Energy Staggering As A Signature Of Collectivity In Nuclei

Amit Bindra
Department of Physics, School of Chemical Engineering and Physical Science,Lovely Professional University
Jalandhar-144011, INDIA

The odd even staggering of gamma band can be viewed as a structural indicator and important to observe the triaxiality in nuclei. TheS(4) can be viewed as signature to observe the triaxiality. The parameter S(4) plotted against Neutron Number N shows sudden jumps from positive to negative values give behavior of transitional nuclei.

Keywords: Nuclear Structure, Staggering, Asymmetric Rotor Model, Moment of inertia.

1. Introduction :

The N = 90 isotones is the best known and most thoroughly studied nuclear region where the isotones are seen to have a maximum deformation. It is interesting to make a correlation between asymmetric parameter(γ), $R_{4/2}$ and energy staggering.Recent experimental data of $R_{4/2}$ have been taken from the website of national nuclear data center, Brookhaven National Laboratory, USA.

Davydov and filippov [1] proposed asymmetric rotor model (ARM) to explain these deviations with the asymmetric parameter ϒ. ϒ varies between 0 and $\pi/3$ and reflect the shape transition in the nucleus from axial symmetry. However BE(2) ratios changes around 140% for ϒ ~ 0^0 to 30^0 when the axial symmetry of nucleus is violated. The staggering S(4) act as a important signature [2] to study the symmetryof nuclei. A deviation in ϒ- band energy staggering from vibrator to axially symmetric rotor indicates the transitional region. The staggering index $S(4)$ clearly defines as 1.67 for rigid triaxial rotor and 0.33 for axially symmetric rotor. For spherical vibrator = −1.0.and for γ -soft rotor, $S(4) = -2.0$.

The Bohr and Mottelson model [3] has been widely used to study the deformation of the nucleus. The energy expression for the study of rotational spectra is

$$E = \frac{\hbar^2}{2\mathfrak{I}} J(J+1)$$

where $\mathfrak{I}$as moment of inertia and J spin of nuclei. For the well deformed nuclei the moment of inertia [4] increases sharply around N = 90 are illustrated.

2. Present Approach

In section 2.1 we study the first differences of $R_{4/2}$ with asymmetric parameter ϒ and neutron number and S(4) vs n and moment of inertia to understand the triaxiality in nuclei at N = 90.

These nuclei lie at an abrupt transition between spherical and rotational nuclear shapes and because of this, have been the subjects of intensive study. The origin of the different deformations is attributed to a subshell closure [5-7] at Z = 64. Figure 1 shows a plot of $\delta R_{4/2}$ = $\delta \frac{E4_1^+}{E2_1^+}$ [6] (as the first differences of this quantity) against an asymmetric parameter lying between γ~ 14^0 for N = 90 isotones. The importance of asymmetric parameter [7] with quadrupole deformation has always been important for the study of nuclear structure.

$$\gamma = \frac{1}{3}\sin^{-1}\left[\frac{9}{8}\left(1-\left(\frac{R_\gamma - 1}{R_\gamma + 1}\right)^2\right)\right]^{\frac{1}{2}}$$

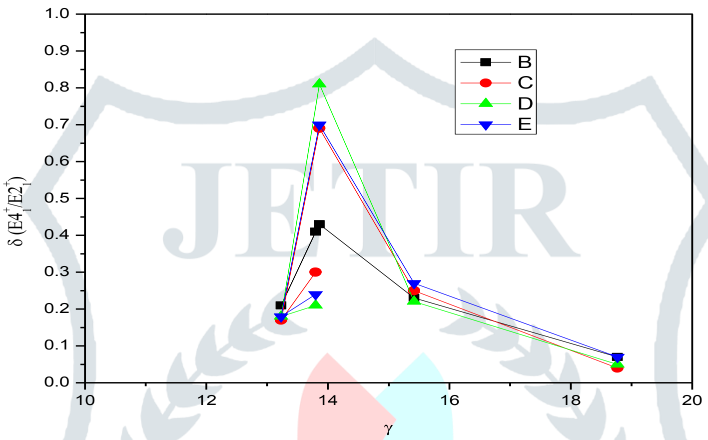

Fig 2.1 $R_{4/2}$(as the first differences) plotted against a asymmetry parameter γ for N = 90

N	Nd	Sm	Gd	Dy
86		-0.437	- 0.7296	
88	-0.3	-0.517	-0.605	-0.594
90	0.108	-0.083	0.036	0.107
92		0.2562	0.1526	0.2117

Table 2.1 S(4) values vs neutron number

The kink in the systematic is exactly the limiting value of γ unstable nuclei and close to the value of triaxiallity.

In present section **2.2** the staggering quantity S(4) is is plotted against a neutron number.

The odd even staggering studied vary in magnitude and cganges its value from positive to negative is found to be a good indication of structure

Odd-even staggering in γ bands can be studied while using the relation

$$S(J) = \frac{\{E(j_\gamma^+) - E[(j-1)_\gamma^+]\} - \{E[(j-1)_\gamma^+] - E[(j-2)_\gamma^+]\}}{E(2_\gamma^+)}$$

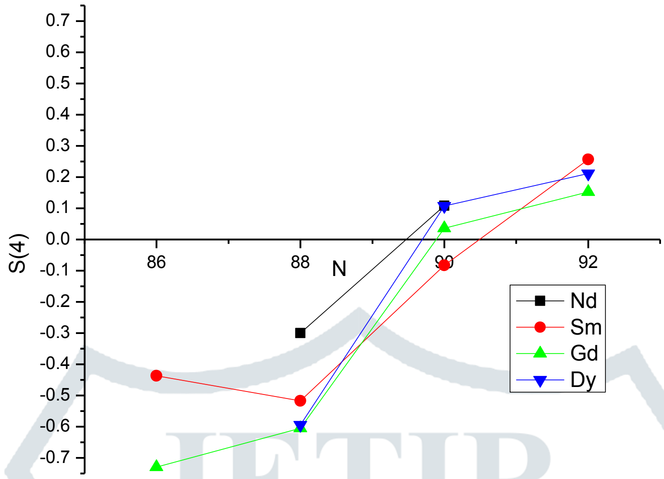

Fig 2.2 Plot between Staggering Signature S(4) varies as a function of collective structure vs neutron number transitional behavior seen around N= 90

N	Nd	Sm	Gd	Dy
86		-0.437	-0.7296	
88	-0.3	-0.517	-0.605	-0.594
90	0.108	-0.083	0.036	0.107
92		0.2562	0.1526	0.2117

Table 2.2 S(4) values vs neutron number

The sudden jumps in S(4) values from slightly negative values to positive values around N = 90 indicates the shape transitional nuclei and triaxiality in behavior.

Conclusion : The Present study reflects that the Energy ratio $R_{4/2}$ plotted against asymmetry parameter γ shows sharp kinks at γ = 14^0~ 16^0 a region of N =90 Isotones and staggering parameter S(4) plotted against Neutron Number N shows sudden jumps from positive to negative values give behavior of transitional nuclei and shows triaxiality near N = 90 isotones. The increased value of moment of inertia around N= 90 confirms that isotones showstriaxiality. These idea allows a detailed understanding of deformation and can be extended to other nucleons.

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