Study of K-Isomers in Hafnium Nuclei

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Introduction

The Hf nuclei are known for K isomers occurring at low excitation energies. A number of strongly deformed bands have been observed in 170Hf [1], 171,172Hf [2, 3]. To understand the properties of the ground and K isomeric bands of Hafnium and other nuclei one needs a theoretical model which takes into account the residual interaction among the nucleons in a large enough valence space and gives the proper deformed single-particle states and the multi-nucleon configurations for these nuclei. To this end, we have adopted in this work the Deformed Hartree-Fock (DHF) model to get the deformed single-particle states and the deformed multi-nucleon configurations. Ground and K-isomeric intrinsic states are constructed, and for each intrinsic state (configuration), states of good angular momenta are obtained by Angular Momentum Projection.

Theoretical Framework

A deformed shape such as one described by Slater determinant of deformed orbits |ΦK> is localized in angle and, by the uncertainty principle, is not a state of good angular momentum (J). Thus |ΦK> does not have a unique J quantum number and is a superposition of various J states [4–7].

|ΦK> = ∑ J CIK |ΨIK>. 

(1)

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

PKM = 2I + 1 8π2 ∫ dΩDMK∗(Ω)R(Ω). 

(2)

Results and Discussion

The deformed HF orbits are calculated with a spherical core of 132Sn, the model space spans the 2s1/2, 1d3/2, 1d5/2, 0g7/2, 0h9/2 and 0h11/2 orbits for protons and the 2p1/2, 2p3/2, 1f5/2, 1f7/2, 0h9/2 and 0i13/2 orbits for neutrons respectively. We use surface delta interaction [9] as the residual interaction among the active nucleons to obtain deformed single particle orbits. The calculated results are presented in Fig. 1.

FIG. 1: Deformed HF orbits of 170Hf.

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Conclusions

We use the deformed HF and angular momentum projection technique to obtain energy spectra of ground and excited large K-bands of $^{170}$Hf. The spectra for the various bands are obtained by angular momentum projection are presented in Fig. 2. The experimental ground band is fairly well explained in our calculation. The K=8$^-$ band coming from proton excitation across the fermi surface ($7/2^+ + 9/2^-$ occupation) is also shown. This band is satisfactorily explained in our calculation compared to experiment. The variation of energy with J of this band matches quite well with the corresponding variation of energy with J of the experimental K$^-$ band. We have also studied the K-isomers of neighboring Hf nuclei, their energy spectra and electromagnetic properties [10].

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References

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