

Universidad
de Huelva
www.uhu.es/gem

Coexistencia de forma en la región del Pb: estados intrusos ocultos frente a estados intruso (a Hg&Pb vs Pt&Po story)

J.E. García-Ramos¹, K. Heyde²

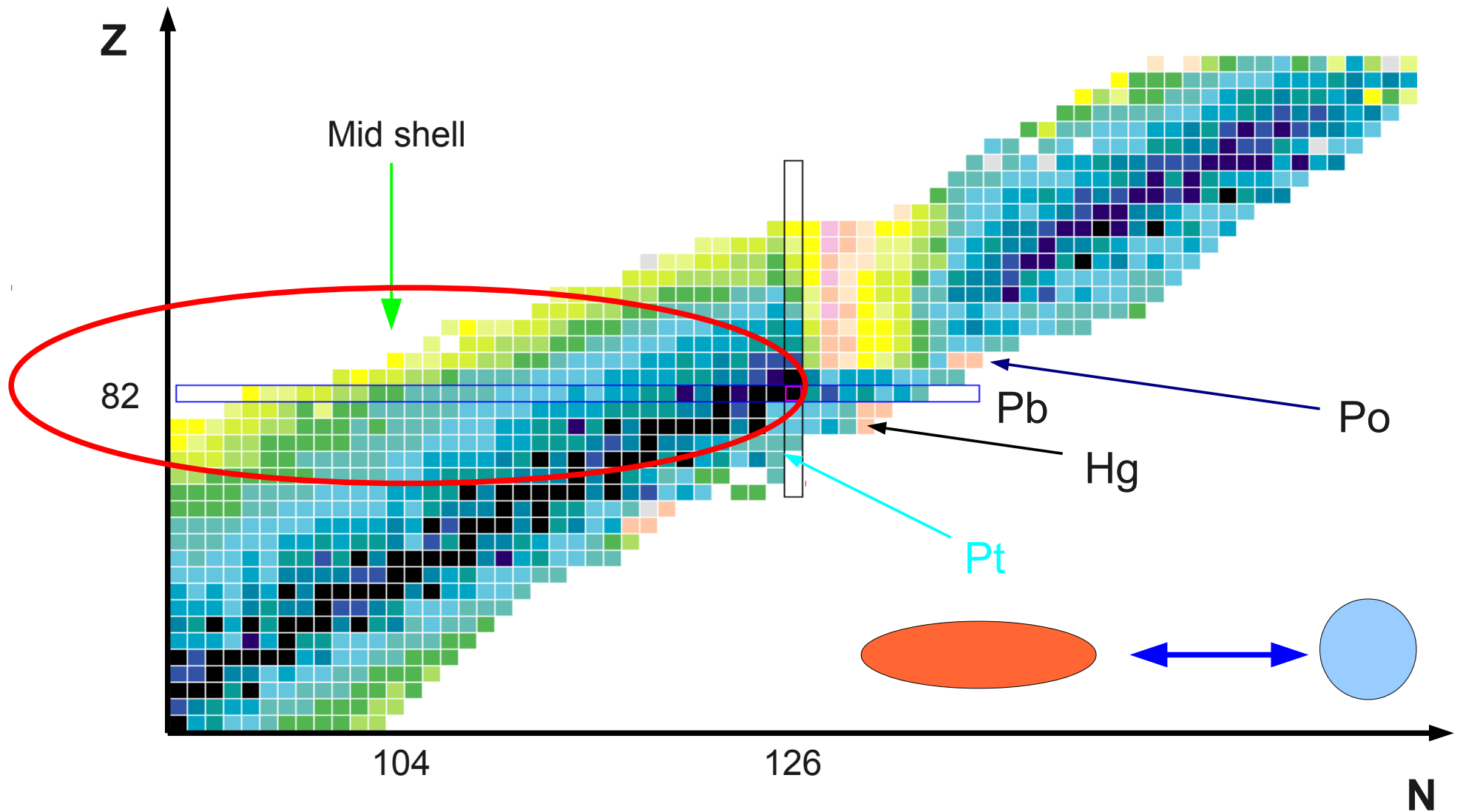
¹Departamento de Física Aplicada, Universidad de Huelva, Spain

