Systematics of Superdeformed bands in the isotopes of Zn and Ge in A=60 Mass region

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Introduction

V.M. Strutinsky [1] first predicted the superdeformed (SD) shapes and the observation of the first high-spin superdeformed (SD) band in ^{152}Dy [2], have been intensively studied in several mass regions A=190, 150, 130 and 80. However, the intraband energies are easy to detect with modern Ge arrays, it is difficult to observe the link between the SD band and normal deformed (ND) states with known spins. Therefore, the exact excitations energies, spins, and parities of SD bands remain unknown. Recently, a link between SD and ND bands has been observed in 190Hg by Wilson et al [3] . It may be pointed out that a lack of knowledge of the spins assignments has led to an emphasis on the study of dynamical moment of inertia of SD bands and the systematics of the kinetic moment of inertia have not been examined in a detailed manner. Sharma and Mittal [4] have studied that all the excited SD bands in even-even nuclei in A=150 mass region are signature partner SD bands because the J_0 value of each signature partner SD band is almost identical. The J_0 values obtained from fitting of SD bands in A=190 mass region exhibit spread in many cases which point towards the presence of structural effects in these SD bands [5].

In this paper, the systematic study of Superdeformed (SD) bands in the isotopes of Zn and Ge has been done. We have calculated the band moment of inertia of all SD bands in the isoptopes of Zn and Ge by using four parameter formula.

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Formalism

Bohr and Mottelson [6, 7] pointed out that the rotational energy of $K = 0$ band in even -even nuclei can be expanded in power series of $I(I+1)$:

$$E(I) = A((I(I+1)) + \frac{B}{A}(I(I+1))^2 + \frac{C}{A}(I(I+1))^3 + \frac{D}{A}(I(I+1))^4) \quad (1)$$

The expansion for $K \neq 0$ band can take a form similar to equation (1), but includes a term for the bandhead energy and $I(I+1)$ has to be replaced by $I(I+1) - K^2$. The energy may also be written in different form as

$$E(I) = \frac{1}{2J_0}((I(I+1)) - \frac{1}{2}\sigma(I(I+1))^2 + \sigma^2(I(I+1))^3 - 3\sigma^3(I(I+1))^4) \quad (2)$$

where the softness parameter $\sigma = \frac{1}{2S(J_0)^3}$ [8] is a small parameter of the expansion with S and J_0 as stiffness constant and moment of inertia respectively. A comparison of equations (1) and (2) suggests that

$$A = \frac{1}{2J_0}, \frac{B}{A} = -\frac{\sigma}{2}, \frac{C}{A} = \sigma^2 \; and \; \frac{D}{A} = -3\sigma^3 \quad (3)$$

For SD bands, where the band quantum number K is not known, the equation (1) can be written as

$$E(I) = E_0 + A(I(I+1) - I_0(I_0+1)) + B((I(I+1))^2 - (I_0(I_0+1))^2) + C((I(I+1))^3 - (I_0(I_0+1))^3) + D((I(I+1))^4 - (I_0(I_0+1))^4) \quad (4)$$

where E_0 is the bandhead energy and I_0 is the bandhead spin. Since the bandhead energy

and spin are generally not known for the SD bands, one may chose to fit the E2 transitions,

$$E_\gamma(I) = E(I) - E(I-2) \quad (5)$$

Using equations (4) and (5), we obtain

$$\begin{aligned} E_\gamma(I \to I-2) \;=\; & A(I(I+1) - (I-2)(I-1)) \\ & +B((I(I+1))^2 - ((I-2) \\ & (I-1))^2) + C((I(I+1))^3 - \\ & ((I-2)(I-1))^3) + \\ & D((I(I+1))^4 - \\ & ((I-2)(I-1))^4) \end{aligned} \quad (6)$$

The parameters A,B,C and D may now be determined by fitting the E2 transitions for the SD cascades. One may then obtain the nuclear softness parameter (σ) by using the relations in (3).

Results and Discussion

Identical band is the phenomenon which everyone wants to understand. The yrast SD band 192Hg(1) was considered as identical to the excited SD band 194Hg(3), because the observed sequence of E2 transition energies are almost identical in the spin range I 20 - 40 [9]. Which implies their dynamical moment of inertia J^2 are almost identical in this spin range. As we know that the two rotational bands having same dynamical and kinematic moments of inertia are considered to be as identical to each other. This fact seems to suggest that the band moment of inertia of these bands should be same. We have calculated the band moment of inertia of SD bands in the isotopes of Zn and Ge in A=60 mass region by using 4-parameter formula. By fitting the γ-ray transition energies and spin in 4-parameter formula, we have calculated the parameters A, B, C and D and ultimately the band moment of inertia. The root mean square deviation (RMSD) has also been calculated for each band. The data has been taken from Ref. [10].

It is interesting to note that the band moment of inertia of SD bands of isotopes of Zn and Ge i.e. band moment of inertia of 62Zn (1) and 68Ge(1) is same and the bands are identical to each other. Therefore, if there exists a significant difference in J_0 values of two SD bands, it is very hard to consider them as a pair of identical band.

Conclusion

The systematics of band moment of inertia of SD bands of isotopes of Zn and Ge in A=60 mass region are investigated. It is found that the band moment of inertia of 62Zn (1) and 68Ge(1) in A-60 mass region is same and theses bands are found to be identical to each other. The systematic of identical SD bands of isotopes of Zn and Ge are studied in detail.

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