B(E2) predictions of the proxy-SU(3) symmetry for isomeric states

Andriana Martinou[1], S.K. Peroulis[1], I. E. Assimakis[1], N. Minkov[2]

[1]Institute of Nuclear & Particle Physics, NCSR "Demokritos", GR–15310, Aghia Paraskevi, Greece

[2]Institute of Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences, 72 Tzarigrad Road, 1784 Sofia, Bulgaria

Motivation

The principal motivation is to understand the nature of the isomeric states. Do they derive from unusual ΔK transitions? Are they due to shape coexistence, or due to shape transitions?

Shell Model SU(3) Symmetry

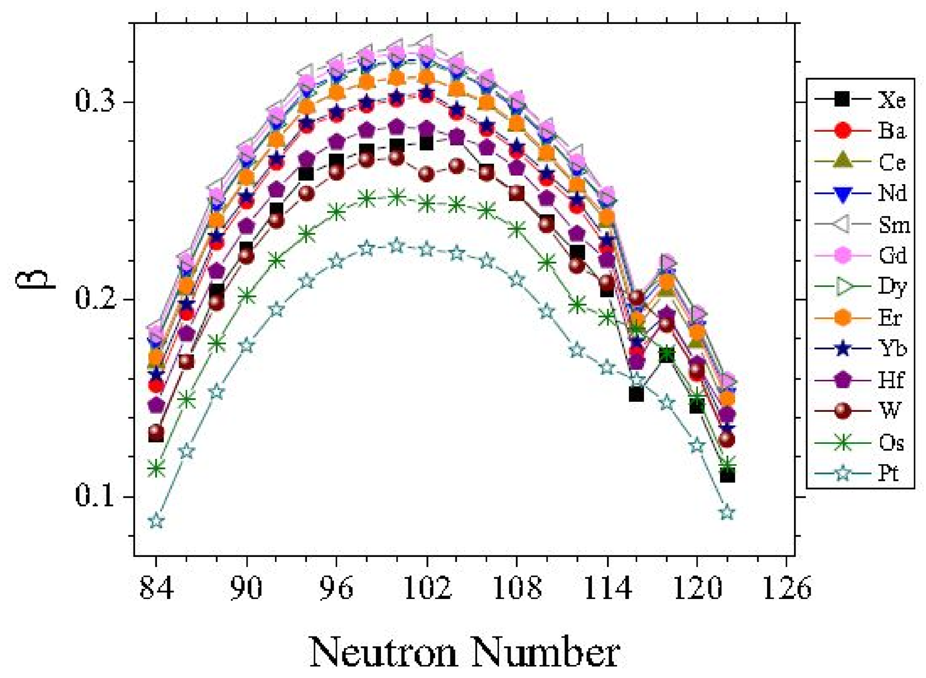
- Introduced by J. P. Elliott in 1958 [1].
- Explains the occurence of the rotational spectra.
- Valid in the light nuclei.

Proxy-SU(3) Symmetry

- Introduced by D. Bonatsos et al. in 2017 [2].
- Expands the Shell Model SU(3) Symmetry in the heavy nuclei.
- Matches the intruder orbitals of each spin-orbit like shell to their de Shalit-Goldhaber counterparts [3].

Prolate-Oblate Shape transition

- Explained in 2017 [4] without any parameter with the use of the proxy-SU(3) symmetry.
- Predicts the prolate-oblate shape transition at the neutron number N=114.



B(E2)s in Proxy SU(3)

B(E2) values are extracted within the Proxy-SU(3) scheme using the expression [5]:

