Parameter free predictions by the proxy SU(3) model

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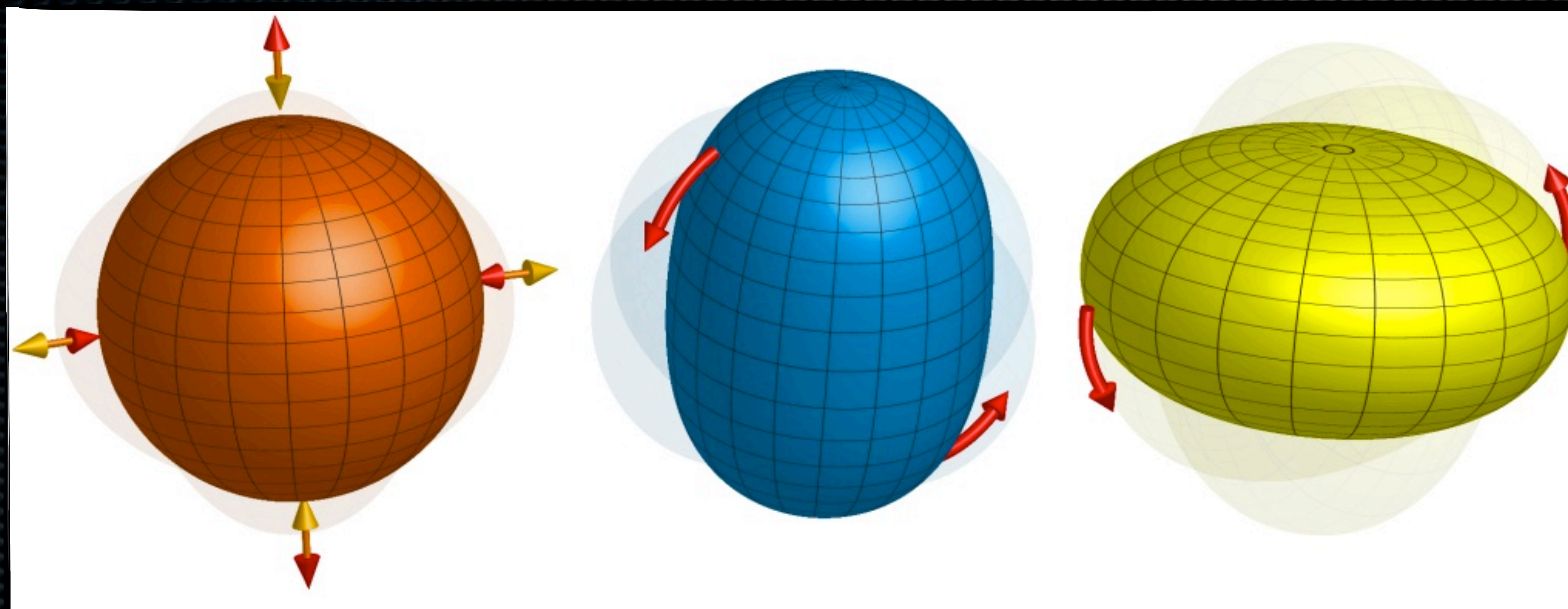
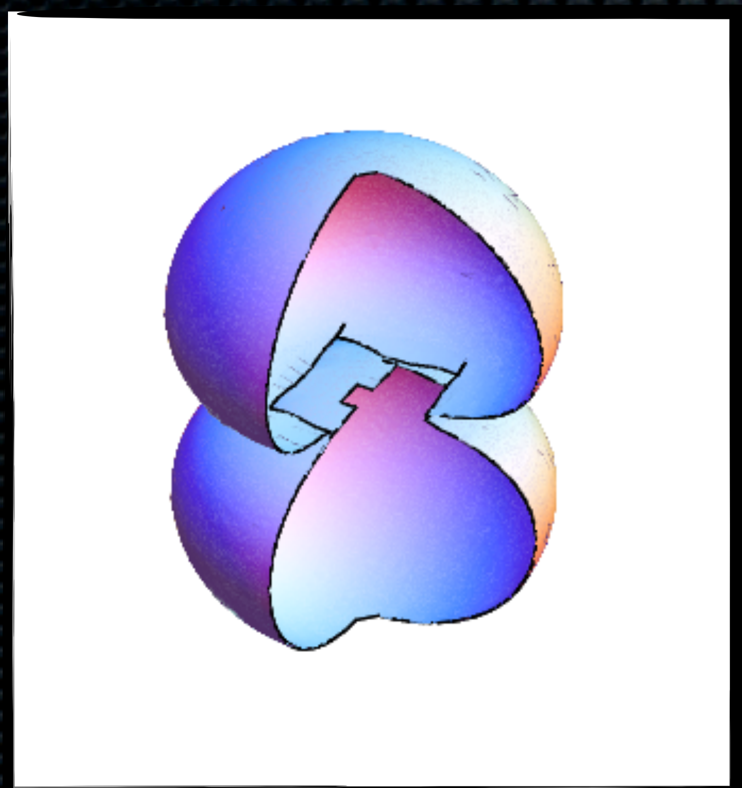
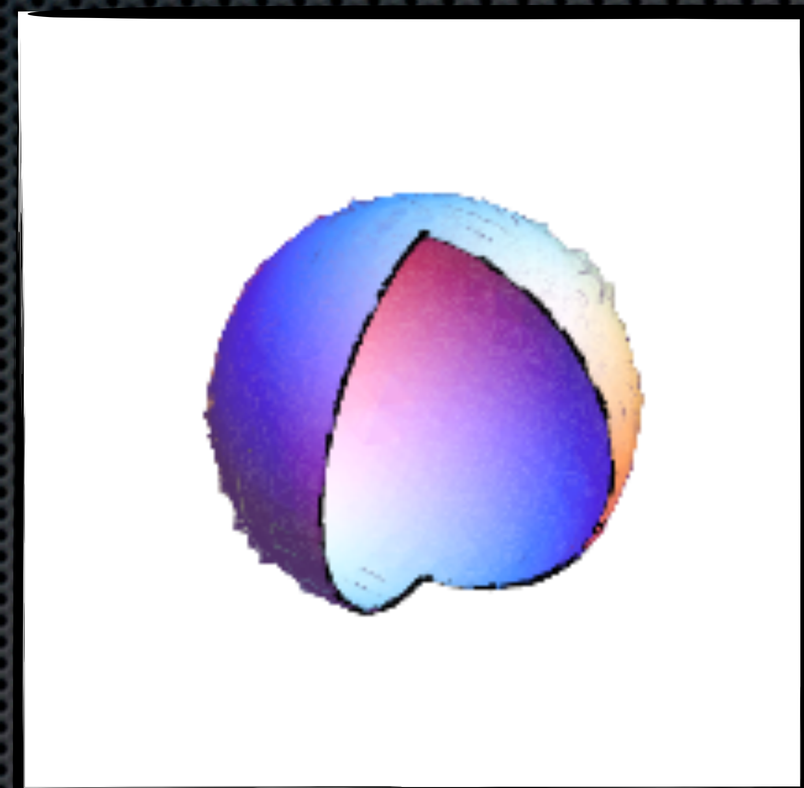
Deformation types



