Validity of Grodzins linearity relation for $4_1^+$, $6_1^+$ states

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The well known Grodzins product rule, (GPR) [1] implies that the product of $B(E2, 0^-\rightarrow 2_1^+)$ and level energy $E(2_1^+)$ in ground bands of even Z even N nuclei is almost a constant, even if the two entities vary by large amount with N and Z. Raman et. al. (1988) [2] on empirical basis suggested the GPR relation

$$E(2_1^+)\times B(E2)\uparrow=2.57(45)Z^2A^{-2/3} \quad (1)$$

$B(E2)$ is in e$^2$b$^2$ units and $E(2_1^+)$ is in keV.

In our earlier study [3, 4], we expressed this relation in the form

$$B(E2)\uparrow=\text{constant} \times (1/E(2_1^+)) \times A^{-2/3} \quad (2)$$

For a range of isotopes of any given element, this yields a linear relations of $B(E2)$ versus the reciprocal $1/E(2_1^+)$. This was verified for the mid mass region, as well as light mass ($N<82$) region of nuclei. Here we test the linearity relation for spin $4_1^+$ and $6_1^+$. However, instead of the reciprocal of energy value $E(2_1^+)$, we use the reciprocal of energy $E_\gamma$ for transition from $4_1^+$ and $6_1^+$. The data is taken from [5].

Results

Out of our study for many nuclei in the Z=54-78 series of isotopes, here we present one example for each of the 4 quadrants for $4_1^+$ state, and one for $6_1^+$ state. Note that the reciprocal $1/E_\gamma(4-2)$ is related to the kinetic MoI of $4_1^+$ state. The same holds for $6_1^+$ state. Thus our linearity plots indicate the linearity relation of $B(E2, 4-2)$ to the corresponding MoI.

Conclusion

Each of our plot also gives an additional information regarding the slow or fast variation of the MoI with neutron number N in the given element. The shape phase transition with N can also be visible. Thus our plots are very useful for the study of structural changes with N.

References

5. www.nndc.gov.in

Available online at www.sympnp.org/proceedings
Fig. 1. $B(E2; 4^+_1 \rightarrow 2^+_1)$ versus $1/E(4^+_1 - 2^+_1)$ for $^{126-134}$Ba isotopes.

Fig. 2. $B(E2; 4^+_1 \rightarrow 2^+_1)$ versus $1/E(4^+_1 - 2^+_1)$ for $^{148-154}$Sm isotopes.

Fig. 3. $B(E2; 4^+_1 \rightarrow 2^+_1)$ vs $1/E(4^+_1 - 2^+_1)$ for $^{156-160, 164-168}$Er isotopes.

Fig. 4. $B(E2; 4^+_1 \rightarrow 2^+_1)$ versus $1/E(4^+_1 - 2^+_1)$ for $^{184-192}$Os isotopes.

Fig. 5. $B(E2; 6^+_1 \rightarrow 4^+_1)$ versus $1/E(6^+_1 - 4^+_1)$ for $^{120-128}$Xe isotopes.