²Department of Physics and Astronomy, University of Ghent, Belgium

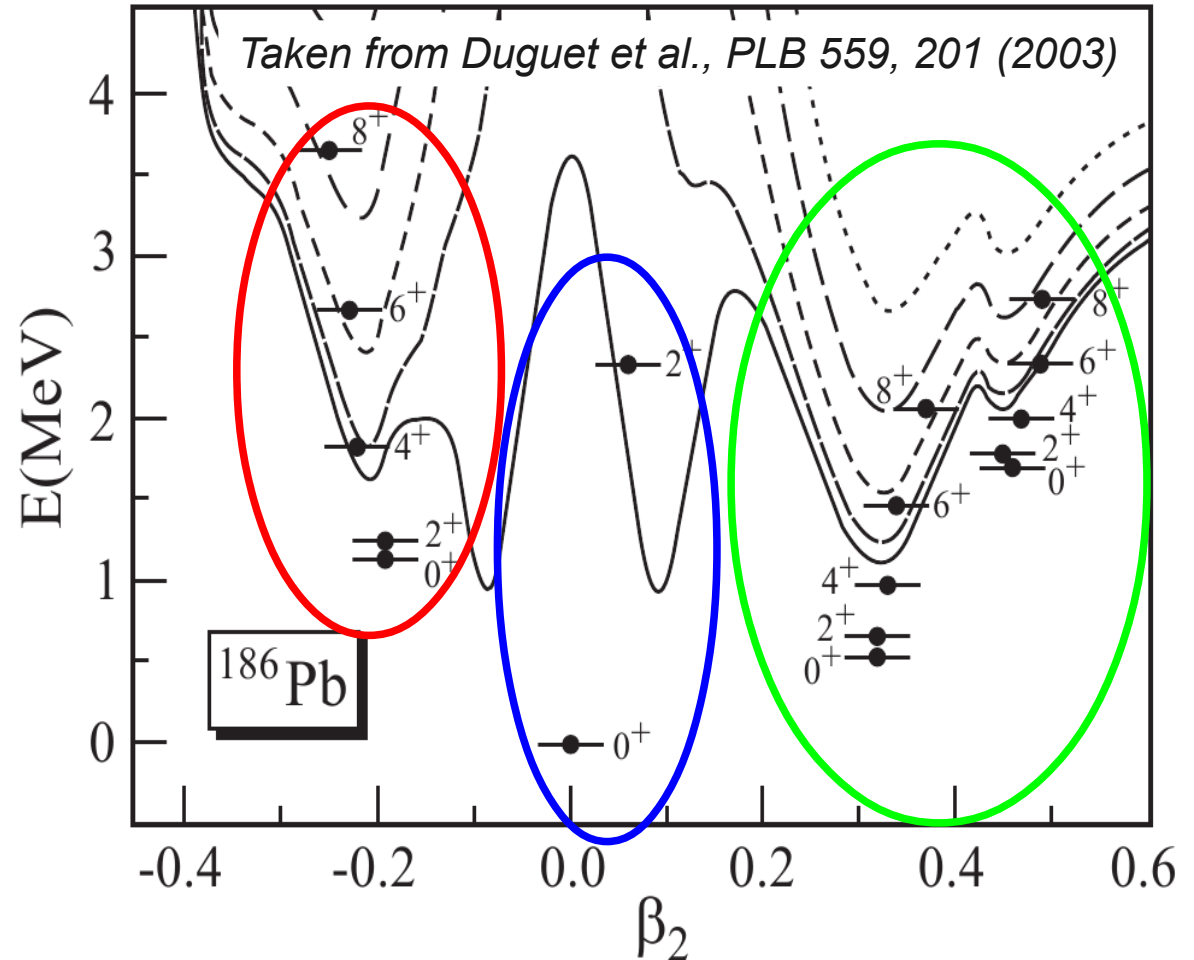
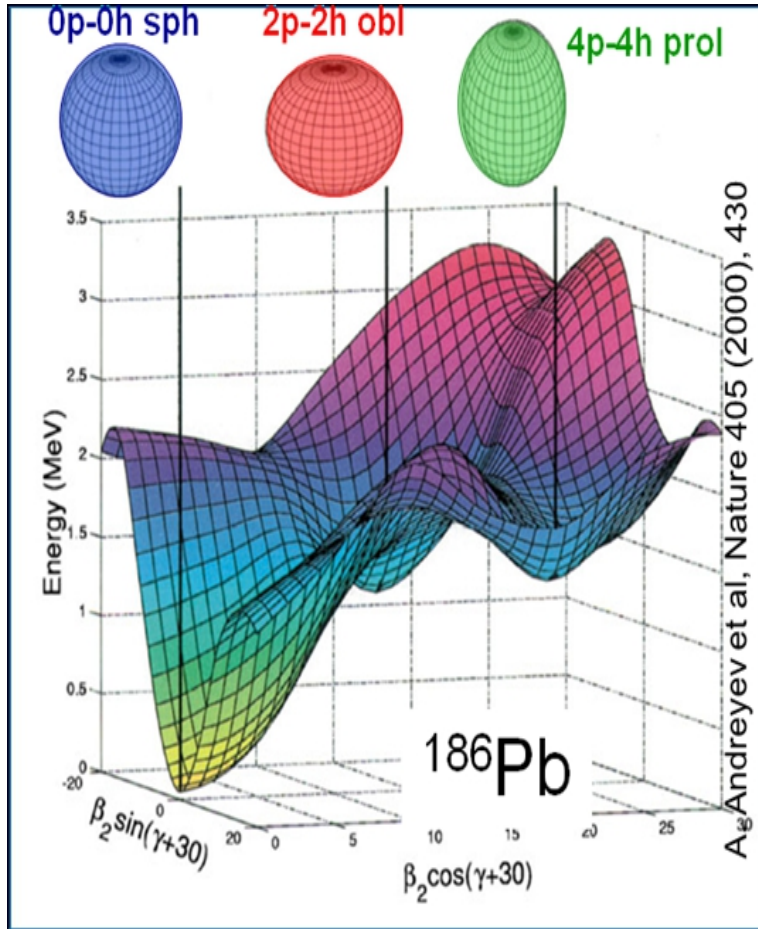