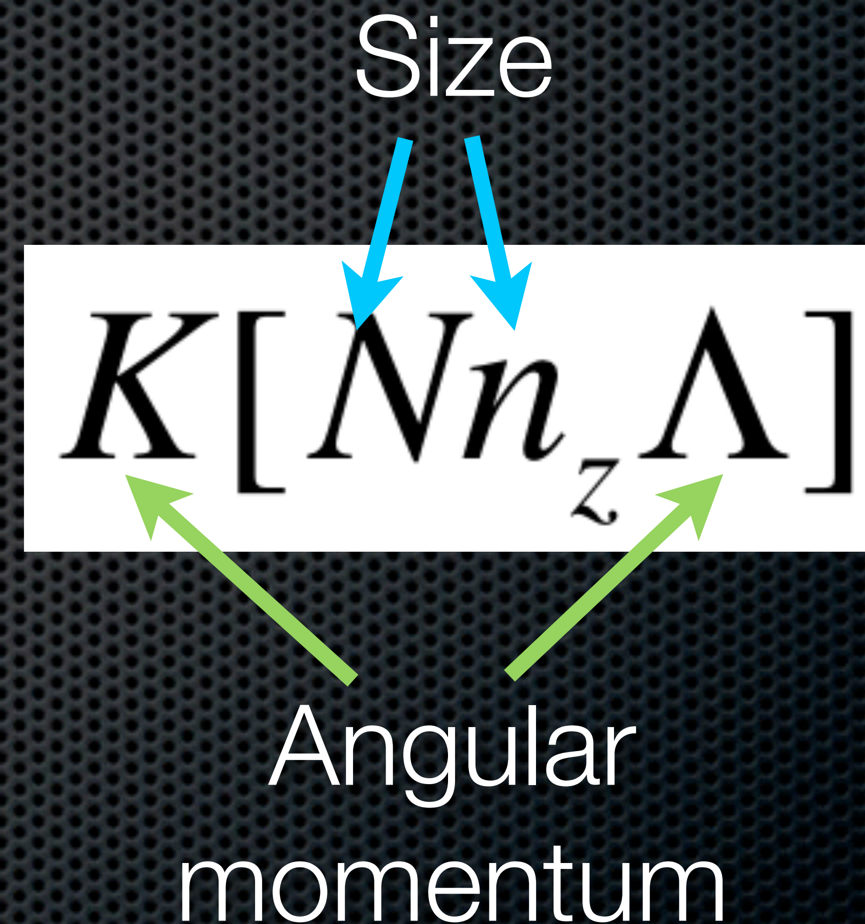
- β is the deviation from the spherical shape.
- γ lies between 0° and 60°, where γ≈30° means triaxial nucleus.

Same angular momentum projections





Nilsson notation



- Orbitals with the same angular momentum (K, Λ) have the same alignment in space and big spatial overlaps.

D. Bonatsos, S. Karampagia, R.B. Cakirli, R.F. Casten, K. Blaum, L. Amon Susam
PRC88, 054309(2013)

An approximation

- Real valence nucleons.

50-82 p	50-82 p	sdg p	sdg p
3s1/2	1/2[400]	3s1/2	1/2[400]
2d3/2	1/2[411]	2d3/2	1/2[411]
	3/2[402]		3/2[402]
2d5/2	1/2[420]	2d5/2	1/2[420]
	3/2[411]		3/2[411]
	5/2[402]		5/2[402]
1g7/2	1/2[431]	1g7/2	1/2[431]
	3/2[422]		3/2[422]
	5/2[413]		5/2[413]
	7/2[404]		7/2[404]
1h11/2	1/2[550]	1g9/2	1/2[440]
	3/2[541]		3/2[431]
	5/2[532]		5/2[422]
	7/2[523]		7/2[413]
	9/2[514]		9/2[404]
	11/2[505]		

