Two-parameter formula for ground-band energy spectra of Xe-Pt nuclei

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Introduction

The understanding of ground-band energies of the $A = 120 - 200$ mass region nuclei is a subject of current interest. The ground-state band structure in even-even nuclei developed many phenomenological and theoretical approaches to understand the structure of nucleus and yrast excitation energies. Bohr and Mottelson [1] studied the $A = 120 - 200$ mass region nuclei involving the axial rotor having an energy ratio $R_{4/2}(= E(4_1^+)/(E(2_1^+)) \geq 3.0$. Sharff-Goldhaber and Weneser [2] studied the Anharmonic Vibrator (AHV) nuclei having $R_{4/2} = 2.0$. There are several approaches to describe the yrast excitation energies. Das et al. [3, 4] studied the AHV-type approach for the ground band energy

$$E(J) = nE(2_1^+) + (n(n-1)/2)\epsilon_4 \qquad (1)$$

where $\epsilon_4 = E(4_1^+) - 2E(2_1^+)$ and $n = \frac{J}{2}$. If $E(2_1^+)$ and ϵ_4 be assumed as the free parameters.If $E(2_1^+)$ and ϵ_4 are assumed to be the free parameters, then this equation is equivalent to the two-term Ejiri expression $E(J) = aJ + bJ(J+1)$. These two expressions yield a linear dependence of $R_J(= E_J/E_2)$ versus $R_{4/2}$ in the Mallmann plot, which is not in conformity with the experimental data. Mallmann [8] pointed out that the plots of $E_J \equiv (E_J - E_0)/(E_2 - E_0))$ are, when put another way, $r_1 \equiv R_J - R_{J-2}$ versus $R_{4/2}$ of the $N = 68 - 126$ even-even nuclei in which nuclei from the regions $N > 82$, $N < 104$ and $N > 104$ show a smooth trend. In Fig. 1, the Mallmann plot directly compares all the formulae with the experimental data over the entire region of nuclei. The two-parameter ab formula is introduced by Zeng et al. [6] and can also be rewritten as:

$$E(J) = a[\sqrt{1 + bJ(J+1)} - 1] \qquad (2)$$

Recently, Brentano et al. [7] proposed a new yrast energy formula for soft rotors:

$$E(J) = (J(J+1))(a(1+bJ)) \qquad (3)$$

This is also called the Soft Rotor Formula (SRF). Bihari et al. [8] also described the signature of the triaxial region in even nuclei with this formula. However, the concept of an arithmetic mean of the two terms used in these expressions was replaced by the concept of a geometric mean in the form of the power law:

$$E_J = aJ^b. \qquad (4)$$

The variation of the parameter values with the number of levels was less problematic. Gupta et al. [9] studied the ^{148}Ce nucleus, in which a geometric mean value of $b = 3/2$ was obtained and which surprisingly was constant, independent of the level spin. The aim of the present work is to compare the power law with other formulae, i.e. ab, Brentano, Ejiri and the standard empirical VMI model. All the energy value below back bending are taken from http://www.bnl.nndc.gov/nsdf [10].

Result and discussion

Gupta et al. [11] divided the mass region $A = 120 - 200$ in a major shell space of $Z = 50 - 82$, $N = 82 - 126$ into four quadrants. Quadrants I (Q-I) and III (Q-III) have a particle-particle (p-p) and hole-hole (h-h) boson space, and Quadrants II (Q-II) and IV (Q-IV) have a hole-particle (h-p) and particle-hole (p-h) boson space. We have divided the whole mass region into four quadrants. The results in terms of the difference between the experimental and calculated energies are presented in Fig. 2.

$$\frac{dE(J)}{E(J)} = [E(J)_{th} - E(J)_{exp}]/E(J)_{exp} \qquad (5)$$

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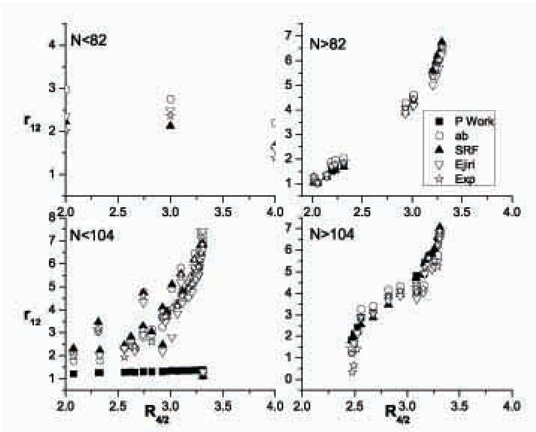

FIG. 1: The Mallmann plots of the power law (P work), ab, SRF and Ejiri formulae compared with the experimental data

) In $N < 82$, the $R_{4/2}$ ratio lies between 2.2 and

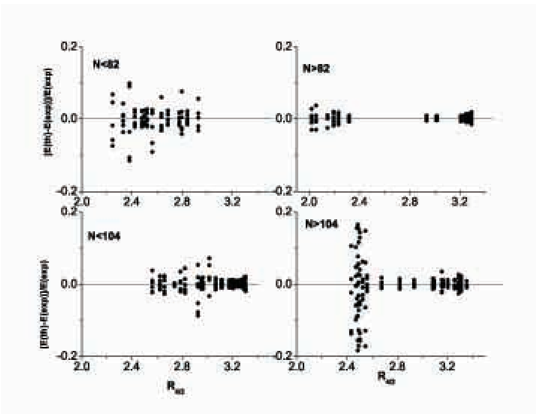

FIG. 2: Relative difference between experimental and calculated energies of power law as a function of $R_{4/2}$ of $N < 82$ nuclei

3.0; at $R_{4/2} = 2.2 - 2.4$, there is E(5) symmetry and the spread of average deviation is large; but at $R_{4/2} = 2.5$ near the γ-soft nuclei [O(6)], there is a small deviation; and in the case of $R_{4/2} = 2.6 - 2.9$, the deviation is large and similar to E(5) symmetry. In $N > 82$, the deviation of nuclei with an increasing neutron number therefore decreases; hence, in this region, deviation is nearly equal to zero. In the $N < 104$ region, when $R_{4/2} = 2.5 - 3.0$, nuclei are obtained from [O(6)] to [X(5)] symmetries; there is a spread in the datum of average deviation but, with increasing neutron number, the $R_{4/2}$ ratio increases. Therefore, at $R_{4/2} = 3.0 - 3.3$, there is a deformed region [(SU(3)]; here, the data is approximately equal to zero. In $N > 104$, the average deviation lies from 0.2 to 0.2 at $R_{4/2} = 2.5$ and that is the maximum deviation in all the corresponding four regions.

Conclusion

The present work provides a new insight to understand the nuclear structure of the ground-state band of $A = 120 - 200$ mass region nuclei. The ground-band energy, by using power law, shows good accuracy in Q-I and Q-II and fairly good in Q-III and Q-IV compared to the other formulae.We also verified it by evaluating the differences between calculated and experimental energies.

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