Extended Grodzins relation for higher spin Dy Nuclei

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In the last fifty years, the data on the reduced transition probability $B(E2; 2_1^+ \rightarrow 0_1^+)$ and the first excited states $E(2_1^+)$ in ground state band of the even *Z* even *N* nuclei have been compiled and updated in [1] and [2].

Long ago, Grodzins [3] pointed out the intimate relation of the two quantities and demonstrated the linear relation between the two, i.e. the product $E(2_1^+) \times B(E2; 2_1^+ \rightarrow 0_1^+)$ is a constant globally for vibrational as well as deformed nuclei. Recently, the smooth systematics of $B(E2; 2_1^+ \rightarrow 0_1^+)$ versus *A* have been displayed [4]. These data provide useful information on the collective structure of the even *Z* even *N* nuclei.

In the present work, we test the Grodzins product rule for the higher spin in the ground band. That is we search for the intimate relation between the $B(E2;(I+2) \rightarrow I)$ and $[E(I+2) - E(I)]$. Here we plot for these quantities for spin 2, 4 and 6 for Dy nuclei. Here the data are taken from NNDC website [5].

Conclusion: The Grodzins relation is equally applicable for higher spin.

Firstly, we plot the energy of first excited states $E(2_1^+)$ with neutron number (*N*). It is observed from the fig. 1 as the neutron number (*N*) increasing from 84 to 98, the energy $E(2_1^+)$ decreases whereas the reduced transition probability $B(E2; 2_1^+ \rightarrow 0_1^+)$ increases, as shown in fig. 2.

Then for next higher spin from spin *I*=4 to 2, the energy difference $\Delta E_{42} = E(4_1^+) - E(2_1^+)$ on plotting with neutron number shows that in fig. 3 as *N* increases the energy difference decreases. Whereas the reduced transition probability $B(E2; 4_1^+ \rightarrow 2_1^+)$ is increases in fig. 4. The trend of energy and B(E2) for spin I=4 to 2 is similar to the nature of the spin I=2 to 0.

Also for spin $I = 6$ and 4, the energy difference $\Delta E_{64} = [E(6_1^+) - E(4_1^+)]$ with neutron number *N* is shown in fig. 5 and the energy difference decreases as the neutron number increases. The reduced transitions probability $B(E2;6_1^+ \rightarrow 4_1^+)$ increases as the neutron number increases. The next higher spins also show same type of the nature.

References : [1] P. H. Stelson & L. Grodzins, Nuclear Data Sheets Section A, Volume 1,1965, Pages 21-102 (1965).
[2] S. Raman, C.W. Nestor Jr., and P. Tikkanen, At. Data Nucl. Data Tables **78**, 1 (2001).
[3] L. Grodzins, Phys. Lett. **2**, 88 (1962).
[4] B. Pritychenko et. al. Atomic Data and Nuclear Data Tables, Vol. 107, pages 1-139 , Jan 2016
[5] http://www.nndc.bnl.gov

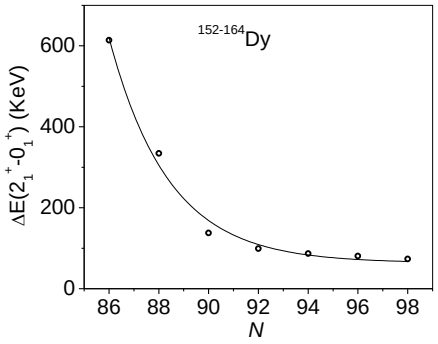

Fig.1 The energy $E(2_1^+)$ with neutron number N

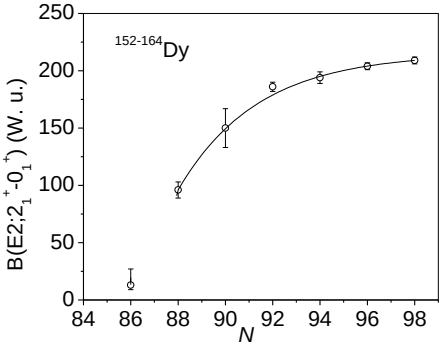

Fig.2 The $B(E2;2_1^+ \rightarrow 0_1^+)$ with neutron number N

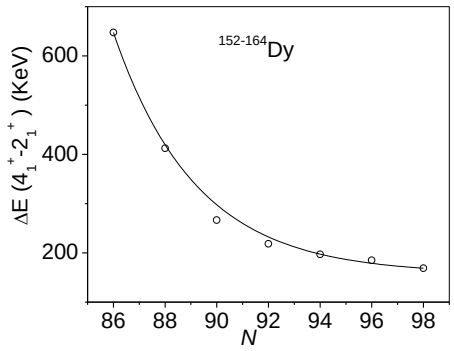

Fig.3 The energy $E(4_1^+\text{-}2_1^+)$ with N

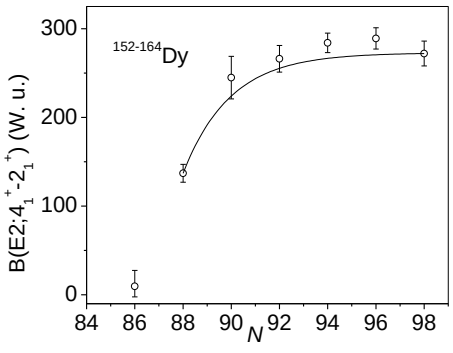

Fig.4 The $B(E2;4_1^+ \rightarrow 2_1^+)$ with N

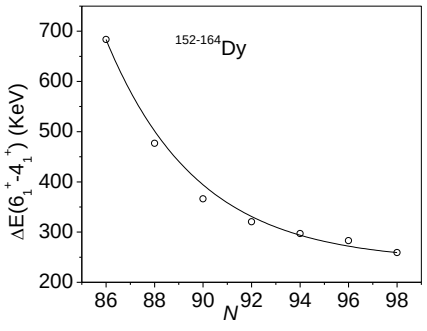

Fig.5 The energy $E(6_1^+\text{-}4_1^+)$ with N

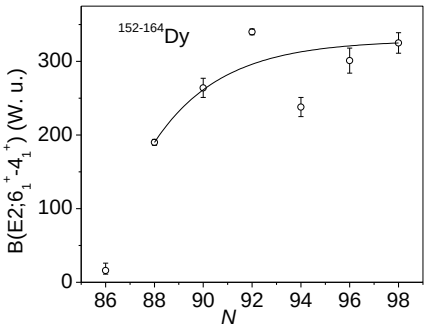

Fig.6 The $B(E2;6_1^+ \rightarrow 4_1^+)$ with N