Yrast band description of $^{80-82}Sr$ and $^{82-84}Zr$ nuclei using two and three parameter formula

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Introduction

Our understanding of nuclear structure is framed within the context of a number of idealized benchmarks. These include the axial rotor [1], the harmonic vibrator [2], γ-soft deformed nuclei [3]-[4] and very recently, the new critical point symmetries [5]-[6] for phase transitional regions. These models generally predict sequences of energies and either subset or all of the $B(E2)$ values within the model space. For example, for the pure rotor, the yrast energies go as J(J+1). No nucleus need obey these paradigms exactly and, historically, their proposal has been rather quickly followed by schemes that embody perturbations to the idealized structures they envision. Examples are the energy expansions in powers of J(J+1), or the Harris formula [7], the variable moment of inertia (VMI) [8], the Ejiri formula [9], and the Holmberg-Lipas formula [10] for rotor-like nuclei.
The simplest well-known examples are the expression for rotational spectra,

$$E = \frac{\hbar^2}{2\Im(J)} J(J+1), \tag{1}$$

(here $\Im$ and J are the moment of inertia and spin of the nuclei, respectively), and the Bohr-Mottelson energy expansion in powers of $J(J+1)$ for deformed nuclei , i.e.,

$$E = AJ(J+1) + B(J(J+1))^2 + C(J(J+1))^3. \tag{2}$$

Holmberg and Lipas [10] noted that the moment of inertia of deformed nuclei increases with level energy linearly, i.e.,

$$\Im(J) = a + bE. \tag{3}$$

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By substituting Eq.(3) in Eq.(1), they obtained the two-parameter ab formula

$$E = a\left[\sqrt{1 + bJ(J+1)} - 1\right], \tag{4}$$

Brentano et. al. obtained the two-parameter formula, called the soft rotor formula (SRF)

$$E = \frac{1}{\Im_0(1+\alpha J)} J(J+1) \tag{5}$$

Gupta et. al. [11] suggested a single-term expression for ground band level energies of a soft-rotor. They replaced the concept of the arithmetic mean of the two terms used in the Bohr-Mottelson expression by the geometric mean and introduced a two-parameter formula called the power law

$$E = aJ^b \tag{6}$$

By using Eq.(6) for any spin (J) the value of b can be determined from the ratio

$$R_J = E/E(2) = (J/2)^b. \tag{7}$$

Result and Discussion

Figure 1 shows the ground energy band for $^{80-82}$Sr and $^{82-84}$Zr nuclei. We compare the calculated result obtained from the ab formula, power law and SRF formula with experimental values. We observe that power law and SRF formula show good agreement with experimental values. Similarly for $^{82-84}$Zr nuclei the power law and SRF is in good agreement as compared to the ab formula. We also able to find some new energy levels of the nuclei.

Conclusion

To summarize, we studied the power law, which is applicable for both deformed and

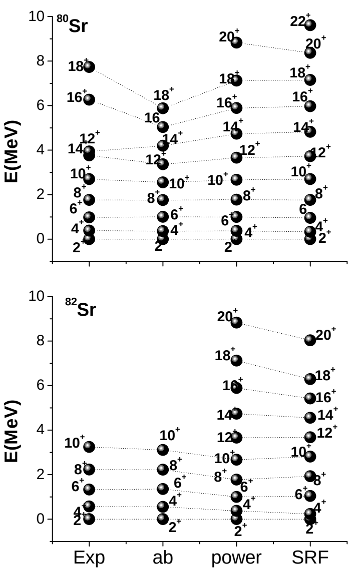

FIG. 1: Result of experimental, ab, power law and soft rotor model (SRF)of ground band energy for $^{80-82}$Sr isotopes.

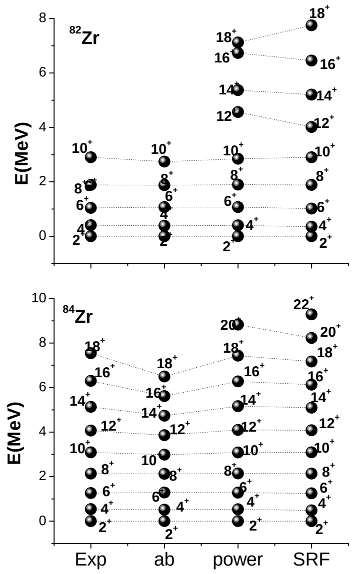

FIG. 2: Result of experimental, ab, power law and soft rotor model (SRF)of ground band energy for $^{82-84}$Zr isotopes.

soft nuclei. The formula is particularly successful in soft rotor and deformed nuclei with $2.8 \leq R_{4/2} \leq 3.3$. In this paper we show that this power law is also alicable for light nuclei of $A < 100$ mass region. We also find some new energy levels that are helpful for experimentalist for their studies.

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