Study of superdeformed bands in ^{154}Er

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Introduction

A significant amount of work has been done since superdeformation in ^{152}Dy [1] was discovered, and the result is better understanding of the nuclear structure of the states at the second minimum of the potential energy in the A$\sim$150 mass region. Nuclei between La (Z=57) and Dy (Z=66) have been shown to exhibit discrete line superdeformation. Total Routhian surface (TRS) and cranked-Hartree-Fock calculations theoretically suggest a well-developed second minimum with a deformation of $\beta_2 = 0.61$ for ^{154}Er(Z= 68) at a rotational frequency of $\hbar\omega = 0.5$ MeV. Bernstein et al. [2] observed superdeformed (SD) bands comprising of 13 E_γ ray transitions in ^{154}Er. In addition to the fission isomers in actinide nuclei, superdeformed (SD) atomic nuclei with very elongated forms (major to minor axis ratio ~ 2) are now known to exist in numerous regions of the nuclear chart [3–8]. Coexistence of superdeformed shapes in ^{154}Er was discovered by Lagergren et al. [9]. Systematic study of SD bands in ^{152}Tb was studied by Sharma and Mittal[10]. In this present paper, the E_γ transition energies, band head moment of inertia ($\Im_0$), pairing gap parameter (Δ_0) and ν of ^{154}Er(1, 2) SD bands is calculated by using the modified exponential model.

Formalism

Using cranking model calculations by Ma and Rasmussen [11], Draper [12] demonstrated the almost exponential dependency of the moment of inertia on pairing correlations. Additionally, Moretto [13] came up with the pairing gap's temperature dependency on angular momentum I, which is comparable to superconductivity's pairing gap dependence. This is expressed as

$$E_\gamma(I) = \frac{\hbar^2}{2\Im_{(Expo)}} I(I+1) e^{\left[\Delta_0 (1 - \frac{I}{I_c})^{1/\nu}\right]} \tag{1}$$

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TABLE I: The band head moment of inertia ($\Im_0$), pairing gap parameter (Δ_0)and ν obtained from modified exponential model for SD bands in ^{154}Er. Here 1, 2 in parenthesis represent band 1, band 2 respectively.

SD Bands	$E\gamma$ (keV)	$\Im_0$ ($\hbar^2 MeV^{-1}$)	Δ_0	ν
$^{154}Er(1)$	696	74.4	0.46	0.23
$^{154}Er(2)$	745	76.9	0.28	0.38

Results and Discussion

Modified exponential model have been applied on ^{154}Er(1, 2) SD bands to calculate the E_γ transition energies, band head moment of inertia ($\Im_0$), pairing gap parameter (Δ_0)and ν. The data has been taken from the tables of SD bands given by Singh et al.[14]. Band head moment of inertia ($\Im_0$), pairing gap parameter (Δ_0)and ν obtained from modified exponential model has been listed in Table I. It has been observed from Table I that the pairing gap parameter Δ_0 is small for ^{154}Er(1, 2) SD bands which is justified due to presence of large shell gaps in A $\sim$150 mass region. The calculated results of E_γ transition energies obtained from modified exponential model for ^{154}Er(1, 2) SD bands have been compared with the experimental results (see Table II and III).

TABLE II: Comparison of the theoretical result of transition energies E_γ obtained by modified exponential model and experimental results of transition energies E_γ of $^{154}Er(1)$ SD band in (keV).

Spin I	$E\gamma$(Exp) (keV)	Modified Exponential Model (KeV)
24	696	688.3
26	734	734.5
28	777	781.6
30	824	829.4
32	875	878.1
34	927	927.8
36	980	978.3
38	1033	1029.8
40	1086	1082.1
42	1138	1135.3
44	1191	1189.2
46	1243	1243.8
48	1300	1298.9
50	1349	1354.6

TABLE III: Comparison of the theoretical result of transition energies E_γ obtained by modified exponential model and experimental results of transition energies E_γ of $^{154}Er(2)$ SD band in (keV).

Spin I	$E\gamma$(Exp) (keV)	Modified Exponential Model (KeV)
26	745	742.9
28	789	788.9
30	833	834.7
32	879	880.5
34	926	926.2
36	972	972.1
38	1018	1018.2
40	1066	1064.6
42	1113	1111.4
44	1159	1158.6
46	1207	1206.4
48	1253	1254.7

Conclusion

In this present work, due to the presence of large shell gaps in A ∼150 mass region, the pairing is small in ^{154}Er(1, 2)SD bands. The calculated results of E_γ transition energies obtained from modified exponential model for ^{154}Er(1, 2) SD bands have been compared with the experimental results. A good agreement is shown by the modified exponential model for ^{154}Er(1, 2)SD bands.

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