Study of Potential Energy Term in VMINS model

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1. Introduction

Now, it has been experimentally [1] suggested that the ground state bands for even-even nuclei away from closed shells can be expected throughout the Periodic Table. Theoretically, a number of models [2-7] have been proposed to correlate such a data. In this attempt, the variable moment of inertia (VMI) model proposed by Mariscotti *et al*; [2] is one of the earliest and very popular among the nuclear science community. In this model, the excitation energy of the state J is defined as the sum of the rigid rotational energy (with moment of inertia 'θ' varying with angular momentum 'J') and a potential energy term (harmonic in angular momentum dependent moment of inertia θ_J about its mean ground state value θ_0. Latter this VMI model extended by Klein and his associates [5, 6] on the basis of the predictions of the interacting boson model [IBM-1] in to two generalizations of VMI model, namely, the Variable A harmonic Vibrator Model (VAVM) and the Generalized VMI (GVMI) model. Batra *et al*; [7-9] extended VMI model by taking in to account the concept of nuclear softness. This extended version of VMI generally called VMINS model. In this present work we studied the importance of potential energy term in VMINS model.

2. The Model

In the original variable moment of inertia (VMI) [2] model, the excitation energy of the member of the ground-state band with angular momentum J is given by

$$E(J) = \frac{\hbar^2}{2I} J(J+1) + \frac{c}{2}(I - I_0)^2 \qquad \text{(i)}$$

Here the potential term is added to the usual rotational term. The coefficients c and I_0 are parameters, characteristic for each nucleus. Where I_0 is called the ground state moment of inertia and c is denoted as stiffness parameter.

Gupta *et al*; [7, 8] expressed the variable moment of inertia (VMI) model for the ground state band in even-even nuclei in terms of his nuclear softness (NS) model [3]. In NS model the variation of moment of inertia θ with J is given by

$$\theta = \theta_0(1 + \sigma J) \qquad \text{(ii)}$$

Where θ_0 is the ground state moment of inertia and σ is the softness parameter.
After putting the value of Moment of Inertia (I) in terms of Nuclear Softness Parameter (σ) in equation (i) we get the following expression-

$$E(J) = \frac{\hbar^2 J(J+1)}{2\theta_0(1+\sigma J)} + \frac{C}{2}\sigma^2\theta_0^2 J^2 \qquad \text{(iii)}$$

Equation (iii) has three parameters
(a) Ground State Moment of Inertia (θ_0)
(b) Softness Parameter (σ)
(c) Stiffness Constant (C)

Two of the parameters Ground State Moment of Inertia (θ_0) and Stiffness Parameter (C) are same as 'I_0' and 'c' in original VMI model, while the Softness Parameter (σ) is different parameter which represents the softness of a particular nucleus. The first term in right hand side of equation (iii) has two parameters (i.e. θ_0 & σ), while the second term has three parameters (i.e. C, θ_0 & σ). The parameters θ_0 and σ are calculated by following the conditions given in reference [9].

In the present work we study the second term of equation (iii) (i.e. Potential Energy Term, $E_{pot.}$) with spin 'J' of the nucleons and with ground state of moment of inertia and with nuclear softness parameters of different nuclei of quadrant-I.

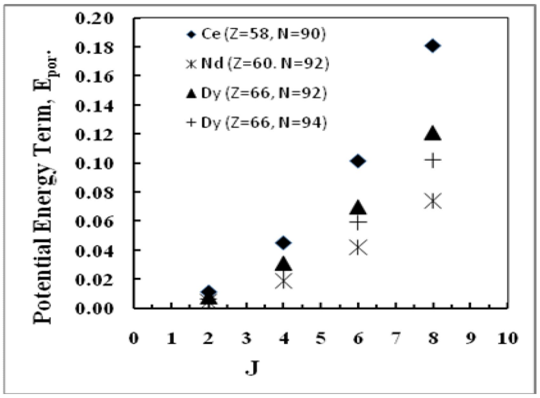

Fig- (1): Variation of Potential Energy Term ($E_{pot.}$) with Spin (J).

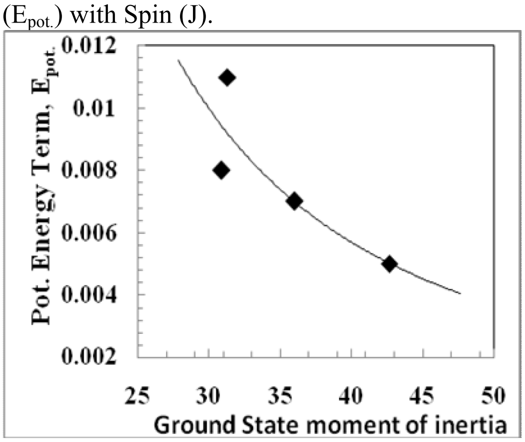

Fig-(2): The Variation of Potential Energy Term ($E_{pot.}$) with Ground State Moment of Inertia.

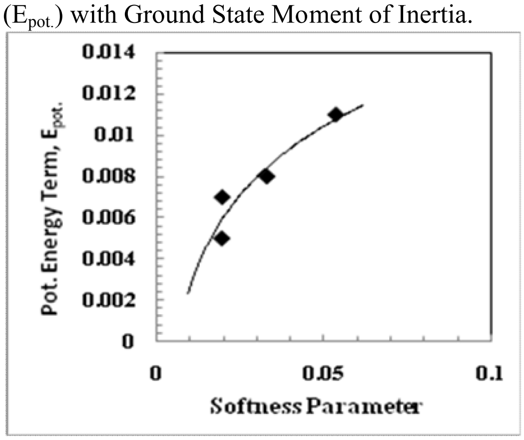

Fig-(3): The Variation of Potential Energy Term ($E_{pot.}$) with Nuclear Softness Parameter.

3. Result and Discussion

3.1: Dependence of E_{pot} on Spin J

The variation of potential energy term for the different even-even nuclei in the region of I-quadrant based on the valence particle and hole pairs consideration [8]{Ce(N=90), Nd (N=92), Dy (N=92) & Dy (N-94)} with spin (J) has been shown in fig. (1). It is clear from fig. (1), that the value of potential energy term is increasing almost linear with increasing spin (J) for all the nuclei. In case of Dy (D=92) the potential energy term is less than that of Dy (N=94) for a particular value of spin (J).

3.2: Dependence of E_{pot} on Ground State Moment of Inertia

In figure (2) the variation of potential energy, $E_{pot,}$ with ground state moment of inertia is shown. It is apparent from this figure that the potential energy term is decreases almost exponentially with ground state moment of inertia.

3.3: Dependence of E_{pot} on Nuclear Softness Parameter

In figure (3) the variation of potential energy, E_{pot}, with nuclear softness parameter has shown. The nuclear softness parameter of nuclei is increases with nuclear softness parameter in the same way as that of decreases with ground state moment of inertia.

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