Universidad
de Huelva

Where to look for



Mean Field

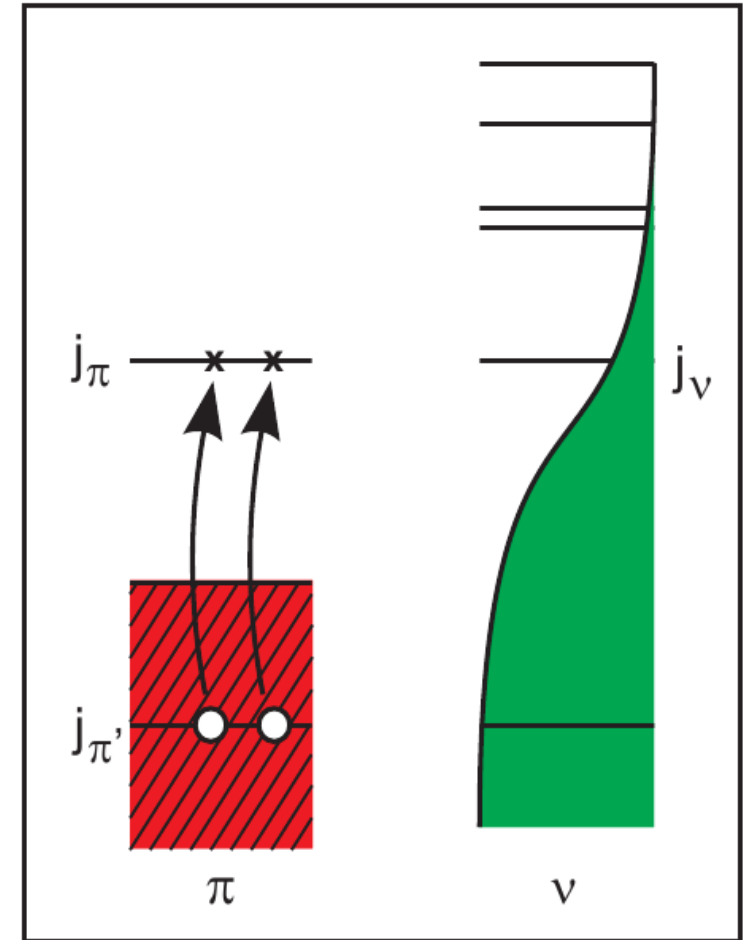


The angular momentum projected mean field plus the Generator Coordinate Method generates different bands with very different deformation.

