Microscopic explanation of observed well-deformed and superdeformed band of ^{62}Zn

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Introduction

Study of superdeformed band is always a topic of research interest because of having large elongated shape with axis ratio of approximately 2:1. The superdeformed (SD) occurs because of a combination of macroscopic and microscopic factors which together lower their energies and make them stable minima of energy as a function of deformation. The SD nuclei are experimentally observed by superdeformed rotational bands in the energy spectrum of rapidly spinning nuclei. The first SD band was observed in ^{152}Dy in the year 1985 and since then it has become very active field of research in both experimental and theoretical nuclear physics [1].

The study of superdeformed bands in the mass A 60 region are unique because these belong to the lightest mass region, exhibiting highest rotational frequencies and their proximity to the N=Z lines. High spin collectivity in the A 60 mass region is induced by particle hole excitation across the spherical shell gap at particle number N=Z=28 [2]. A limited number of holes in the $1f_{7/2}$ sub-shell and excitation of one or more nucleons in to $1g_{9/2}$ intruder orbitals above the ^{56}Ni closed core give rise to nuclear structure phenomena associated with collective excitation including superdeformation.

The nucleus ^{62}Zn is a very good example in the A 60 mass region. Recently this nuclei has been populated through fusion-evaporation reaction [2, 3]. The deduced level scheme ^{62}Zn have 260 excited states which are connected with more than 450 γ-rays. The γ-rays distribution consists of eleven welldeformed (WD) and five superdeformed bands along with other normal deformed bands. The experimental findings are compared with results of crank Nilsson-Strutinsky calculation. But the complete theoretical description and the electromagnetic properties are missing. So the band structure and the electromagnetic properties of these SD and WD bands will be studied with a microscopic technique known as Projected Deformed Hartree-Fock (DHF) Model.

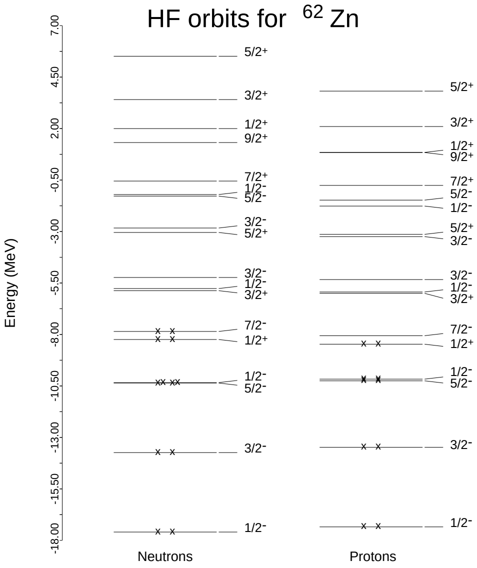

FIG. 1: The SD prolate HF orbits of ^{62}Zn with β=0.47. The parity and Ω are mention in the figure. Occupied orbits are denoted by (x).

Formalism

The microscopic investigation of various band structure of ^{62}Zn nuclei are carried out

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*Electronic address: `lisha.pattnayak010@gmail.com` with Deformed Hartree-Fock and Angular Momentum Projection model [4, 5]. The deformed nucleon orbits are calculated by deformed HF calculation and intrinsic wave functions $| \phi_K \rangle$ are obtained by suitable particle occupation to these deformed orbits. The $| \phi_K \rangle$ are states of good K but are not states of good J because we have assumed axial symmetry in our calculation (here J is total angular momentum). We performed J projection to get good J states; hence spectra and electromagnetic properties of the bands are obtained (for details of formalism see Ref. [4, 5]).

We have performed DHF calculation using surface delta residual interaction among the active nucleons with interaction strength V_{pp}=V_{pn}=V_{nn}=0.372 MeV. The model space consists of $p_{1/2}$, $p_{3/2}$, $f_{5/2}$, $d_{5/2}$, $f_{7/2}$ and $g_{9/2}$ for both protons and neutrons with reasonable single-particle energies. In our calculation, 10 active protons and 12 active neutrons have been considered above ^{40}Ca spherical inert core. We have consider upto six quasi-particle configurations for explaining well-deformed band Superdeformed band structures of this nuclei.

Results and Discussion

Here we have tried to give microscopic explanation to the observed WD and SD bands of ^{62}Zn [2]. Some of these bands have been observed first time. We have tried understand the structure of these bands based on our configuration mixing calculation. For J projection calculation we have taken two different HF orbit set one with Normal Deformation (β =0.104) and other with Superdeformation (β= 0.47). First one we get by giving small initial quadrupole moment. Second one we get by giving very large quadrupole moment (without constrain calculation). The HF orbits we get for SD HF calculation is shown in figure 1.

Before we performed calculation for SD and WD bands we have performed calculation for Normal deformed bands. With 2 by 2 band-mixing calculation is sufficient to explain experimental GS band (comparison is shown in Fig. 2). Also we have spectrum of other normal deformed bands. By considering particle hole excitation across Z=N=28 shell closure we have obtained several SD and WD bands. The excitation energy of SD band shown in the figure is 3.066 MeV. Along with, band head and γ-energy we have performed calculation for Q_s, μ, Q_0 and β of all these WD and SD bands.

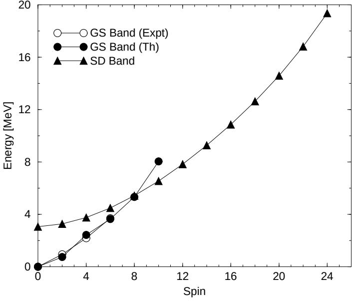

FIG. 2: Comparison of theoretical and experimental spectrum of Ground State band and theoretical SD band.

Conclusion

An attempt is made to study the WD and SD band structures of ^{62}Zn with a microscopic model. Level spacings of SD and WD bands are explained. B(M1)/B(E2) ratio for various transition of these bands are calculated. Also other electromagnetic properties are predicted for future experimental verification.

References

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