Band Structure Study of ^{161}Er Nucleus

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Introduction

Nuclear rotational motion is a remarkable example of correlated single particles in a deformed field generating a collective mode. For odd-mass rotational nuclei the coupling of single-partcle and collective rotational degrees of freedom leads to a rich variety of band structures [1, 2]. The study of high spin states in deformed odd-N nuclei is interesting because of the coupling of odd neutron to the deformed core and the role of large j orbits giving rise to many bands extending to high spins. For finer description of the states in deformed nuclei, such as band-crossing, rotation-alignment and signature effects in the spectra and electromagnetic transitions etc., one needs a many-body description of the system using two-body interaction among nucleons [3, 4]

In the present work, we have studied the multiquasiparticle bands of ^{161}Er at high spins using Deformed Hartree Fock (DHF) and Angular Momentum Projection technique to study the spectra and electromagnetic matrix elements. The calculated results have been compared with available experimental data.

Theoretical Framework

A deformed shape such as one described by slater determinant of deformed orbits $\mid \Phi_K >$ is localized in angle and, by the uncertainty principle, is not a state of good angular momentum (J). Thus $\mid \Phi_K >$ does not have a unique J quantum number and is a superposition of various J states [5–7],

$$\mid \Phi_K >= \sum_I C_{IK} \mid \Psi_{IK} > . \qquad (1)$$

One needs to project out states of good angular momenta from the intrinsic state Φ_K with the Angular Momentum Projection operator,

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

In general two states $\mid \Psi_{K_1}^{JM} >$ and $\mid \Psi_{K_2}^{JM} >$ projected from two intrinsic configurations are not orthogonal to each other even if $\mid \Phi_{K_1} >$ and $\mid \Phi_{K_2} >$ are orthogonal. Thus, whenever necessary, we do band-mixing using the following equation:

$$\sum_{K'} (H_{KK'}^J - E_J N_{KK'}^J) C_{K'}^J = 0. \qquad (3)$$

1. Results and Discussion

The deformed HF orbits are calculated with a spherical core of ^{132}Sn. The model space spans $2s_{1/2}$=3.645, $1d_{3/2}$=3.288, $1d_{5/2}$=0.731, $0g_{7/2}$=0.0, $0h_{9/2}$=7.1, $0h_{11/2}$=2.305 MeV orbits for protons and $2p_{1/2}$=4.462, $2p_{3/2}$=2.974, $1f_{5/2}$=3.432, $1f_{7/2}$=0.0, $0h_{9/2}$=0.68, $0i_{13/2}$=1.487 MeV orbits for neutrons. We use a surface δ interaction among the active nucleons in these orbits with nucleon-nucleon interaction strength V_{pp}=V_{np}=V_{nn}= 0.3 MeV. The resulting HF orbits of protons and neutrons corresponding to the lowest prolate solution of ^{160}Er is shown in Fig. 1. From this figure, the single particle orbits of the

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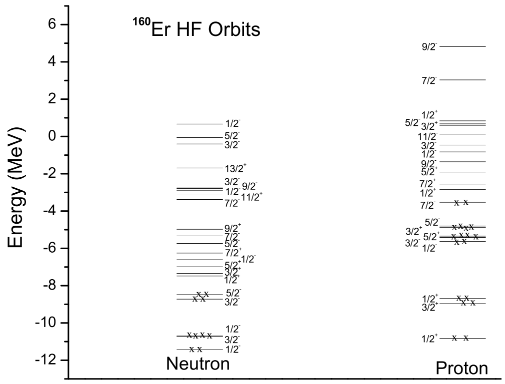

FIG. 1: Prolate deformed HF orbits of ^{160}Er. The orbits are denoted by $|2m|^{\pi}$. Occupied orbits are denoted by x.

next odd nucleus near the Fermi surface are identified and different band mixing between various orbitals are performed. Using the above deformed Hartree-Fock and Angular Momentum Projection formalism we study the band structures for the nucleus ^{161}Er. The energy spectra associated with each intrinsic state is obtained by angular momentum projection in the appropriate model space (We use surface delta residual interaction) in the above formalism. The $K = 1/2^{+}$, with $5/2^{+}$ 1p1h bands and their mixing for both favoured and unfavoured bands are given in Fig. 2. The experimental data for the ground band is given. We found that our band mixing result matches pretty well with the data. We also predict a lowlying $K = 1/2^{-}$ band at low excitation.

Conclusions

We have studied the high spin states of the neutron-deficit ^{161}Er odd mass nucleus. Using our Projected HF model with band mixing, we predict many bands upto high spin values. The spectra of ^{161}Er are obtained. These results may be useful in future experimental studies of these nuclei. As a whole our microscopic model can be useful to study the band structure and electromagnetic properties of deformed nuclei.

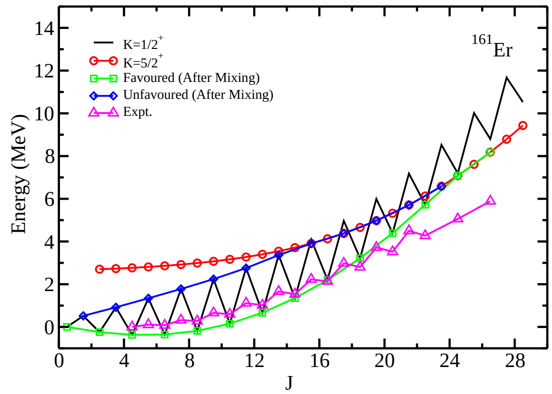

FIG. 2: Band mixing of $K = \frac{1}{2}^{+}$ with $\frac{5}{2}^{+}$ of ^{161}Er. The experimental values are also shown for comparision [8].

Acknowledgments

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