Shell Model

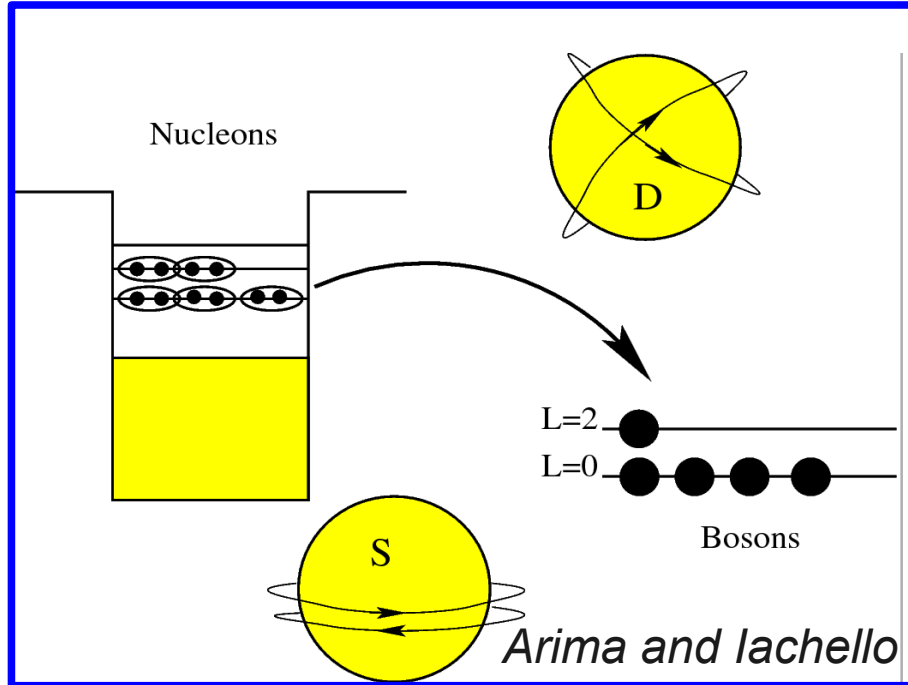
- For nuclei near to closed shells, either for neutrons or for protons, it can be energetically favorable to have excitations of 2p-2h, 4p-4h ... crossing the energy gap.
- The np-nh excitations have a lower excitation energy than expected due to the correlation energy: pairing and deformed correlations.
- Restricted to light and medium-heavy nuclei, at present.

$$\phi(J, M) = a(J, M) + b(J, M)$$



In heavy nuclei the huge model space imposes some kind of truncation: symmetry dictated truncation.

Interacting Boson Model (IBM)



Nucleons couple preferably in pairs with angular momentum either equal to 0 (**S**) or equal to 2 (**D**). Those pairs are then described by means of bosons: **s** and **d**.

$$s^\dagger, d_m^\dagger (m = 0, \pm 1, \pm 2)$$

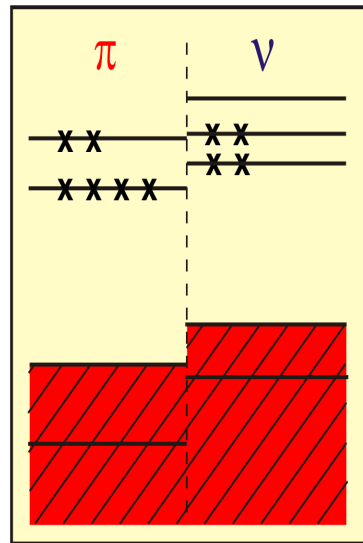
$$s, d_m (m = 0, \pm 1, \pm 2)$$

$$\hat{H}_{ECQF} = \epsilon \hat{n}_d + \kappa \hat{Q} \cdot \hat{Q} + \kappa' \hat{L} \cdot \hat{L}$$

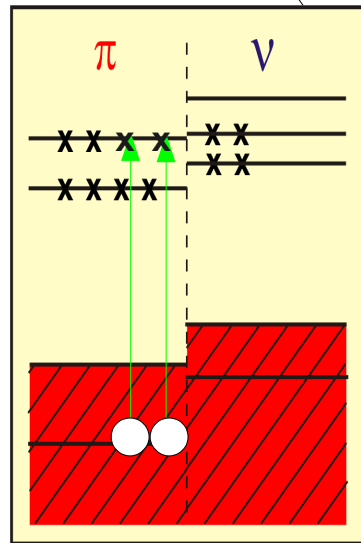
Interacting Boson Model

(configuration mixing)

