*Available online at* www.pelagiaresearchlibrary.com

**Pelagia Research Library**

**Advances in Applied Science Research, 2012, 3 (5):2648-2651**

**ISSN: 0976-8610**
**CODEN (USA): AASRFC**

# An Analytical Study of Potential Energy Term in Variable Moment of Inertia Nuclear Softness (MINS) Model

**Hardik P. Trivedi[1], Pallavi Bhatt[1], Anil Kumar [1, 2]*, Lalit K. Gupta[3], Jai Prakash Gupta[4], Krishna Chandra[5], Than Singh Saini[6] and Archna Kansal[7]**

[1]*Department of Physics, Mewar University, Chittorgarh (Rajasthan) INDIA*
[2]*Deptartment of Physics, Vivekananda College of Technology and Management, Aligarh (UP) – 202 002, INDIA*
[3]*Department of Physics, Krishna Engineering College, Ghaziabad, INDIA*
[4]*Department of Physics, D. S. College, Aligarh (UP) - 202 001, INDIA*
[5]*Department of Physics, Goldfield institute of Technology & Management, Faridabad-, INDIA*
[6]*Department of Physics, Delhi Technological University, Delhi-42 INDIA*
[7]*Department of Physics, ITM, Gwalior (MP) INDIA*

---

**ABSTRACT**

*In this paper, we have calculated potential energy term in variable moment of inertia nuclear softness which shows 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). The value of potential energy term is increasing almost linear with increasing spin (J) for all the nuclei.*

**Key Words:** *Ground State Moment of Inertia ($\theta_0$); Softness Parameter ($\sigma$); Stiffness Constant (C)*

---

## 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 $\theta_J$ about its mean ground state value $\theta_0$. 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 An harmonic Vibrator Model (VAVM) and the Generalized VMI (GVMI) model. Batra *et al;* [7-10] extended VMI model by taking in to account the concept of nuclear softness. This extended version of VMI generally called VMINS model. In the present work we studied the importance of potential energy term using VMINS model.

## MATERIALS AND METHODS

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 $\theta_0$ 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 ($\theta_0$)
(b) Softness Parameter (σ)
(c) Stiffness Constant (C)

Two of the parameters Ground State M I ($\theta_0$) 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. $\theta_0$ & σ), while the second term has three parameters (i.e. C, $\theta_0$ & σ). The parameters $\theta_0$ 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.