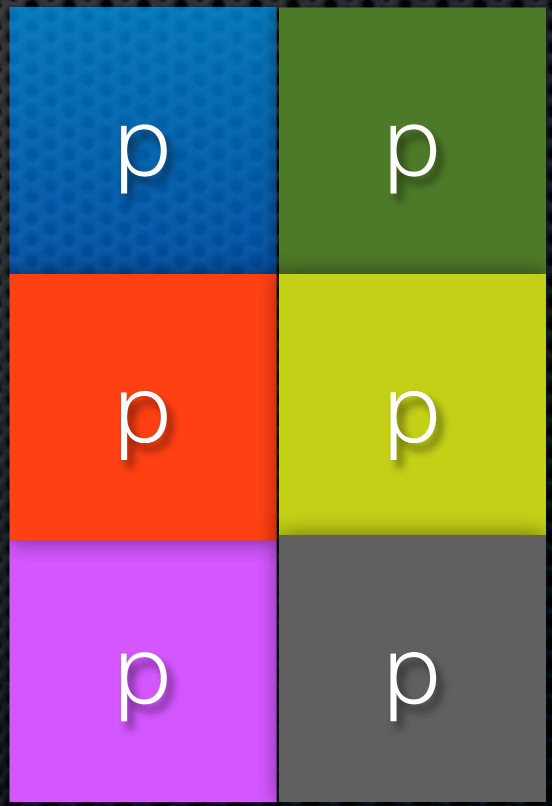
- Proxy SU(3) valence nucleons

Nilsson orbitals: $K[Nn_z\Lambda]$

Fermion-fermion pairs

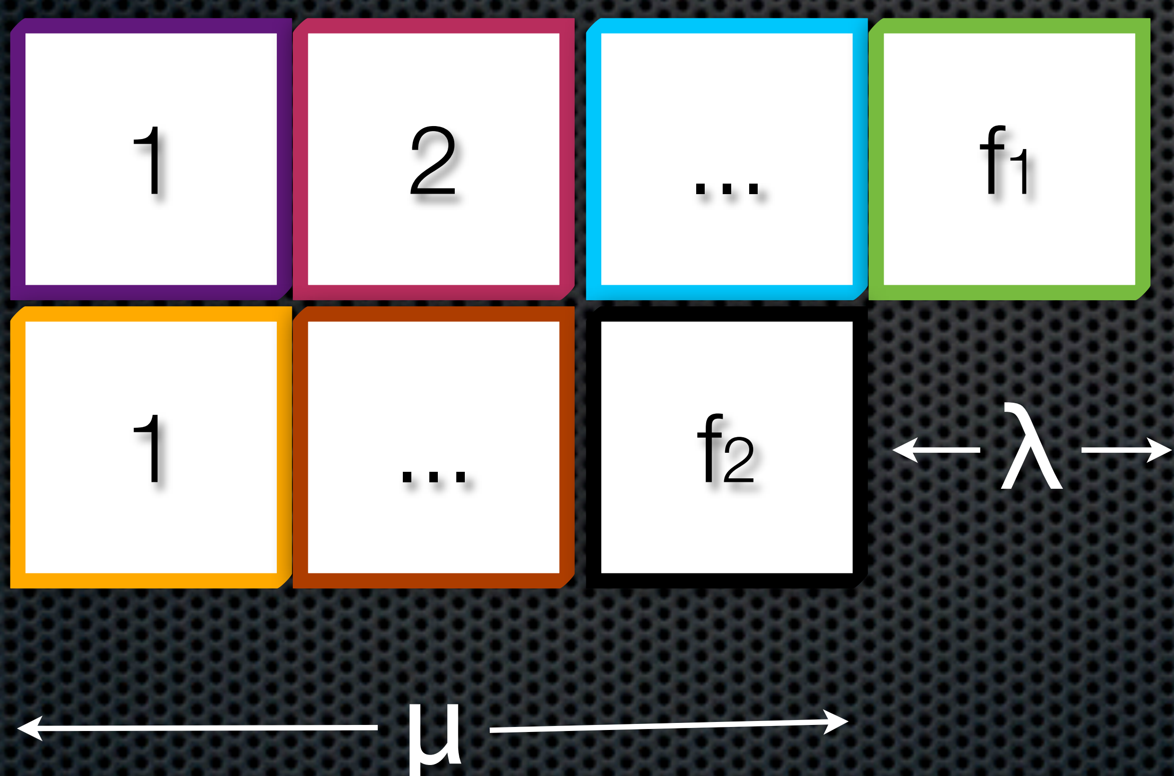
- The sdg shell contains (80-50)/2=15 orbitals ☞ **U(15)**.
- Coupling them results to an **antisymmetric** wave function.

Antisymmetric Young Diagram of 6 proton pairs.



U(n)⊃SU(3)

- The reduction leads to (λ,μ) quantum numbers of SU(3) Young diagrams.



Elliott notation

$$\lambda = f_1 - f_2$$
$$\mu = f_2$$

J.P.Draayer, Y.Leschber, C.S.Park and R.Lopez Representations of U(3) in U(N) Computer physics communications 56 279-290 (1989)

Hamiltonian of the nucleus

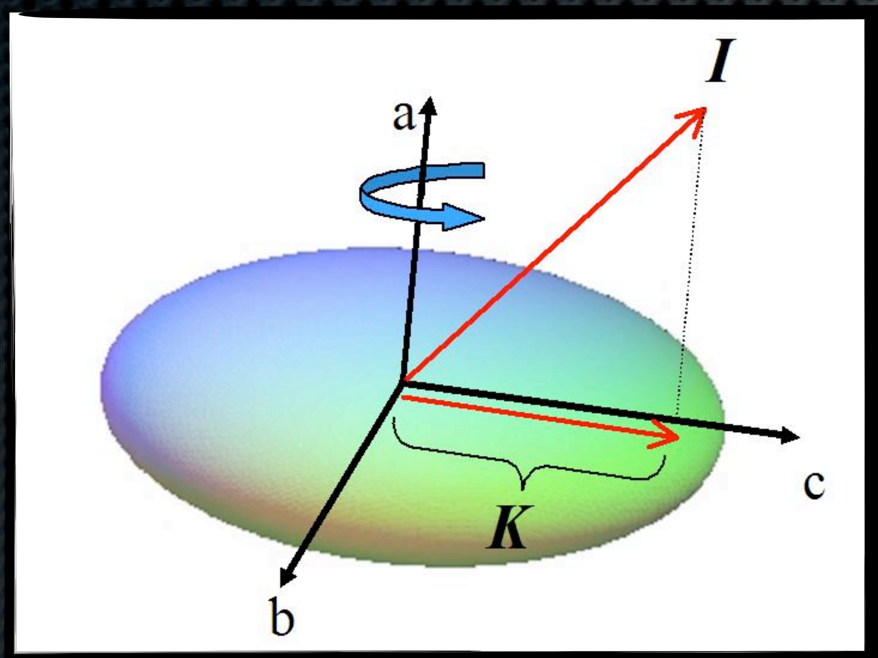
$$\hat{H} = \hat{L}^2 + c_1\hat{\Omega} + c_2\hat{Q}\cdot\hat{Q}$$

- **Ω**: "three body" interaction operator which conserves the SU(3) symmetry and breaks the degeneracy between the first β and the first γ band.
- **Q**: quadrupole operator
- A two parameter model.

β and γ predictions

Two models.

- Quantum Rotor of the rotational limit of the Geometric Model.



- SU(3) algebraic shell model description.

