Systematic dependence of asymmetric parameter in light and medium mass region

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Introduction

The study of collective nuclear structure with N, Z, N_B and N_pN_n provide a detailed information of nuclear interactions involved. Several studies have been carried out to study the collectivity, deformation and systematic dependence of other nuclear properties on N_pN_n. de-Shalit & Goldhaber [1] pointed out the important role of valence nucleons. Talmi [2] noted the constancy of nuclear level structure in semi-magic isotones/isotopes. Hamamoto [3] observed that the p^+ & n^0 both are required for producing deformation. In IBM-1[4], the structure of nuclei depends on the total boson numbers N_B**.** The concept of F-spin multiplets was based on this and was well explained by Brentano et al. [5]. Casten [6] noted that the E_{2g}+ have smooth dependence on N_pN_n. Various studies [7] have been carried out to study the collectivity, deformation and systematic dependence of various nuclear observables on the product N_pN_n.

Gupta [8] observed that 1/α was linearly dependent on N_pN_n, where the coefficient α contributes for rotational part of energy in the SU(3) symmetry limit of IBM[4] as,

$$E([N](\lambda, \mu)\ KLM) = \alpha\ L(L+1) + \beta\ C(\lambda, \mu)$$

The $B(E2;\ 2_1^+ \rightarrow 0_1^+)$ values were also related with N_pN_n. Gupta et al. [9] noted a systematic dependence of γ–g B(E2) ratios on the N_pN_n in different parts of the major shell space Z=50–82, N<82 and N=82–126. Casten and Zamfir [6] presented a review on the evolution of nuclear structure based on N_pN_n product. The N_pN_n scheme was further modified to use P- factor [9].

In this paper, we study the role of valence nucleons and holes on the nuclear structure, through N_pN_n. Casten and Zamfir [7] covered the various regions, viz., A=100, 130, 150 (Z<64, Z>64) and A=190. We present our results for 50≤Z≤82 and 82≤N≤126 region on *quadrant wise basis*.

The values of asymmetry parameter (γ) have been calculated for 50≤Z≤82 and 82≤N≤126 region and the whole data is divided into four quadrants and it has been plotted with N_pN_n to study its systematics dependence.

Calculation of Asymmetric Parameter

The value of γ can be evaluated using the experimental energies $E2_2^+$ and $E2_1^+$ states [10]. The energy ratio $R\gamma = E_{2\gamma} / E_{2g}$ and γ is:

$$\gamma = (1/3)\sin^{-1}[(9/8)\{1-((R\gamma-1)/(R\gamma+1))^2\}].$$

It can be evaluated using: (a) The energy ratio $R_4 = (E_{4g}/E_{2g})$ but only the nuclei with $2.8 \leq R4 \leq 3.33$ will be allowed [11, 12]. (b) The B(E2) values which are very small and available with uncertainties. Therefore the values from energy ratio Rγ are more reliable.

Result and discussions

The variation of γ versus Np.Nn product for quadrant-I for 50≤Z≤66 and 82≤N≤104 has been shown in Fig. 1. There is smooth dependence of γ with NpNn. The γ decreases from a maximum value of 30° for N_pN_n =0 (i.e. SU(5) limit of IBM) to a minimum values of about 9°(i.e. SU(3) limit of IBM). The γ saturates for $N_pN_n \geq 30$. This shows non-dependence of γ with N_pN_n

because for a fixed value of N_pN_n the γ is having varying values.

The variation of γ versus N_pN_n for quadrant-II for $66 \leq Z \leq 82$ and $82 \leq N \leq 104$ has been shown in Fig. 2. There is smooth dependence of γ with N_pN_n except Yb for N_pN_n >50 and few Pt isotopes.

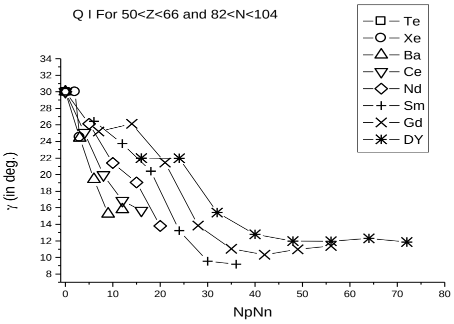

Fig.1 The variation of asymmetric parameter (γ) versus N_pN_n.

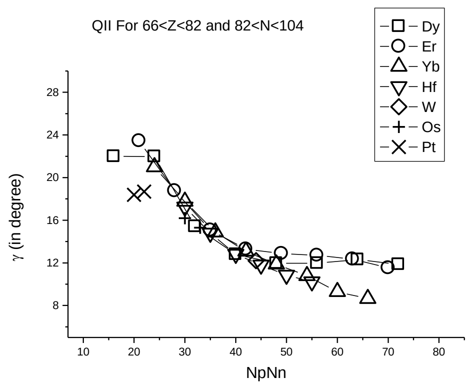

Fig. 2 The variation of asymmetric parameter (γ) versus N_pN_n product for quadrant-II.

The variation of γ versus N_pN_n for quadrant-III for $66 \leq Z \leq 82$ and $104 \leq N \leq 126$ has been shown in Fig. 3. There is smooth dependence of γ with N_pN_n except Hg isotopes.

The graphs of γ against N_pN_n vividly displays the formation of isotonic multiplets in quadrant-I, strong dependence on N_pN_n in quadrant-II and weak constancy with Z in quadrant-III is illustrated and support the findings of Gupta [13].

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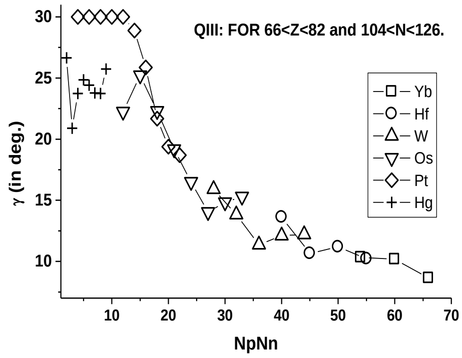

Fig. 3 The variation of asymmetric parameter (γ) versus N_pN_n product for quadrant-III.

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