Systematic study of rotational energy formulae in superdeformed bands of ^{86}Zr

Honey Sharma* and H. M. Mittal‡

*Department of Physical Sciences,
Sant Baba Bhag Singh University,
Padhiana, Punjab, India
and
‡Department of Physics,
Dr. B. R. Ambedkar National Institute of Technology,
Jalandhar, Punjab, India

Introduction

The investigation of the first SD band in ^{83}Sr awaits the arrival of the array of large Ge-detectors like Eurogam-I [1]. However, Eurogam-I therefore generates the first case of superdeformation (SD) in A∼80 mass region. As a consequence, in ten medium-mass nuclei more than 20 SD bands have been established. These series include the multiple SD bands in $^{80,81,82}Sr$, $^{83,84}Y$, ^{83}Zr, ^{87}Nb as well as the yrast SD bands in ^{83}Sr, ^{82}Y, and ^{84}Zr [2–10]. The highly collective nature, large moment of inertia and average transition quadrupole moment implied that the SD bands in A∼80 mass region have prolate shape with $\beta \approx 0.5$ [4–9]. Strutinsky Bogolyubov model and Cranking model with Wood Saxon average potential was incorporated by Dudek et al. [11] to found the shape co-existence effects and SD deformation in ^{84}Zr nucleus. The observation of the triaxial SD bands in ^{86}Zr was studied by Sarantities et al. [12]. The good agreement amid experiment and configuration-dependent shell correction calculations was observed. Out of the four SD bands of ^{86}Zr three bands possess triaxiality. Band head spin assignment of SD bands in A∼60-80 mass region through nuclear softness formula was calculated by Sharma and Mittal [13]. In this present paper, we have studied the E_γ transition energies of three bands (SD-1, SD-3 and SD-4) of ^{86}Zr nucleus by using a four parameter formula and the power index formula.

*Electronic address: `honeyshrma777@gmail.com`

Formalism

Four parameter formula

$$E_\gamma(I \to I-2) = A(I(I+1) - (I-2)(I-1)) + B((I(I+1))^2 - ((I-2)(I-1))^2) + C((I(I+1))^3 - ((I-2)(I-1))^3) + D((I(I+1))^4 - ((I-2)(I-1))^4), \quad (1)$$

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

Power index formula

$$E_\gamma(I) = a\bigg(I^b - (I-2)^b\bigg). \quad (2)$$

where a, b are the model parameters which can be resolved by fitting the E_γ transitions for the SD bands.

Results and Discussion

A four parameter formula and the power index formula has been applied on the three SD bands (SD-1, SD-3 and SD-4) [14] of ^{86}Zr nucleus in A∼80 mass region. We have calculated the transition energies of three bands (SD-1, SD-3 and SD-4) of ^{86}Zr nucleus by using both the formulae; and the result of which are compared with the experimental data (see Table I,II,III). The calculated results are in good agreement with the available experimental data.

TABLE I: Comparison of the theoretical result(Four parameter formula and Power index formula) and experimental results of transition energies E_γ of $^{86}Zr(1)$ SD band in (keV).

$E_\gamma(I \to I-2)$	F.P formula	P.I formula
1518	1515.6	1498.4
1646	1649.0	1644.3
1785	1786.2	1791.0
1929	1928.1	1938.5
2077	2075.3	2086.7
2228	2227.5	2235.5
2383	2383.6	2385.1
2540	2541.0	2535.2
2696	2695.4	2685.8

TABLE II: Comparison of the theoretical result(Four parameter formula and Power index formula) and experimental results of transition energies E_γ of $^{86}Zr(3)$ SD band in (keV).

$E_\gamma(I \to I-2)$	F.P formula	P.I formula
1866	1864.7	1862.6
1959	2008.7	1962.8
2062	2058.7	2060.3
2155	2153.5	2155.5
2244	2247.8	2248.4
2343	2340.7	2339.4
2429	2429.4	2428.6

TABLE III: Comparison of the theoretical result(Four parameter formula and Power index formula) and experimental results of transition energies E_γ of $^{86}Zr(4)$ SD band in (keV).

$E_\gamma(I \to I-2)$	F.P formula	P.I formula
1648	1649.7	1672.2
1811	1807.5	1816.5
1967	1967.3	1960.2
2123	2125.0	2103.4
2273	2273.4	2246.1
2403	2401.2	2388.3
2491	2491.6	2530.1

Conclusion

In this present work, it is observed that the four parameter formula and power index formula very well proves its efficiency in order to explain experimentally observed E_γ transition energies of $^{86}Zr(1,3,4)$ SD bands.

References

[1] C. Baktash et al., Phys. Rev. Lett., 74: 1946 (1995)

[2] C. Baktash, B. Haas and W. Nazarewicz, Ann. Rev. of Nucl. Part. Sci., 45: 485 (1995)

[3] M. Devlin et al., Phys. Lett. B, 415: 328 (1997)

[4] F. Cristancho et al., Phys. Lett. B, 357: 281 (1995)

[5] A.G. Smith et al., Phys. Lett. B, 355: 32 (1995)

[6] H. Q. Jin et al., Bull. Am. Phys. Soc., 41: 881 (1996)

[7] D. Rudolph et al., Phys. Lett. B, 389: 463 (1996)

[8] D. R. LaFosse et al., Phys. Rev. Lett., 78: 614 (1997)

[9] P. J. Dagnall et al., Z. Phys. A, 353: 251 (1995)

[10] H. Q. Jin et al., Phys. Rev. Lett., 75: 1471 (1995)

[11] J. Dudek, W. Nazarewicz and N. Rowley, Phys. Rev. C, 35: 1489 (1987)

[12] D. G. Sarantites et al., Phys. Rev. C, 57: R1 (1998)

[13] H. Sharma and H. M. Mittal, Int. J. Mod. Phys E, 26: 1750074 (2017)

[14] http://www.nndc.bnl.gov/