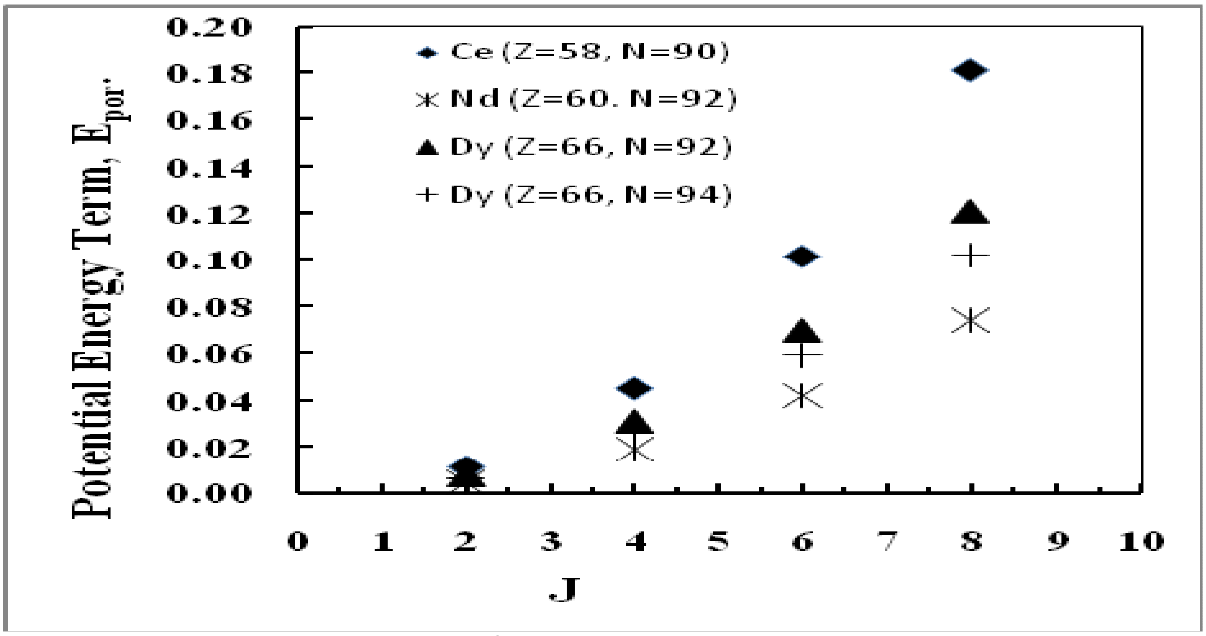


**Fig.-(1): Variation of Potential Energy Term ($E_{pot.}$) with Spin (J).**

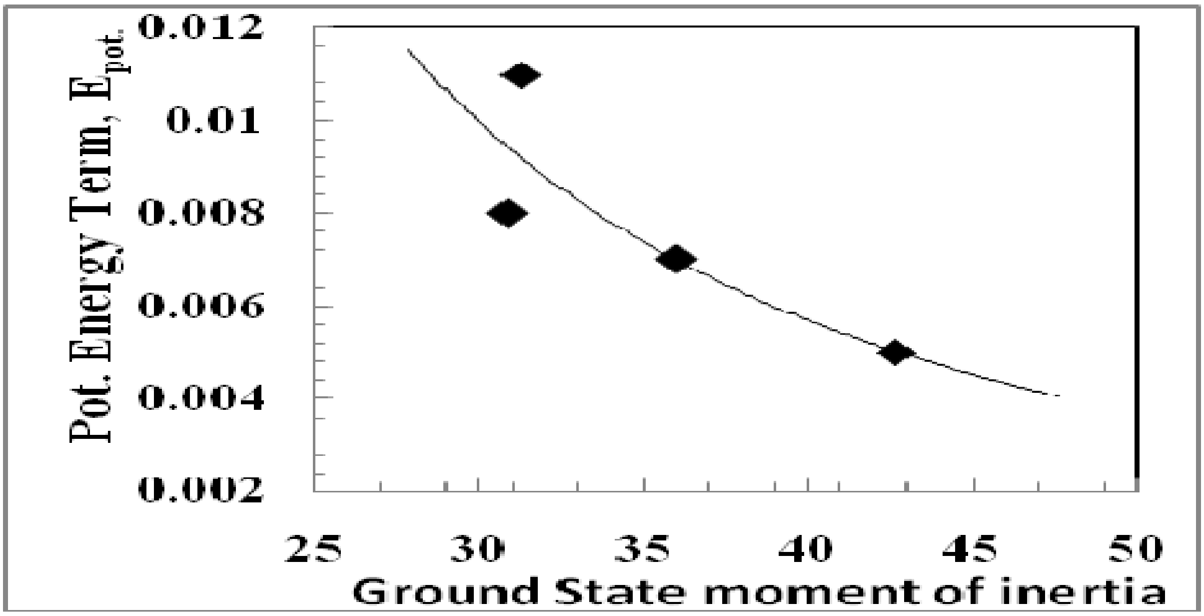


**Fig.-(2): The Variation of Potential Energy Term ($E_{pot.}$) with Ground State Moment of Inertia.**

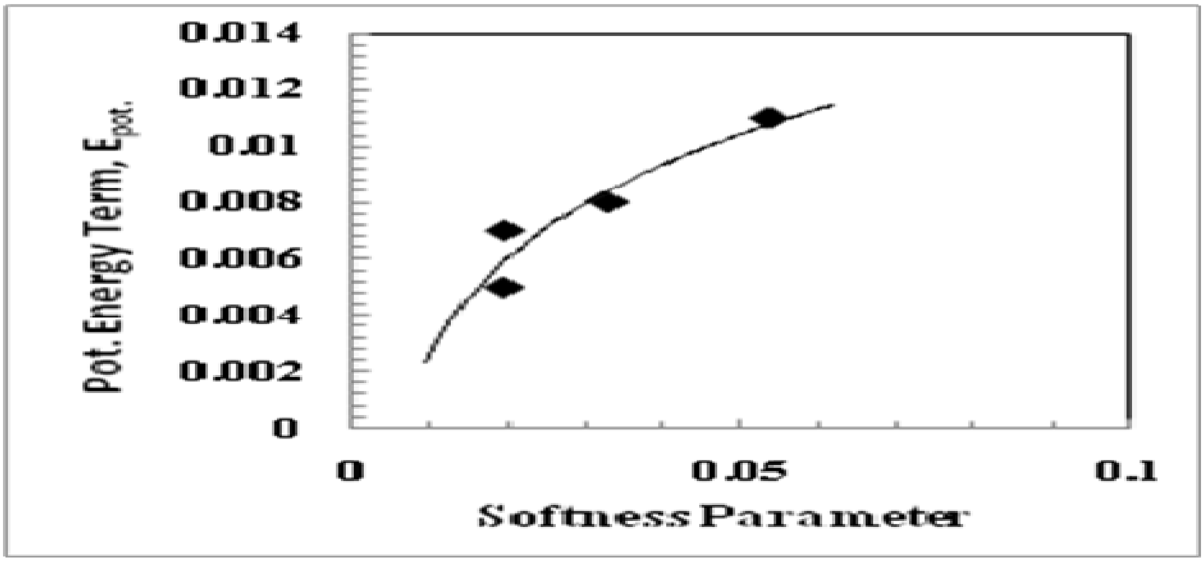


**Fig.-(3): The Variation of Potential Energy Term ($E_{pot.}$) with Nuclear Softness Parameter.**

## RESULTS AND DISCUSSION

### (a) 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).

**(b) 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.

**(c) 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.

**Acknowledgement**

Hardik P. Trivedi. is very grateful to the Dr. Ajay Kumar Mahur and Dr. R. K. Saraswat Associate Professor, Department of Applied Science, VCTM, Aligarh for fruitful discussion and proper guidance.

## REFERENCES

[1] M. Sakai, Quasi-Bands (Institute for Nuclear Study, University of Tokyo, Tokyo, **1982**)
[2] M. A. J. Mariscotti, G. Scharff-Foldhaber and B. Buck, Phys. Rev. 178, 1864 (**1969**)
[3] R. K. Gupta, Phys. Lett. 36B, 173 (**1971**)
[4] M. Satpathy and L. Satpathy, Phys. Lett. 34B 377 (**1971**)
[5] D. Bonatsos and A. Klein, Phys. Rev. C29, 1879 (1984), Atomic data and Nuclear Data Tables 30, 27 (**1984**)
[6] A. Klein, Nucl. Phys. A 347, 3(**1980**)
[7] R. K. Gupta, *et al;* Nucl. Data for Sci. & Tech. (Mito, Japan), 729 (**1988**)
[8] J. S. Batra, *et.al;* Phys. Rev. C43, 1725(**1991**)
[9] J. B. Gupta, *et al;* Phys. Rev. C56, 6, 3417 (**1997**)
[10] J. H. Hamilton, *et.al;* Bull. Am. Phys. Soc. 32, 2130 (**1987**)