Testing the validity of rotational energy formulae for superdeformed bands in ^{58}Ni

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Introduction

The phenomenon of superdeformation in A∼60 mass region was foreseen by Ragnarsson [1]. Later, the first SD band in A∼60 mass region was observed by Svensson et al. [2]. In comparison to heavier mass regions, lighter mass region is of special importance due to their lighter mass [3–6] and high rotational frequency. Majority of the nuclei in this mass region exhibits an identical response for dynamic moment of inertia ($J^{(2)}$) versus rotational frequency ($\hbar\omega$). To understand the detail physics of SD bands; spin determination is a vital asset. Band head spin assignment of SD bands in A∼60-80 mass region through nuclear softness formula was computed by Sharma and Mittal [7]. Many theoretical models/rotational energy formulae [8–13] were suggested to attain reliable spins. In this present paper, we are testing the validity for two of the rotational energy formulae i.e. Power index formula and Four parameter formula for SD bands in $^{58}Ni(1,2)$.

Formalism

Here, we have used the two of the rotational energy formulae i.e. Power index formula and Four parameter formula in order to test the validity for SD bands in $^{58}Ni(1,2)$.

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1. Power index formula

$$E_\gamma(I) = a\left(I^b - (I-2)^b\right). \tag{1}$$

The parameter a and b are the model parameters, which can be found by using the fitting techniques.

2. Four parameter formula

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

where A, B, C and D are the model parameters which can be resolved by fitting the E_γ transitions for the SD bands.

Results and Discussion

The observed transition energies [14] for $^{58}Ni(1,2)$ SD bands has been fitted to power index formula and four parameter formula. At a particular band head spin a smaller fixed minimum value of root mean deviation is obtained by the four parameter formula. The computed and experimental transition energies are in accordance with each other, whenever accurate band head spin is accredited. The deduced band head spin for $^{58}Ni(1,2)$ SD bands using power index formula and four parameter formula and its comparison with experimental results [14] have been given in Table I. It is well noticed from the Table I that the band head spin for $^{58}Ni(1,2)$ SD bands obtained using power index formula diverges widely from the values given experimentally [14]. However, the band head spins achieved by four parameter formula is more close to the experimental data. Thus, the four parameter formula is more reliable than the power index formula in determination of spin for $^{58}Ni(1,2)$ SD bands.

TABLE I: The band head spin (I_0) for $^{58}Ni(1,2)$ SD bands using Power index formula (P.I), Four parameter formula (F.P) and its comparison with experimental results [14].

SD bands	$E_\gamma(I \rightarrow I-2)$	P.I	F.P	[14]
$^{58}Ni(1)$	1663	19	17	15
$^{58}Ni(2)$	1685	42	13	12

Conclusion

In this present work, it is observed that out of the two rotational energy formulae the four parameter formula proves to be a powerful tool to detect the band head spin for $^{58}Ni(1,2)$ SD bands than the power index formula.

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