Nuclear structure of Uranium isotopes in the frame work of two parameter formula

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Introduction

There are a number of idealized paradigms to study and understand the nuclear structure, which involve axial rotor [1], anharmonic vibrator [2] and γ-soft deformed nuclei [3, 4]. These models predict energy sequences and $B(E2)$ values. There are several empirical formulae to express the ground state band level energies of nuclei. The simplest well-known examples are the expression for rotational spectra,

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

(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 [5], i.e.,

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

Holmberg and Lipas [6] noted that the moment of inertia of deformed nuclei increases with level energy linearly, i.e.,

$$\Im(J) = a + bE. \quad (3)$$

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

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

Further, Brentano et al. [7] noted that $\Im$ depends upon the spin (J) and energy (E) by relation:

$$\Im = \Im_0(1 + aJ + bE). \quad (5)$$

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By dropping the energy-dependent term in Eq.(6) and substituting the value in Eq.(1), Brentano et al. obtained the two-parameter formula, called the soft rotor formula (SRF)

$$E = \frac{1}{\Im_0(1 + \alpha J)} J(J+1) \quad (6)$$

Gupta et al. [8] 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

$$E = aJ^b \quad (7)$$

By using Eq.(8) for any spin (J) the value of b can be determined from the ratio

$$R_J = E/E(2) = (J/2)^b. \quad (8)$$

Until now scarce informations are available about the Uranium isotopes. The aim of the present work is to study the structure of Uranium isotopes by using power law, ab formula and SRF.

Theory and Method of Calculation

The results obtained by fitting all the two parameter formula, power law, ab, Ejiri and SRF formula, to 6^+, 8^+ energy levels are summarized in Figure 1. Power law, ab formula and SRF give good agreement for deformed and soft nuclei by fitting to the energy levels. The SRF formula also gives predicted energy levels up to $J = 42$. All predicted values are in excellent agreement with the experimental values.

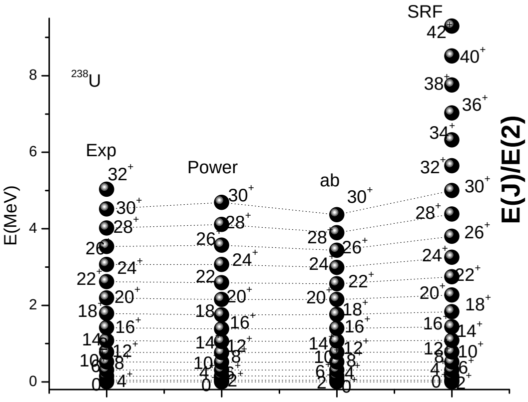

FIG. 1: Comparison between the experimental spectra and theoretically calculated spectra of ^{238}U nuclei.

Figure 2 displays the ratios of $E(J)/E(2_1^+)$ of $^{232-238}$U as a function of angular momentum J. The staggering is negligible in between the even positive parity states and lying close to each other. We note that predicted energy ratio by using power law, ab formula and SRF are in good agreement with the experimental data

Conclusion

To summarize, we studied the power law, ab formula and SRF which are applicable for both deformed and soft nuclei. The formula is particularly successful in soft rotor and deformed nuclei with $2.8 \leq R_{4/2} \leq 3.3$. The power law gives good fit of the data for b and a derived either from 2^+, 4^+ or 6^+, 8^+ energy levels. This study help to understand the structure of isotopes of Uranium and useful to find some new energy level of these isotopes theoretically.

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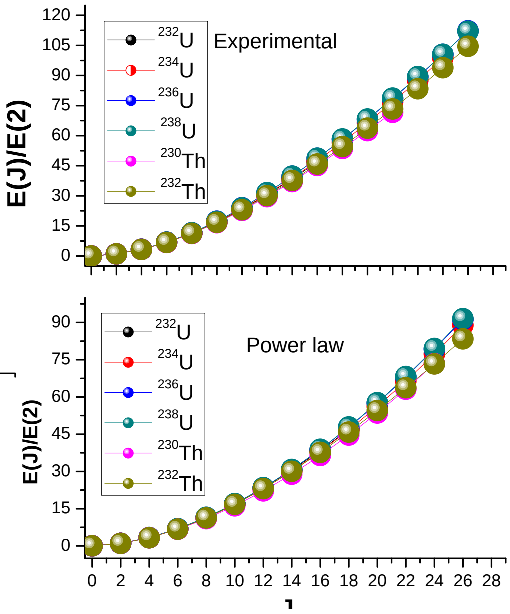

FIG. 2: The experimental and calculated energy ratio $E(J)/E(2)$ by using power law for different isotopes of Uranium.

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