Low-lying deformed rotational bands in $N = 50$ Ge nuclei

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Introduction

The study of neutron rich nuclei in the vicinity of most neutron rich doubly magic nucleus, ^{78}Ni (with N/Z≈1.8) gained momentum with recent advancements of experimental techniques like fusion evaporation reactions using radioactive ion beams and fission fragment.

In general, closed shell nuclei exhibit spherical ground state, whereas the breaking of a closed shell can provide coexisting deformed configurations. One of the vital indications of the deformed configurations is the appearance of low-lying excited $K = 0^+$ rotational bands. Recently, Hwang et al. [1], have observed deformed rotational bands in ^{82}Ge. To our knowledge, these deformed rotational bands have not been studied theoretically so far. Here, we study the structure of the exotic nucleus ^{82}Ge using a self-consitent mean-field model.

The Model

The ground band as well as the excited deformed bands and their electromagnetic properties of ^{82}Ge are studied by employing the deformed Hartree-Fock (HF) and Angular Momentum (J) projection method. Details of HF and J-projection methods are given in Refs.[2, 3].

Results and Discussions

The deformed HF orbits are calculated with a spherical core of ^{56}Ni; the model space spans the $1p_{3/2}$, $0f_{5/2}$, $1p_{1/2}$, $0g_{9/2}$, $0d_{5/2}$, $0g_{7/2}$, $2s_{1/2}$, $0d_{3/2}$ and $0h_{11/2}$ orbits both for protons neutrons with single particle energies 0.0, 0.78, 1.08, 3.44, 7.88, 10.47, 11.73, 12.21 and 13.69 MeV respectively. We use a surface delta interaction [4] (with interaction strength 0.38 MeV for $p - p$, $p - n$ and $n - n$ interactions) as the residual interaction.

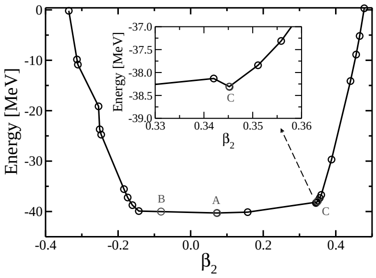

FIG. 1: Energy surface of ^{82}Ge.

For constrained HF calculation we use a quadrupole constrained Hamiltonian given by

$$H'(\lambda) = H - \lambda(Q^p_{20} + Q^n_{20}) \qquad (1)$$

with λ being constraining parameter & $\langle Q^p_{20}\rangle$ and $\langle Q^n_{20}\rangle$ being quadrupole moments of protons and neutrons, respectively. The energy surface is obtained by plotting $\langle H\rangle$ against deformation parameter β_2. The energy surface for ^{82}Ge is shown in Fig. 1.

In Fig.1, we see that ^{82}Ge exhibits 'almost' spherical shape in its ground state. The very weekly deformed prolate (A) and oblate (B) solutions have energy difference less than 1 MeV. Therefore we have taken into account the shape mixing after angular momentum projection calculations to obtain the low-lying states. With the constrained calculation,

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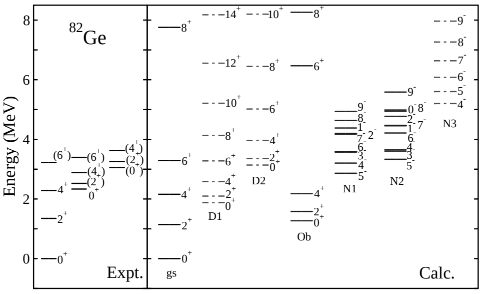

FIG. 2: Comparison of experimental spectra (Expt.) and DHF model results (Calc.) for ^{82}Ge. Bands obtained with the unconstrained HF calculations are represented by solid lines whereas those obtained from constrained calculations are represented by dotted lines. The notation 'gs' stands for ground state band, 'D1' for deformed 1st excited band and 'D2' for deformed 2nd excited band.

there exists a local minimum (denoted by 'C' in Fig. 1). We get excited rotational bands from this local minimum and from neutron 2p-2h excitation based on this.

To study the recently observed deformed bands, we have considered the well-deformed constrained HF solution for this nucleus. The large deformation causes the migration of prolate deformed levels from the shell above the $N = 50$ and hence leads to breaking of the shell gap. The first deformed band (denoted by D1 in Fig. 2) built on the constrained HF configuration ('C' in Fig. 1) has rotational structure. The calculated band head energy is within ~400 keV of the experimental result and the "moment of inertia" of the band matches quite well. We excite two neutrons from the orbits $\pm 7/2^+$ below the neutron Fermi surface to the well-mixed $\pm 1/2^+$ orbit above the neutron Fermi surface in order to get the second deformed rotational band, D2 of Fig. 2. A fairly good agreement between calculated and available experimental results is achieved for this case.

Apart from these bands, we predict a low-lying positive parity band ('Ob' in Fig. 2) based on the oblate unconstrained HF solution 'B'. We also obtain negative parity bands (N1 and N2 in Fig. 2) from proton 1p-1h excitation in unconstrained HF solution (prolate). A $K = 4^-$ band (N3 in Fig. 2) is obtained by 1p-1h excitations across the neutron Fermi surface (constrained HF solution) with dominant configuration $\nu 1/2[301]^{-1} \otimes \nu 9/2[404]^1$.

To check the collectivity of the various bands, we also calculated electromagnetic properties of these bands. The detail results will be shown during presentation.

Conclussions

To summarize, we have used a self-consistent mean field model to study the structure of $N = 50$ Ge nucleus with special interest to deformed rotational bands. We find low-lying $K = 0^+$ deformed rotational bands in ^{82}Ge due to the neutron excitations across the $N = 50$ shell gap. The present theoretical work throws light on the structures and deformation properties at higher excitation energies in ^{82}Ge.

Acknowledgments

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