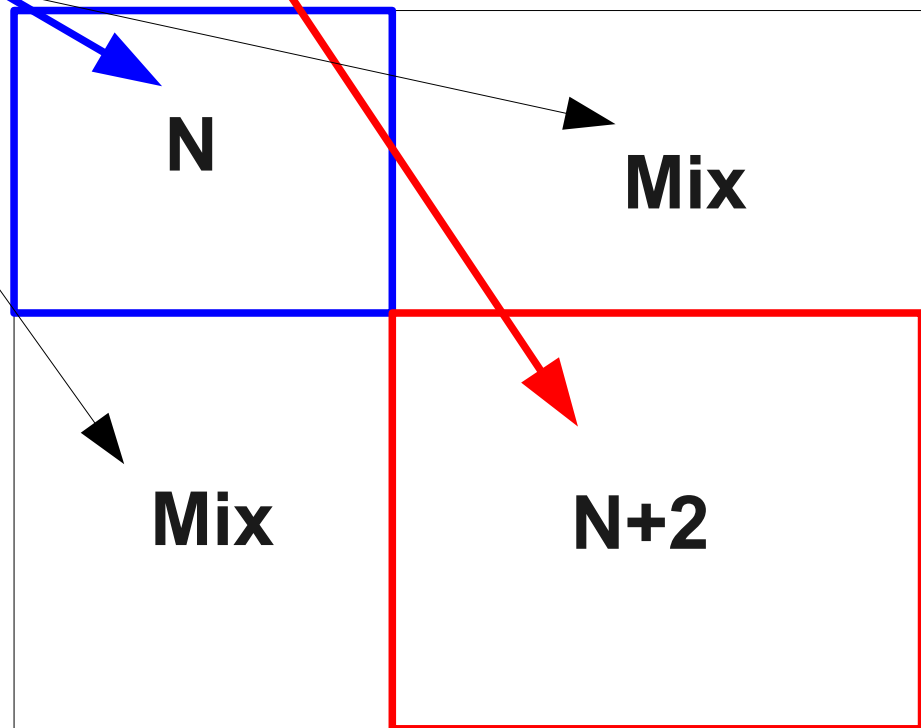
$$\hat{H} = \hat{P}_N^\dagger \hat{H}_{\text{ECQF}}^N \hat{P}_N + \hat{P}_{N+2}^\dagger (\hat{H}_{\text{ECQF}}^{N+2} + \Delta^{N+2}) \hat{P}_{N+2} + \hat{V}_{\text{mix}}^{N,N+2},$$



