nuclear spectroscopic properties of ^{150}Nd.

Deformed Hartree-Fock Method

We have used the deformed Hartree-Fock and angular momentum projection technique [3, 4] to studied the band structures of ^{150}Nd.

The Hartree-Fock field is assumed to be axially symmetric. The nuclear Hamiltonian consists of single-particle and residual two-body interactions terms. We solve the Hartree-Fock (HF) equations self-consistently and the deformed HF orbits are obtained [3, 4].

Discussion

After choice of ^{132}Sn as an inert core, we choose a suitable model space which consists of one major shell each for protons and neutrons outside the core. We use the proton states $s_{1/2}$, $d_{3/2}$, $d_{5/2}$, $g_{7/2}$, $h_{9/2}$, $h_{11/2}$ having energies 3.654, 3.288, 0.731, 0.0, 7.1, 2.305 MeV and neutron states $p_{1/2}$, $p_{3/2}$, $f_{5/2}$, $f_{7/2}$, $h_{9/2}$, $i_{13/2}$ having energies 4.462, 2.974, 3.432, 0.0, 1.667, 2.963 MeV resectively. The residual two-body interaction in the present case is taken to be the surface delta residual interaction with interaction strength $V_{pp} = V_{np} = V_{nn}$= 0.3 MeV. This is a reasonable interaction which gives the deformation properties in these mass region.

We have considered prolate HF solutions, since these are lower in energy than oblate one. Deformed HF orbits (prolate) of ^{150}Nd are given in the Fig. 1.

Deformed HF orbit is in general a superposition of various j states. An intrinsic state is a Slater determinant of such deformed orbits and is obtained from the HF configuration by appropriate particle-hole arrangement near the proton and neutron Fermi surfaces. The nuclear Hamiltonian is rotationally invariant, here rotational symmetry is restored by angular momentum (J) projection. By angular momentum projection from these intrinsic states the band spectra and other spectroscopic properties (transition rates) can be obtained. The angular momentum projected

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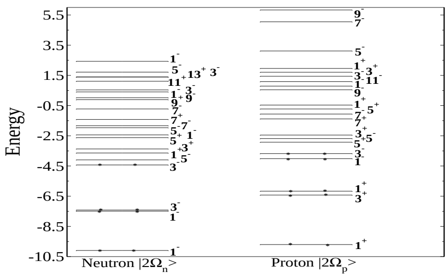

FIG. 1: Deformed HF orbits of ^{150}Nd. The orbits are denoted by $|2m|^{\pi}$

spectra of the various bands with respective experimental spectra are presented in the Fig. 2. For K=0^+ band our theoretical level spacings are matching quit well with the experimental values. The excited K=0^+ band is compared with the experimentally observed β-band and K=2^+ band is compared with γ-band. Both the bands show good agreement with the experimental results.

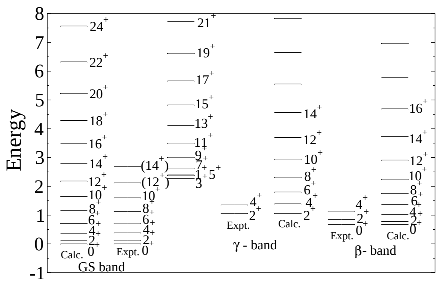

FIG. 2: Band mixing result of positive parity bands of ^{150}Nd.

The transition energy, B(E2) and sectroscopic qudrupole moments are calculated using the band mixing wave function. Effective charges of 1.7e for protons and 0.7e for neutrons are used to calculated B(E2) values.

TABLE I: J→J-2 transition energy (E_T), B(E2;J→J-2), Spectroscopic quadrupole moment (Q_S) for ^{150}Nd. Experimental data are from ref. [5].

K	J_i	E_T [MeV]		B(E2) [e^2b^2]		Q_S [eb]	
		Th.	Expt.	Th.	Expt.	Th.	Expt.
0^+	2^+	0.108	0.130	0.581	0.542	-1.46	-2.0(51)
	4^+	0.245	0.251	0.827	0.820	-1.857	–
	6^+	0.360	0.339	0.905	0.991	-2.04	–
	8^+	0.442	0.410	0.938	–	-2.144	–

Conclusion

Our calculations, based on deformed Hartree-Fock and Angular Momentum Projection from suitable intrinsic states, reproduced the spectra quite well in comparison to the experimental results. B(E2) and B(M1) values of all these bands are calculated. Other electromagnetic properties are also predicted quite well.

This model is presently being used for understanding the structure of ^{150}Pm and ^{150}Sm nuclei so that one can get reliable NME within this framework.

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