

Spectroscopic Study of ^{171}Hf Nucleus

B.B. Sahu^{1,*}, S.K. Ghorui², Z. Naik³, S.K. Patra^{4,†} and C.R. Praharaj^{4‡}

¹*School of Applied Sciences, Kalinga Institute of Industrial Technology (KIIT) University, Bhubaneswar-751 024, INDIA*

²*Department of Physics and Meteorology, IIT Kharagpur, Kharagpur-721 302, INDIA*

³*School of Physics, Sambalpur University, Jyotivihar, Sambalpur-768 019, INDIA and*

⁴*Institute of Physics, Sachivalaya Marg, Bhubaneswar-751 005, INDIA*

Introduction

Recently a number of strongly deformed bands have been observed in the heavier Hf isotopes $^{171,172}\text{Hf}$ [1] and $^{173,174}\text{Hf}$ [2, 3]. For odd-mass rotational nuclei the coupling of single-particle and collective rotational degrees of freedom leads to a rich variety of band structures [4, 5]. 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 [6, 7]

In the present work, we have studied the multiquasiparticle bands of ^{171}Hf 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 $|\Phi_K\rangle$ 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

J quantum number and is a superposition of various J states [8–10],

$$|\Phi_K\rangle = \sum_I C_{IK} |\Psi_{IK}\rangle. \quad (1)$$

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

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

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

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

I. RESULTS AND DISCUSSION

The deformed HF orbits are calculated with a spherical core of ^{132}Sn . The model space spans $2s_{1/2}=3.654$, $1d_{3/2}=3.288$, $1d_{5/2}=0.731$, $0g_{7/2}=0.0$, $0h_{9/2}=6.46$, $0h_{11/2}=1.705$ MeV orbits for protons and $2p_{1/2}=4.462$, $2p_{3/2}=2.974$, $1f_{5/2}=3.432$, $1f_{7/2}=0.0$, $0h_{9/2}=0.686$, $0i_{13/2}=1.487$ 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. Using the deformed Hartree-Fock and Angular Momentum Projection formalism we study the band structures for the nucleus ^{171}Hf . The energy spectra associated with each intrinsic

Available online at www.symppnp.org/proceedings

*Electronic address: bhusan@iopb.res.in

†Electronic address: patra@iopb.res.in

‡Electronic address: crp@iopb.res.in

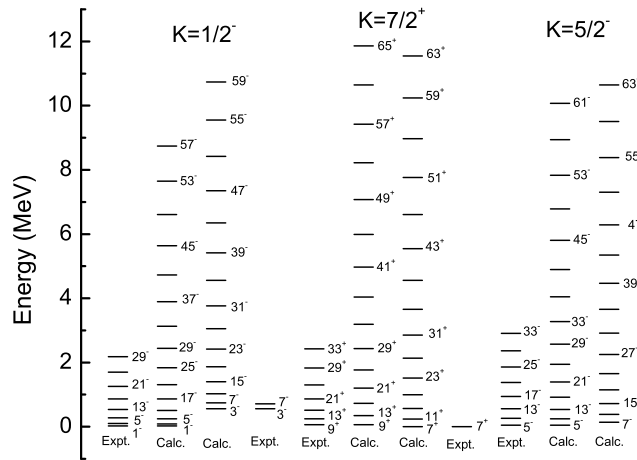


FIG. 1: Comparison of experimental spectra with deformed HF model results (Calc.) of ¹⁷¹Hf. The experimental data are taken from [11].

state is obtained by angular momentum projection in the appropriate model space (We use surface delta residual interaction) in the above formalism. The $K = 1/2^-$, $7/2^+$ and $5/2^-$ bands are given in Fig. 1. The experimental data for comparison is given. We found that our result matches pretty well with the data.

Conclusions

We have studied the high spin states of the neutron-deficit ¹⁷¹Hf odd mass nucleus. Using our Projected HF model with band mixing, we predict many bands upto high spin values. The spectra of ¹⁷¹Hf are obtained. These results may be useful in future experimental studies of this mass region. As a whole our microscopic model can be useful to study the band structure and electromagnetic properties of deformed nuclei.

Acknowledgments

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