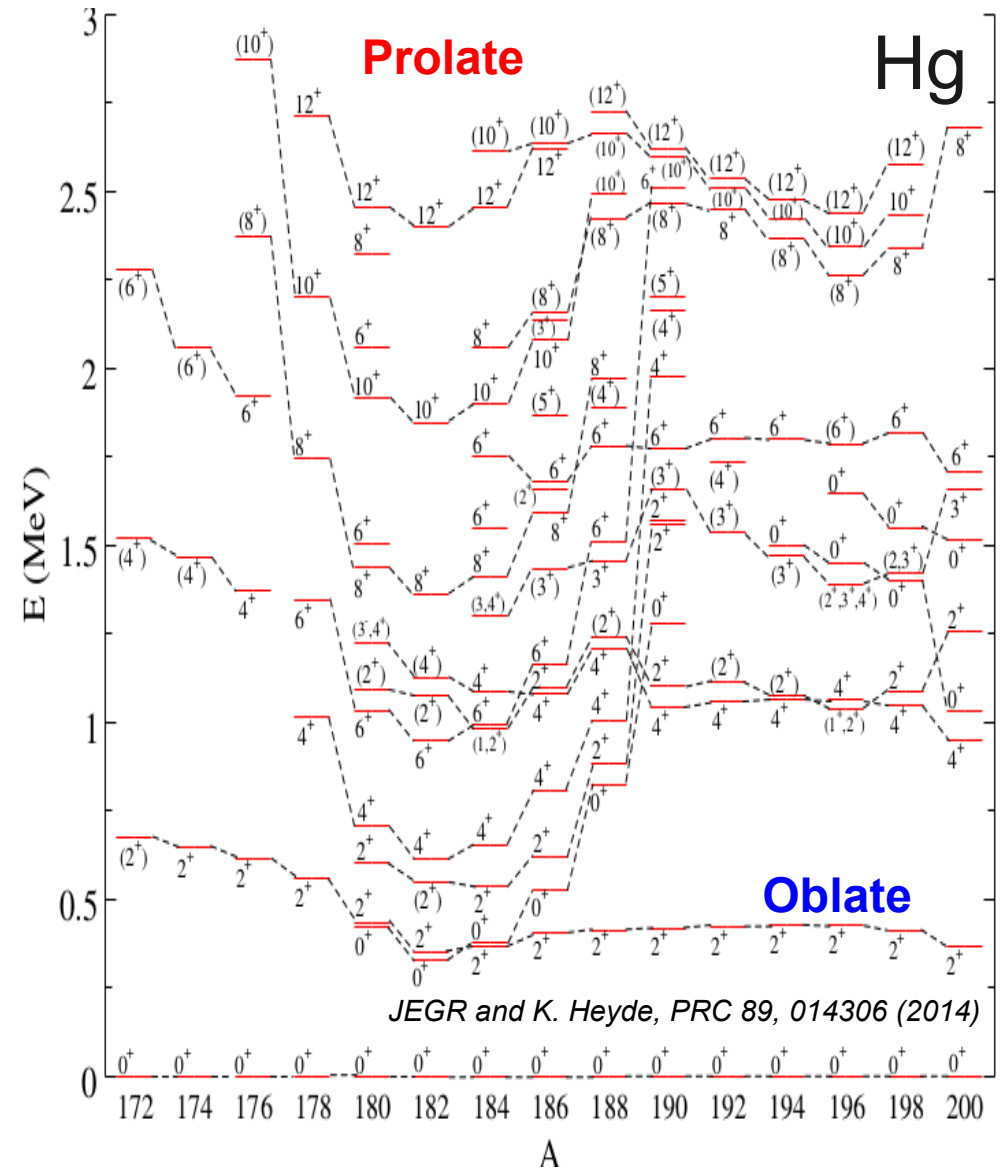
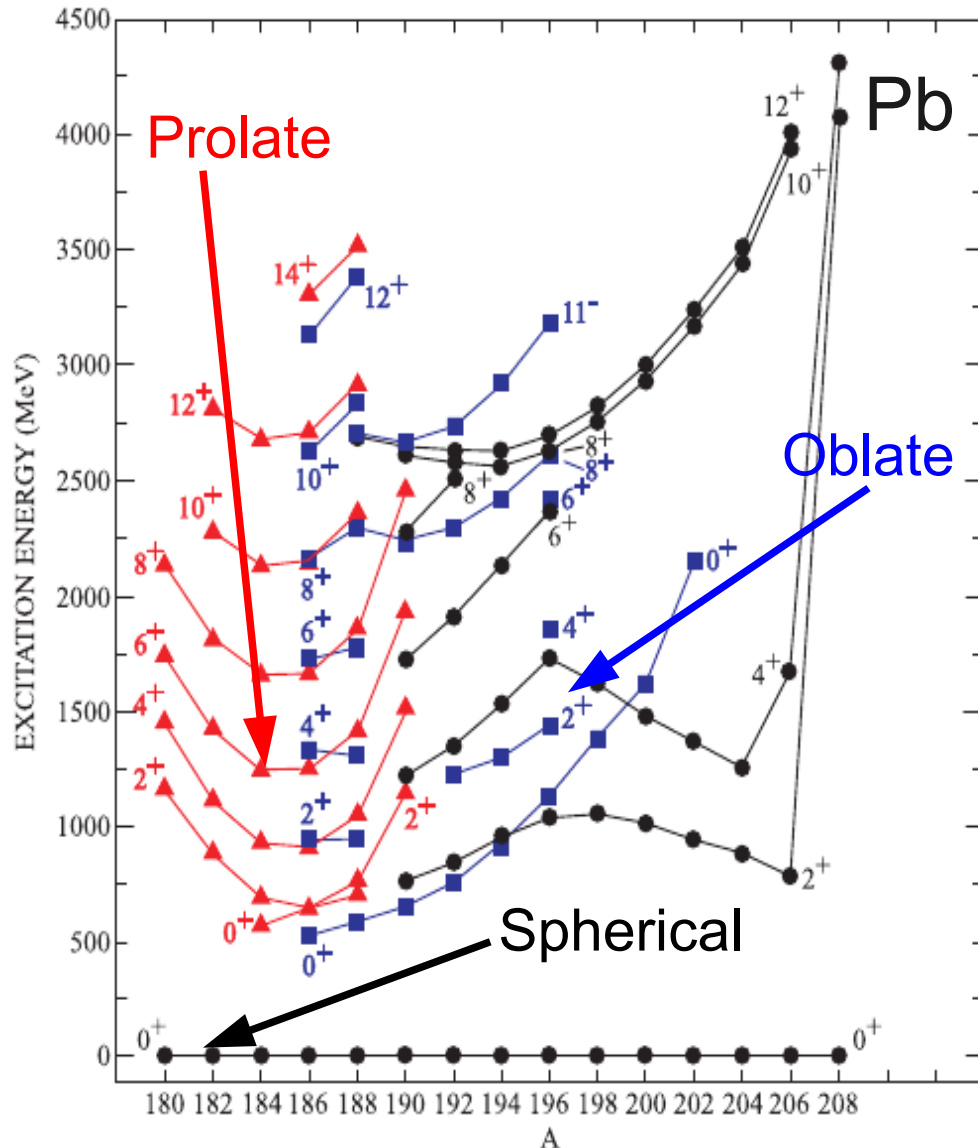
N