3s1/2
2d3/2
2d5/2
1g7/2
1g9/2

$$H_{ROT} = A_1 I_1^2 + A_2 I_2^2 + A_3 I_3^2 = H_{SU(3)} = aL^2 + bX_3 + cX_4$$

Quantum rotor and its SU(3) realization, O. Castanos, J.P. Draayer and Y. Leschber, Computer Physics Communication 52 (1988) 71-84

Rotor-SU(3) connection

- Rotor invariants
- SU(3) invariants

$$k\beta^2 \longleftrightarrow [\lambda^2 + \lambda\mu + \mu^2 + 3(\lambda + \mu)]$$

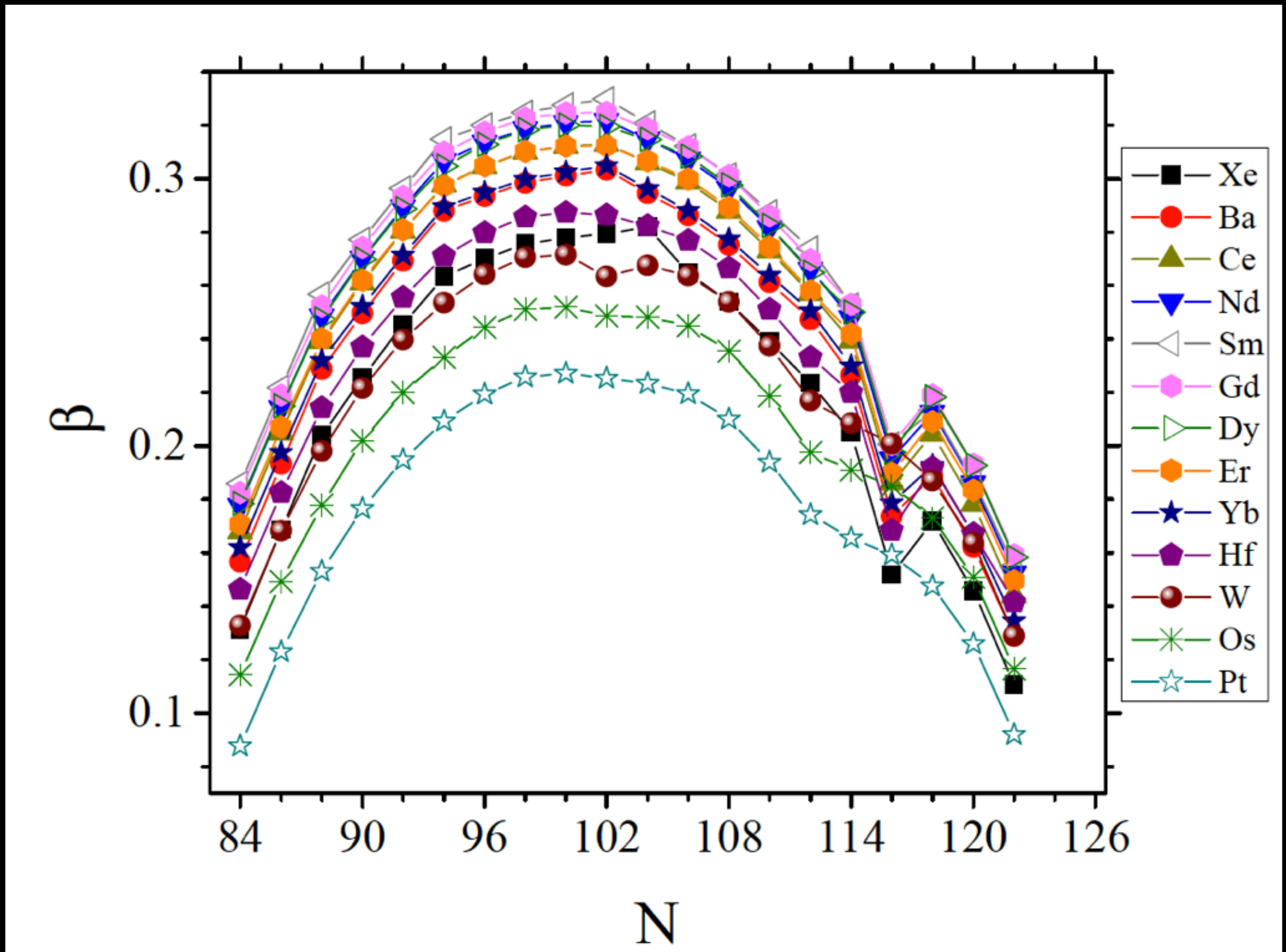
$$(k\beta)^3 \cos(3\gamma) \longleftrightarrow [(\lambda - \mu)(\lambda + 2\mu + 3)(2\lambda + \mu + 3)]$$

Connection between invariants:

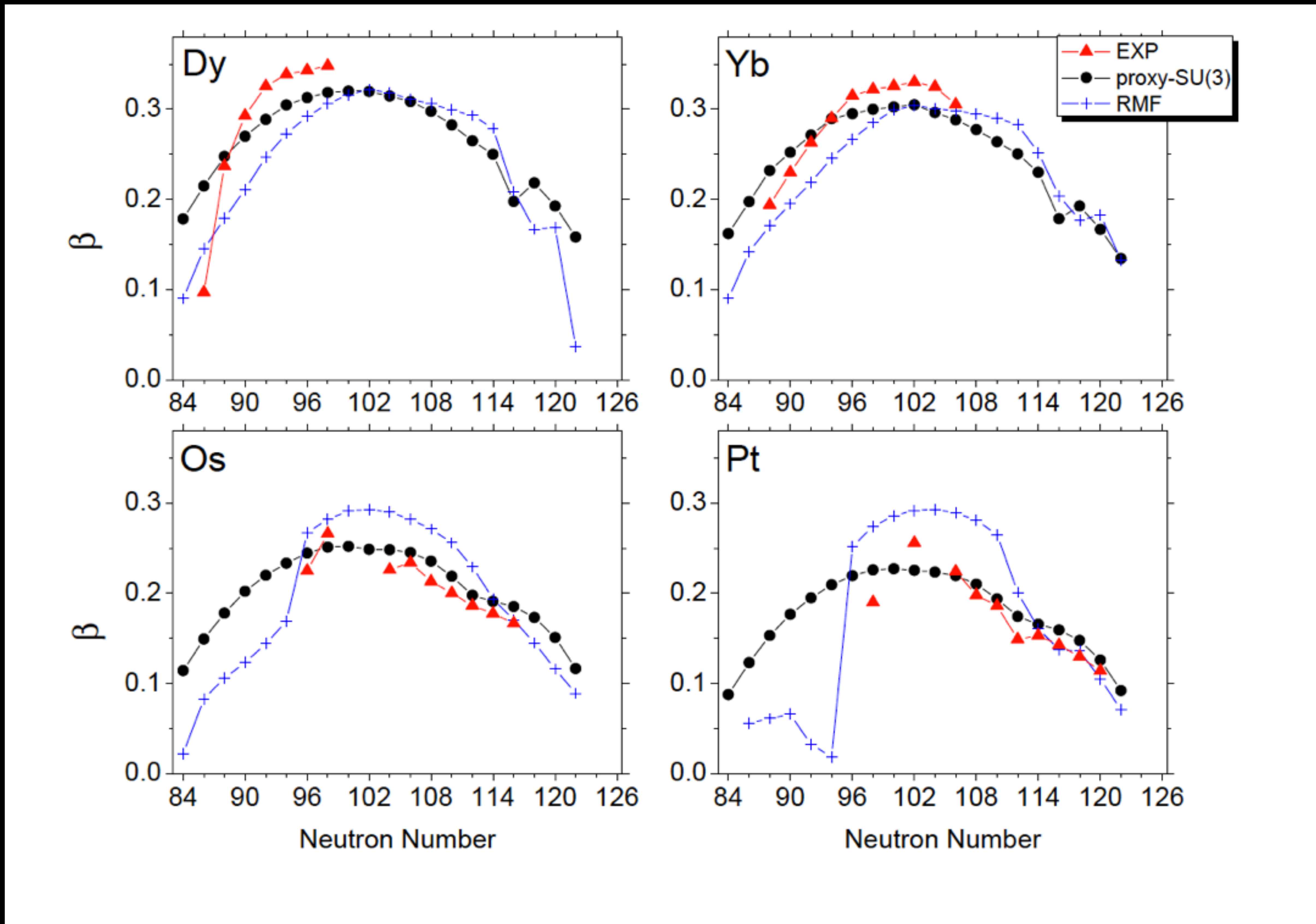
$$\beta^2 = \frac{4\pi}{5} \frac{1}{(A\bar{r^2})^2} (\lambda^2 + \lambda\mu + \mu^2 + 3\lambda + 3\mu + 3)$$

