Deformed Band Structures and K Isomers in ^{170}Er

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Introduction

The structure of neutron rich nuclei is of much current interest. With the availability of radioactive ion beams the neutron-rich rare-earth nuclei, among others, are accessible for experimental study. In this work we provide theoretical results about deformation of Erbium nuclei and the structure and spectra of the various bands of ^{170}Er. We use the deformed Hartree-Fock (HF) procedure to obtain the deformed ground configuration. K-isomeric configurations are particle-hole excited configurations. The spectra of the ground and K-isomeric bands of ^{170}Er are obtained by Angular Momentum Projection [1–4].

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 [1–3],

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

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

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

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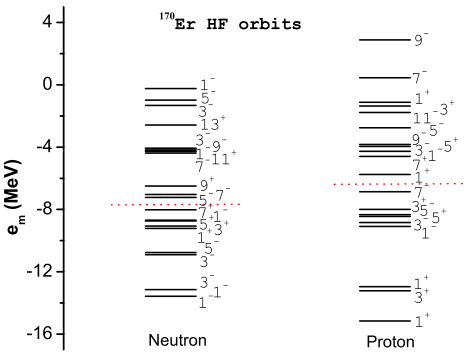

FIG. 1: Prolate deformed HF orbits of ^{170}Er. The Fermi surface is indicated by dotted lines.

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

$$\sum_{K'} (H^J_{KK'} - E_J N^J_{KK'}) C^J_{K'} = 0. \qquad (3)$$

Results and Discussion

The deformed HF orbits are calculated with a spherical core of ^{132}Sn, the $\mathrm{sdg}_{7/2}\mathrm{h}_{11/2}\mathrm{h}_{9/2}$ space with single particle enrgies 3.654, 3.288, 0.731, 0.0, 7.1 and 2.305 MeV for protons and $\mathrm{pfh}_{9/2}\mathrm{i}_{13/2}$ space with energies 4.462, 2.974, 3.432, 0.0, 0.3 and 1.487 MeV for neutrons. We use surface delta matrix elements as the residual two-body interaction. The interaction strength is taken as 0.3 MeV

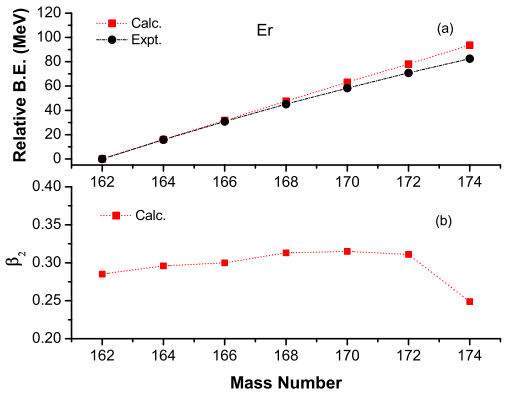

FIG. 2: Prolate HF energies of vaious Er nuclei calculated with PHF theory (squares) compared with the experimental binding energies (circles) taken from [5] shown in the upper part and the deformation in lower part.

for p-p, n-n and n-p interactions. This interaction gives a good description of the systematics of binding energies and deformations in this mass region shown in Fig.2(a) and 2(b). The prolate Hartree-Fock solution is the lowest in energy and the orbits for this solution are plotted in Fig.1 for ^{170}Er. The spectra of this nucleus, for various intrinsic states using Angular Momentum Projection techniques [1–3], are shown in Fig.3.

Conclusions

The deformation properties of Erbium nuclei have been studied by us in deformed HF and Angular Momentum Projection theory. Reasonable quadrupole deformation parameters are obtained. The β_2 peaks around N=102 in this calculation and decreases thereafter. The rotational bands and bands based on K-isomeric configurations of neutron rich ^{170}Er nucleus have been obtained using J projection from various intrinsic states. Three K isomers (neutron excited K=4$^-$ band, proton 2qp K=4$^-$ and K=7$^-$ bands) have been studied and their spectra are calculated to high spin values.

Acknowledgments

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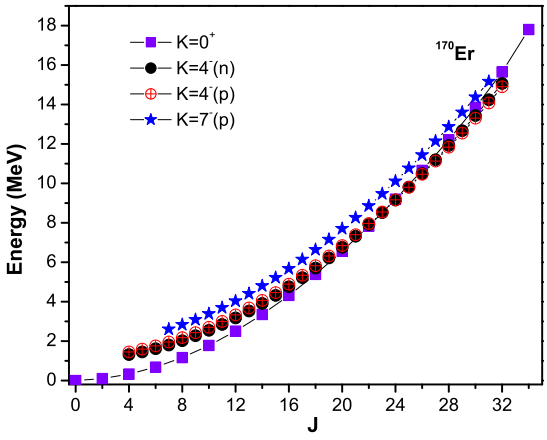

FIG. 3: Energy spectra with deformed HF model of ^{170}Er.