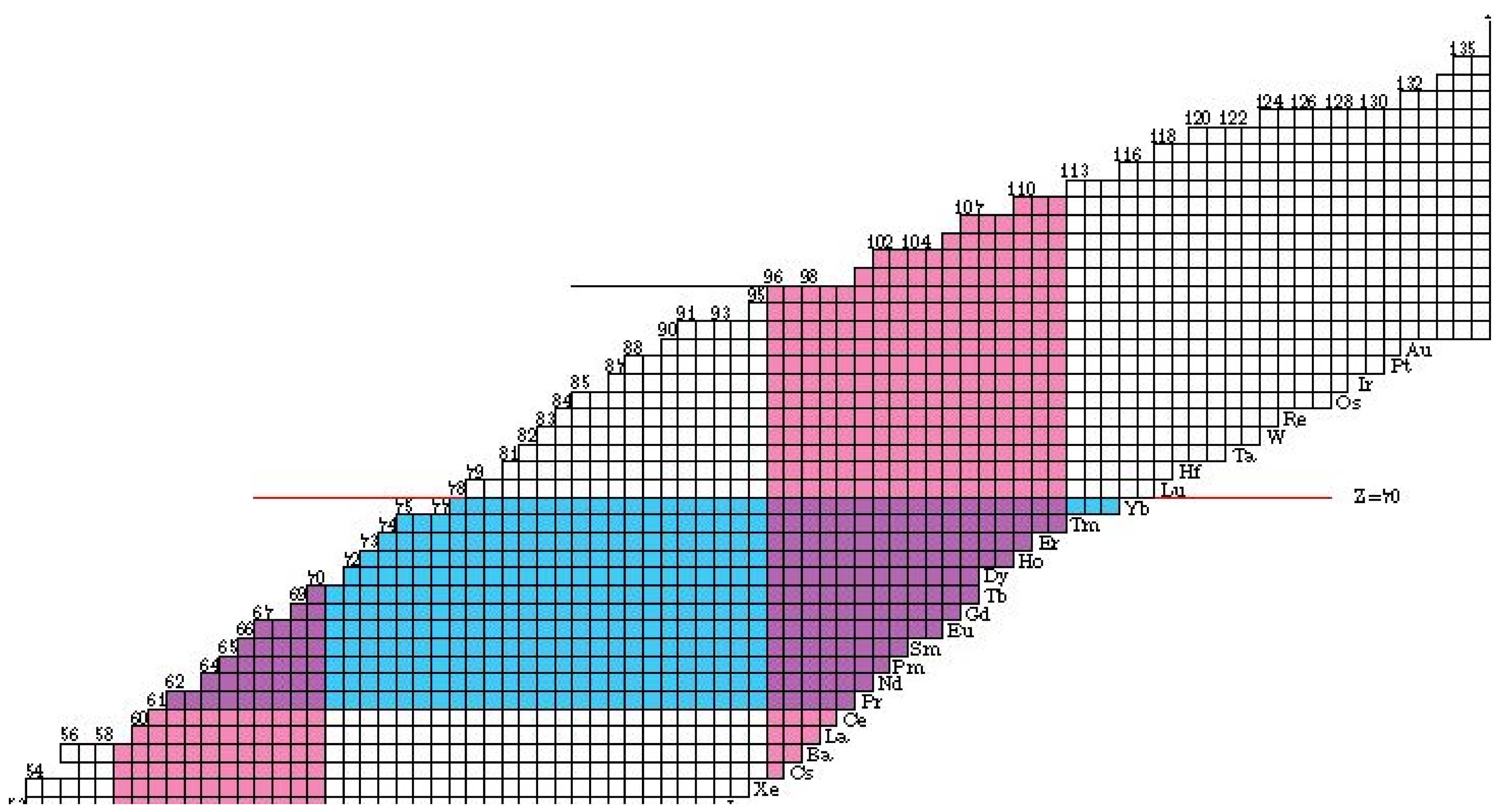
$$B\left(E2; K_i L_i \rightarrow (\lambda,\mu) K_f L_f\right) = \frac{5}{\pi} 1.01^4 A^{2/3} C_2 \frac{2L_f+1}{2L_i+1} \langle (\lambda,\mu) K_i L_i; (1,1) 2 \| (\lambda,\mu) K_f L_f \rangle^2 e^2 fm^4$$

- C_2 is the SU(3) Casimir operator related with the nuclear deformation.
- $\langle (\lambda,\mu) K_i L_i; (1,1) 2 \| (\lambda,\mu) K_f L_f \rangle$ is the $SU(3)$ to $SO(3)$ coefficient calculated by the code of Ref. [6].