$$\gamma = \arctan\left(\frac{\sqrt{3}(\mu + 1)}{2\lambda + \mu + 3}\right)$$

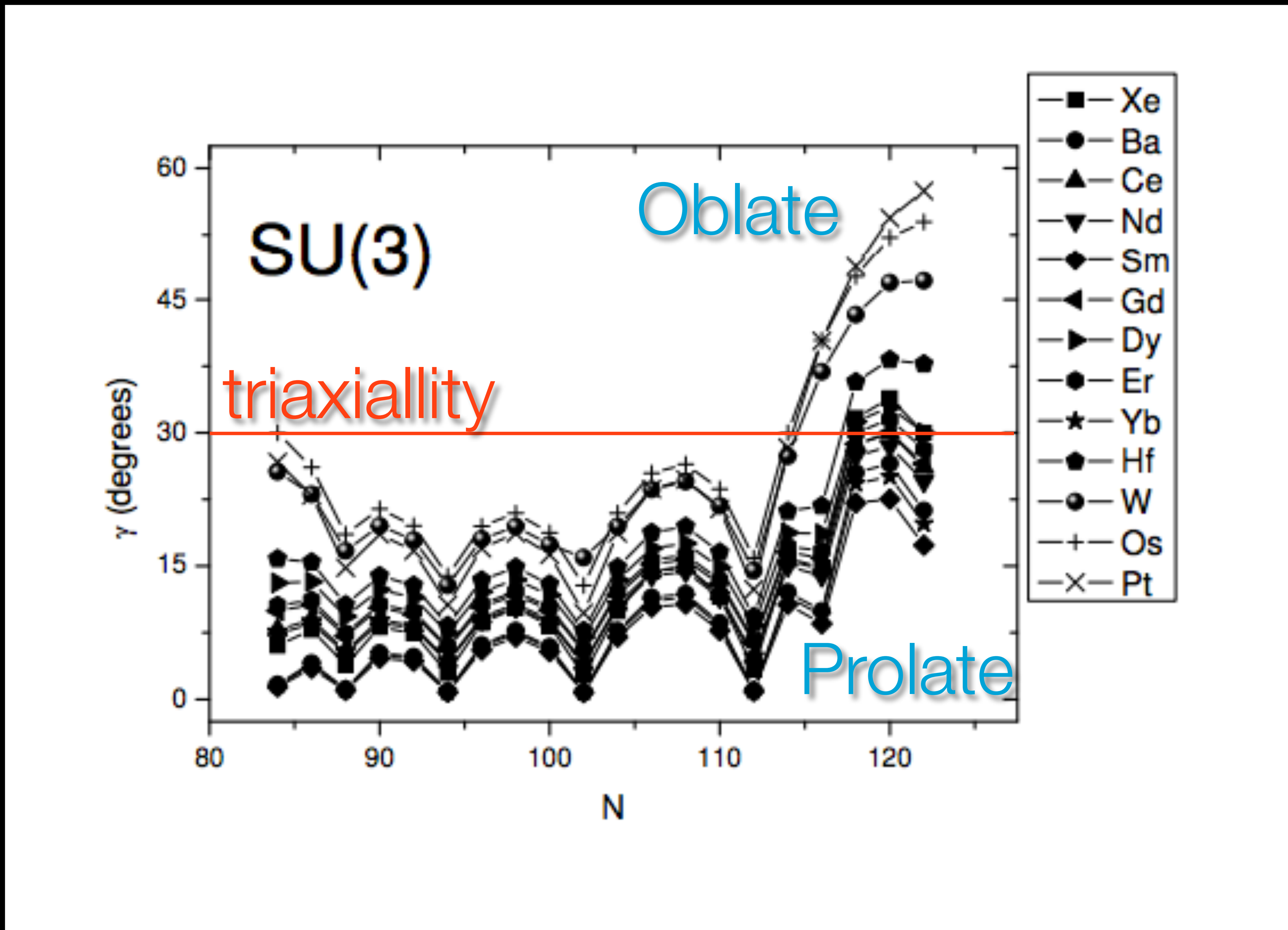
β Results


β
0.1
0.2
0.3
84
90
96
102
108
114
120
126
N
Xe
Ba
Ce
Nd
Sm
Gd
Dy
Er
Yb
Hf
W
Os
Pt

Comparison on β

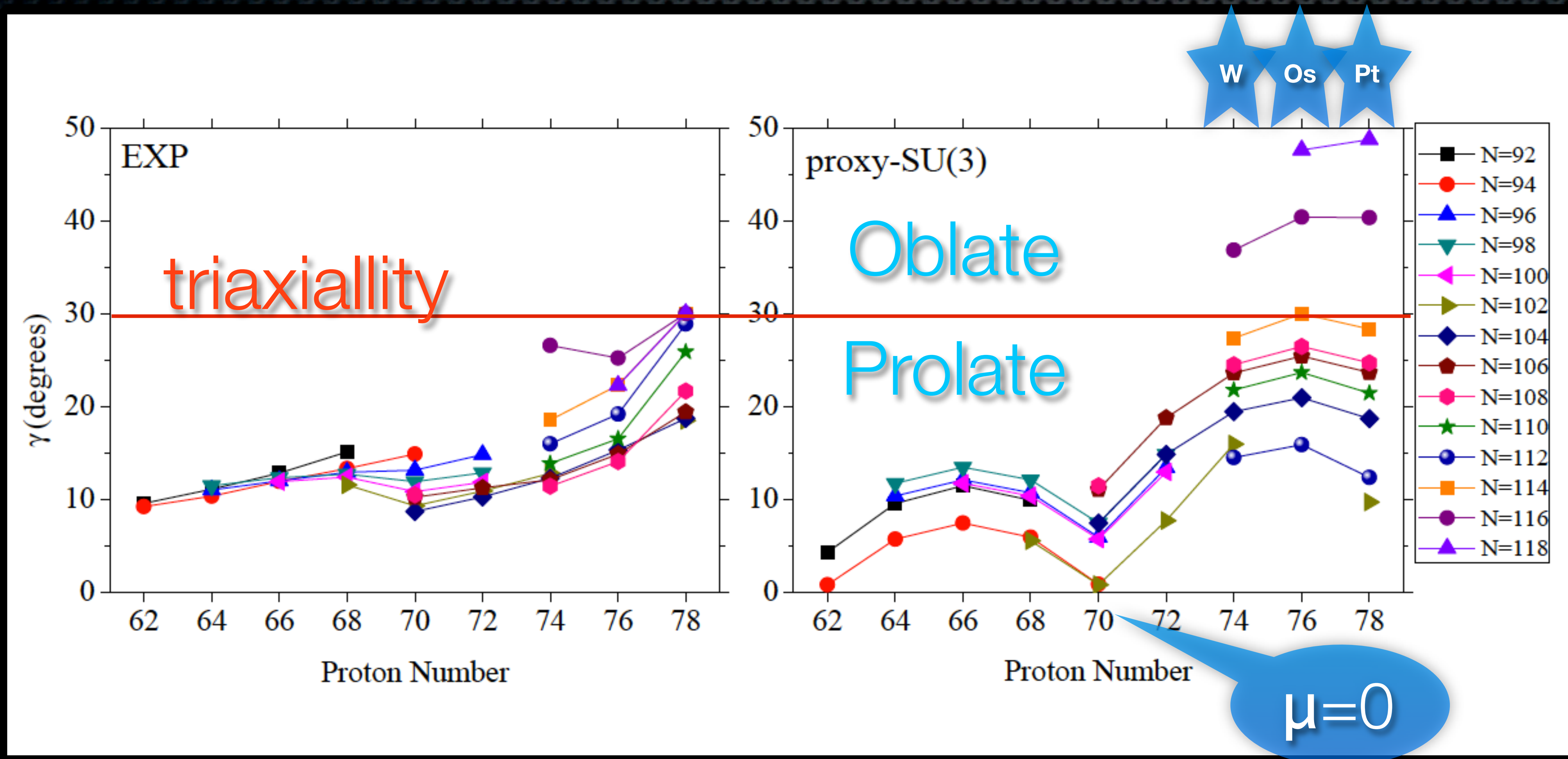


γ Results



SU(3)
Oblate
triaxiallity
Prolate
γ (degrees)
N
0
15
30
45
60
80
90
100
110
120
Xe
Ba
Ce
Nd
Sm
Gd
Dy
Er
Yb
Hf
W
Os
Pt

γ Comparison



- Most nuclei are predicted to be prolate.
- Minimum of γ happens when μ=0 (symmetric wavefunction)

B(E2) Predictions

SU(3) limit of IBM

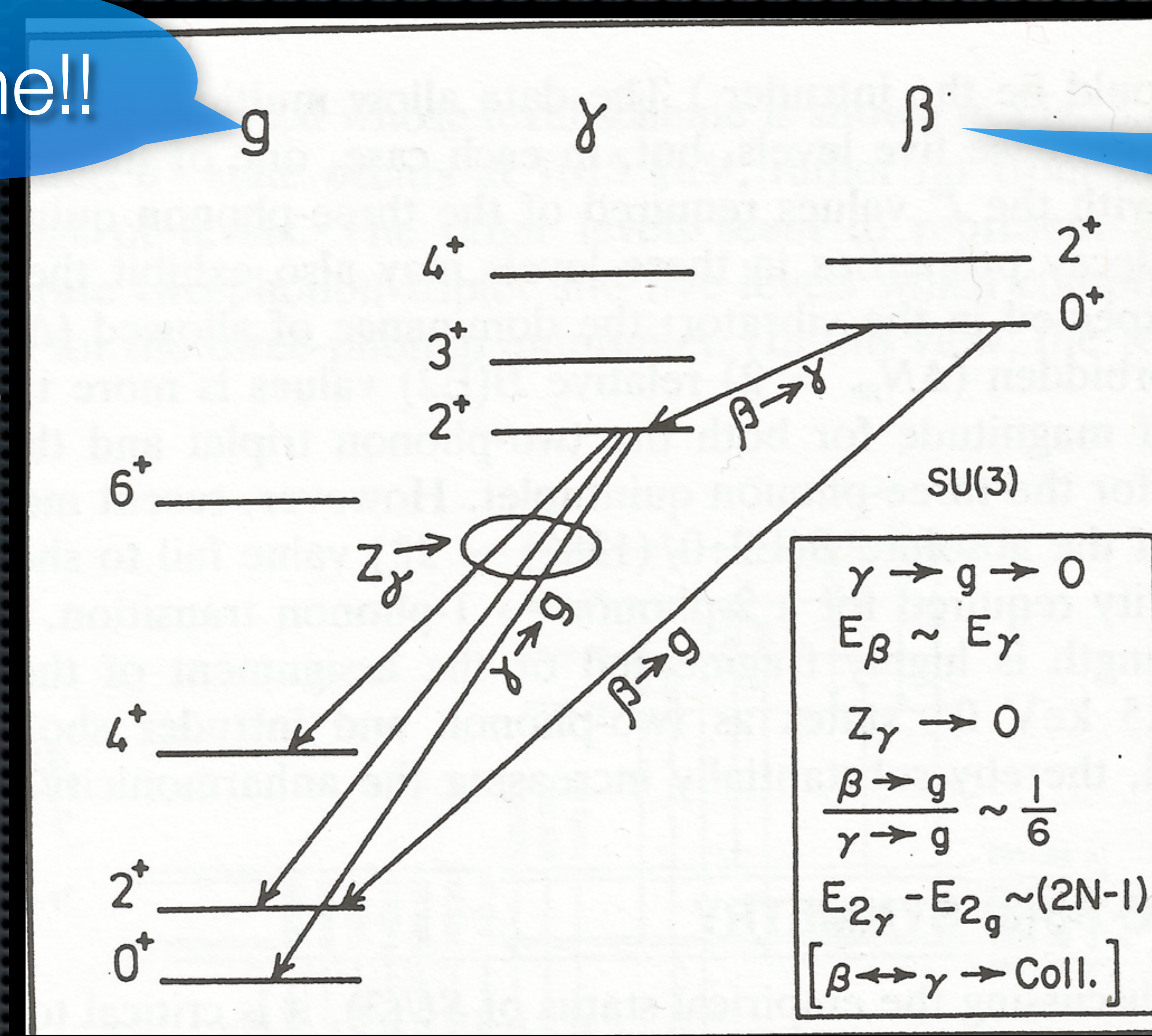
- No Pauli Principle → Ground state band always has **μ**=0.