Table 1: Predictions for the $6^+ \rightarrow 4^+$ and $10^+ \rightarrow 8^+$ B(E2) transition rates (in W.u.) in ^{178}W and ^{182}W isomeric states guessing different isomer K-values.

Isotope	L_i	L_f	K_i	K_f	E_i (keV)	E_f (keV)	B(E2) Theory	B(E2) Data
^{178}W	6^+	4^+	6	0	1664.94	342.74	$6.58 \cdot 10^{-11}$	0.00046
^{178}W	6^+	4^+	4	0	1664.94	342.74	0.00056	
^{182}W	10^+	8^+	10	0	2230.65	1144.32	0	
^{182}W	10^+	8^+	8	0	2230.65	1144.32	$5.14 \cdot 10^{-10}$	$1.9 \cdot 10^{-6}$
^{182}W	10^+	8^+	6	0	2230.65	1144.32	$3.29 \cdot 10^{-8}$	
^{182}W	10^+	8^+	4	0	2230.65	1144.32	$1.34 \cdot 10^{-3}$	

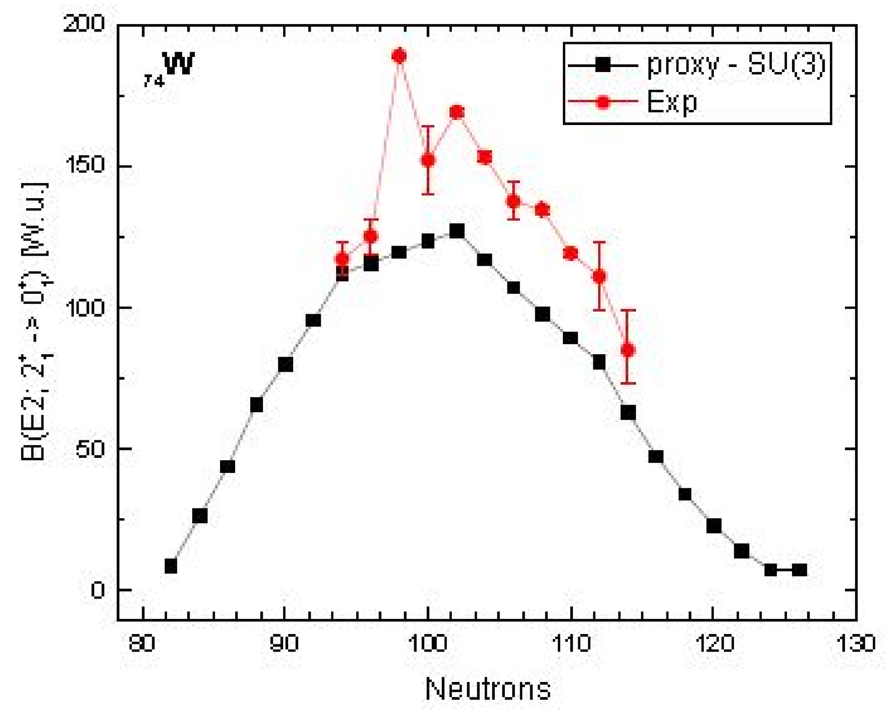
The islands of shape coexistence

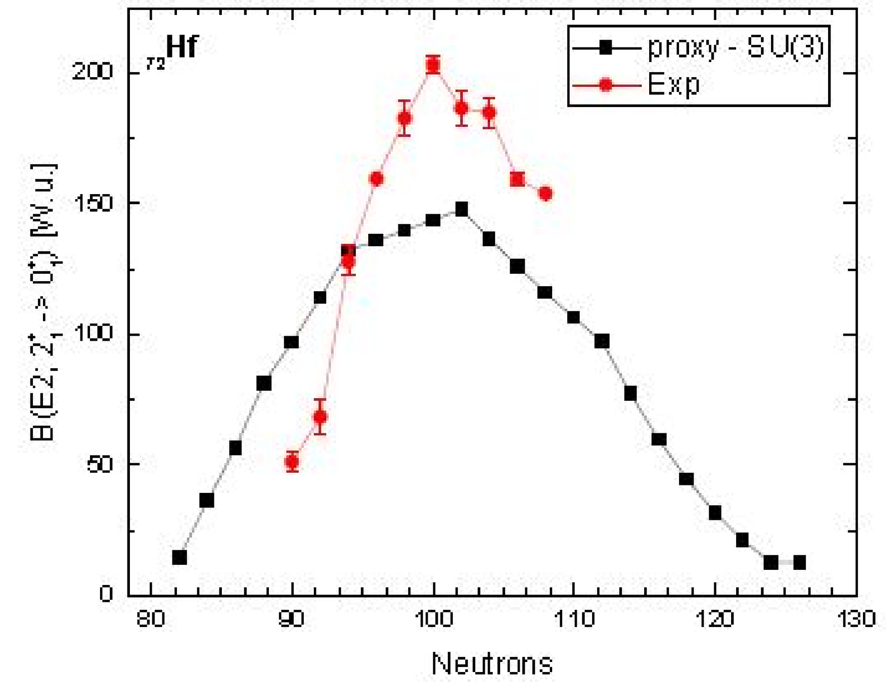


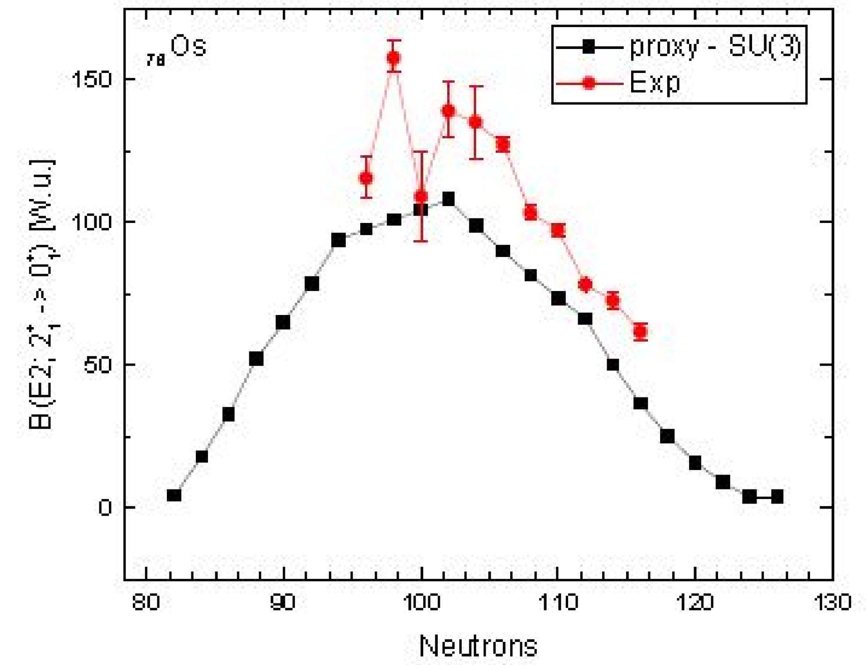
- Various nuclei with isomeric states lie within the islands of shape coexistence [7].
- We can predict if shape coexistence manifests using Energy Density Functional Theory [8].

$B(E2; 2_1^+ \rightarrow 0_1^+)$

Various calculations have been performed in Ref. [9].







[1] J. P. Elliott, Proceedings of the Royal Society of London, 25(1240) p. 128, (1958).
[2] D. Bonatsos et al., Physical Review C, 95 064325 (2017).
[3] A. Martinou et al., European Physical Journal A, 56 239, (2020).
[4] D. Bonatsos et al., Physical Review C, 95 064326 (2017).
[5] J. P. Draayer and J. K. Weeks, Annals of Physics, 156 41, (1984).
[6] Y. Akiyama and J. P. Draayer, Computer Physics Communications, 5 405, (1973).
[7] A. Martinou et al., European Physical Journal A, 57 84, (2021).
[8] D. Bonatsos et al., Physics Letters B, 829 137099, (2022).
[9] S. Peroulis Master Thesis, National Technical University of Athens (2021).