When **μ**=0 g.s. band is always alone in the most leading irreducible representation.

SU(3) limit of IBM

Alone!!

Always Together

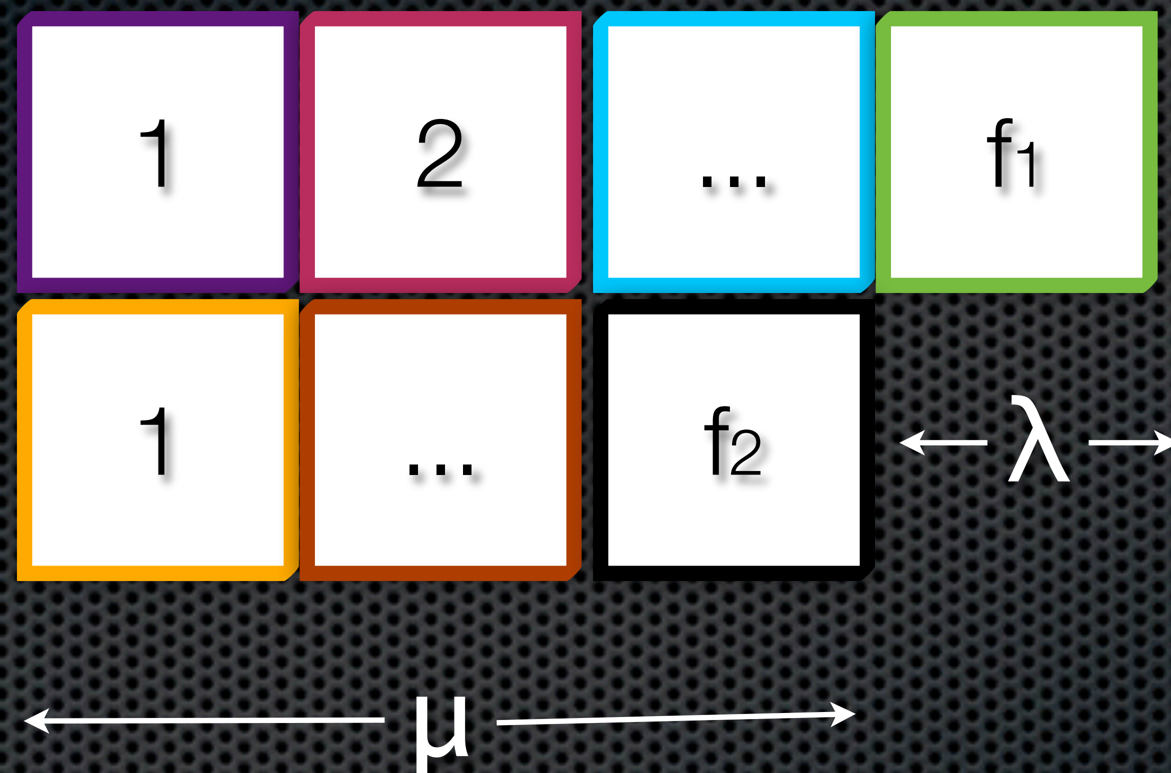


Algebraic approaches to Nuclear Structure, Casten, Lipas, Warner, Otsuka, Heyde, Draayer, Harwood 1996.

- B(E2) γ-> g.s. band are zero.
- This is not the experimental fact.

Proxy SU(3)

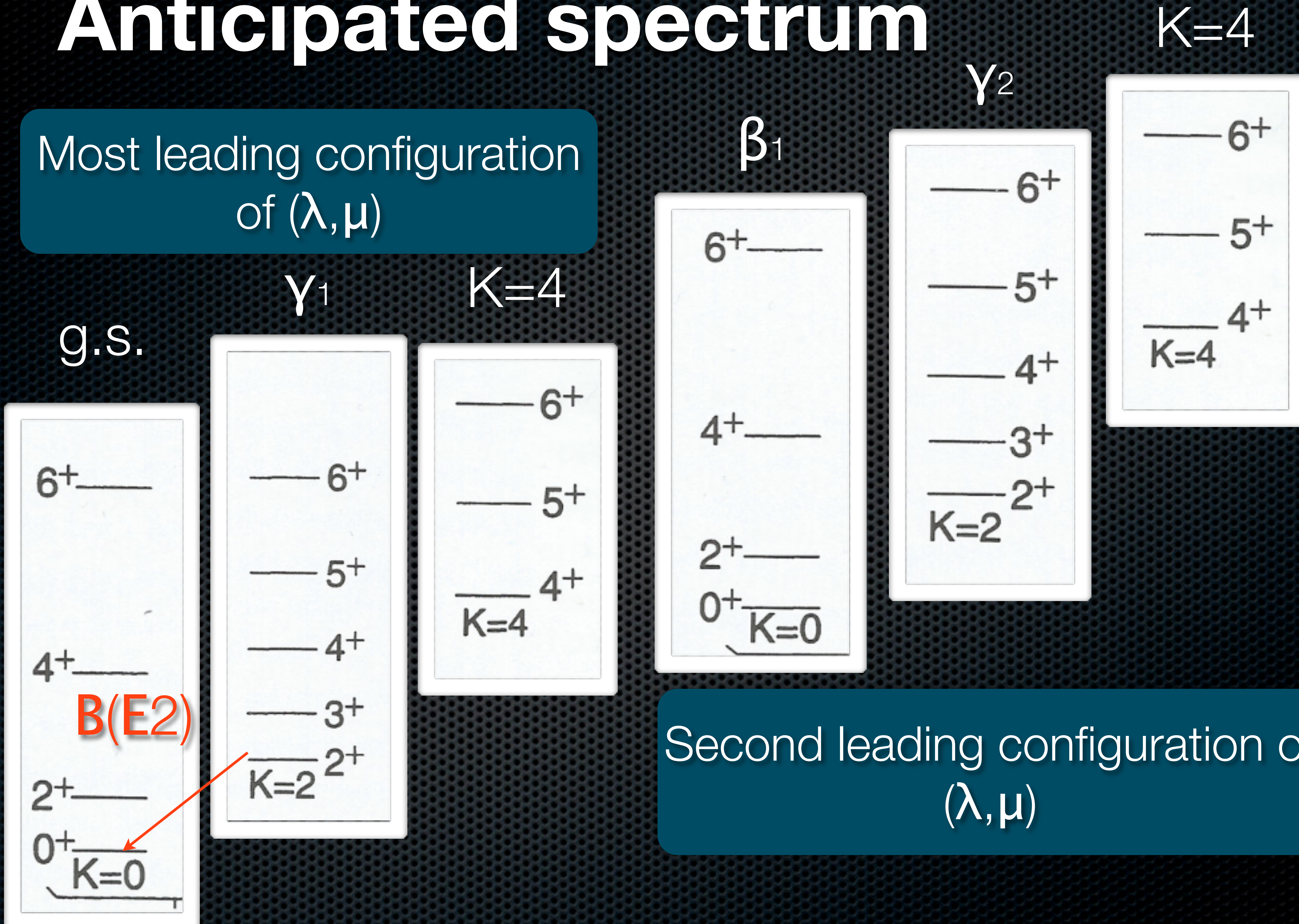
Pauli Principle



- When $\mu \neq 0$ the ground state band is always in the same configuration of (λ, μ) with the γ_1 band. Therefore we expect high B(E2) among them.

Anticipated spectrum

Most leading configuration of (λ,μ)



Second leading configuration of (λ,μ)

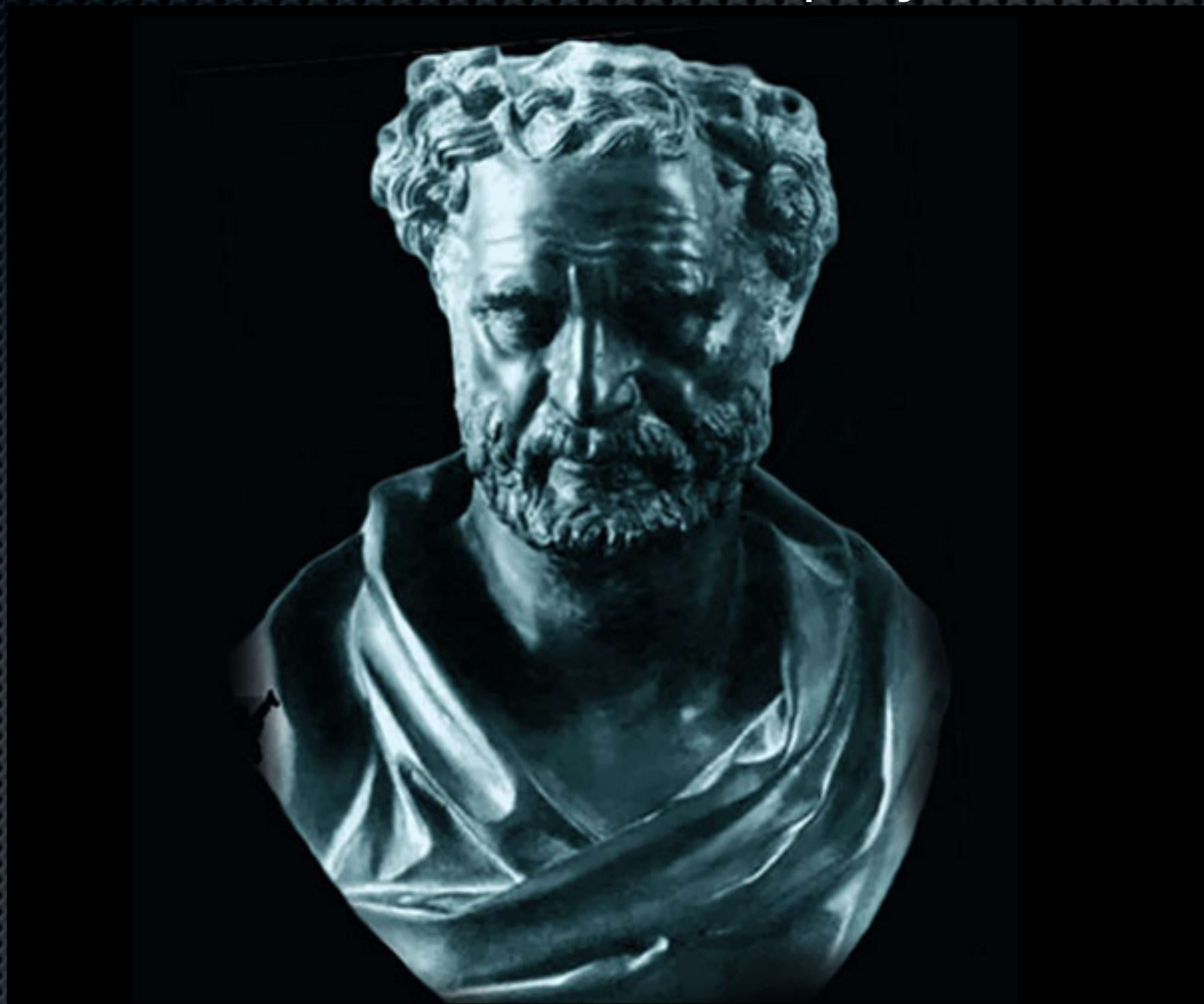
Conclusions

- An algebraic model based on the Pauli principle.
- Due to the Pauli principle g.s. band, γ_1 and first K=4 are within the same configuration of (λ,μ).
- Bands of the same configuration have large B(E2) values.
- Great success on β,γ predictions.

Future “Plans”

- Spectrum calculations.
- Parameter free energy differences ratios.
- B(E1) values.
- B(M2) values.
- Applications in nuclear astrophysics.

Demokritos
Father of nuclear physics



- 460 B.C. to 2016 A.C.= **2.476 years and we are still searching!!!!!!!!!**