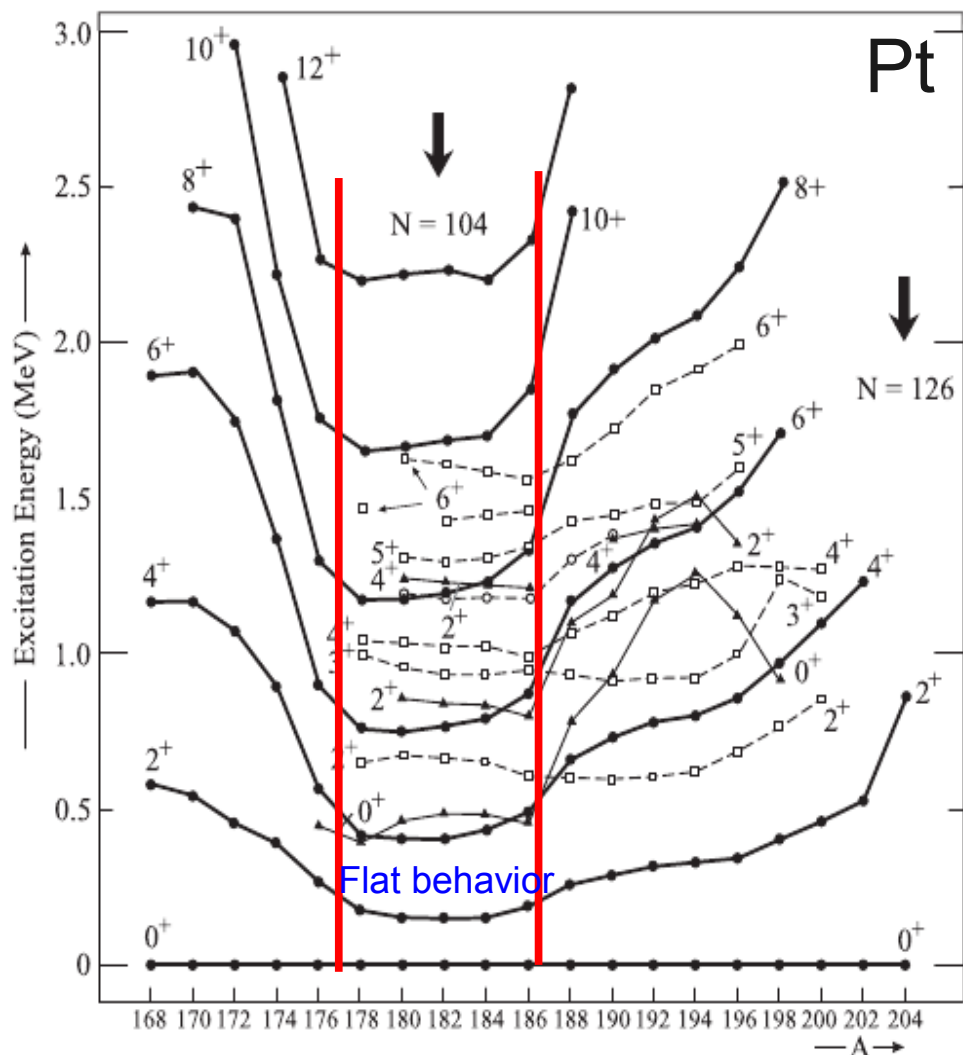
N+2



Pb and Hg isotopes

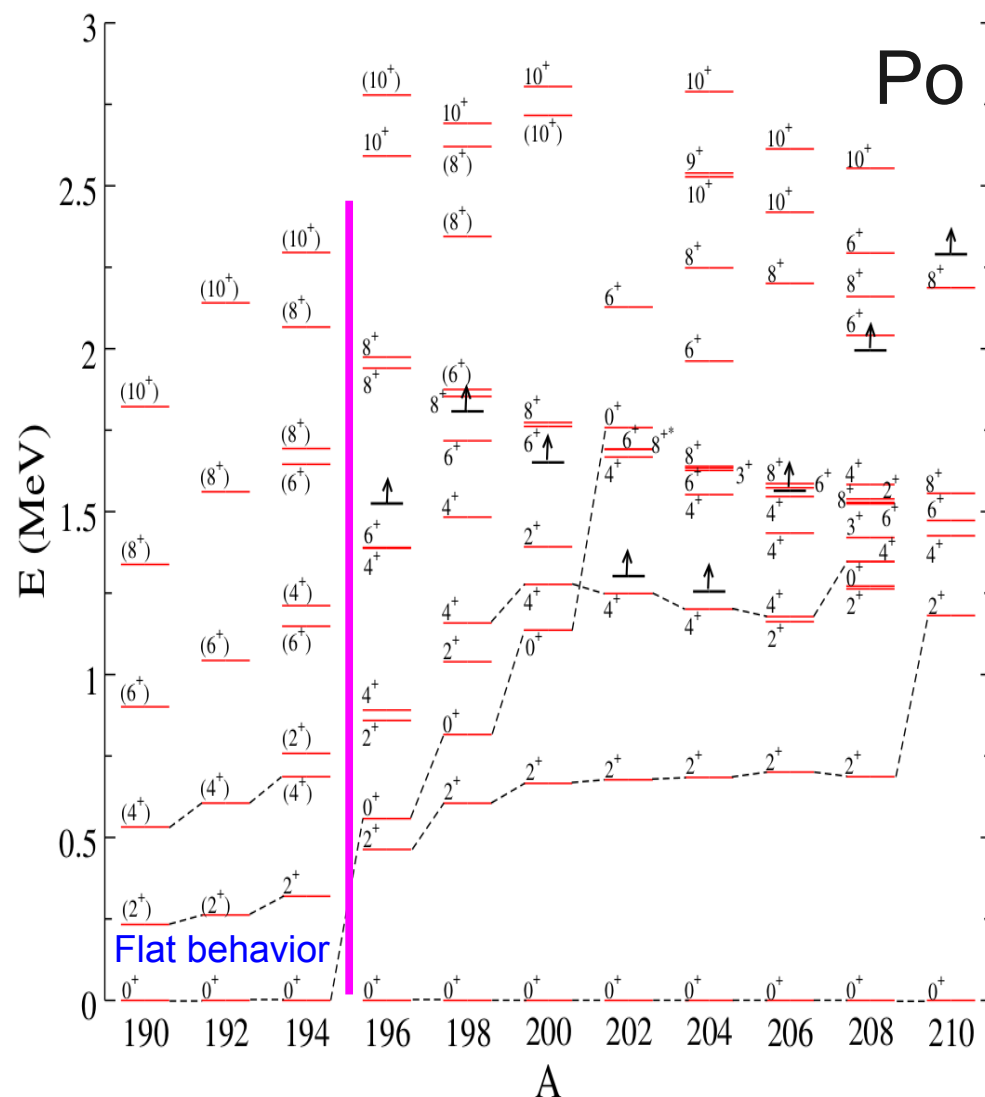


Pt and Po isotopes



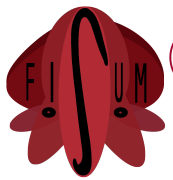
JEGR and K. Heyde, NPA 825, 39 (2009),

JEGR, V. Hellemaans, and K. Heyde, PRC 84, 014331 (2011).



JEGR and K. Heyde, PRC submitted (2015)

Gijón 13-17 July 2015



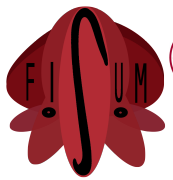
How to fix the parameters

Least squares fit to the experimental data, including excitation energies and absolute B(E2) transitions.

$$\chi^2 = \frac{1}{N_{data} - N_{par}} \sum_{i=1}^{N_{data}} \frac{(X_i(data) - X_i(IBM))^2}{\sigma_i^2}$$

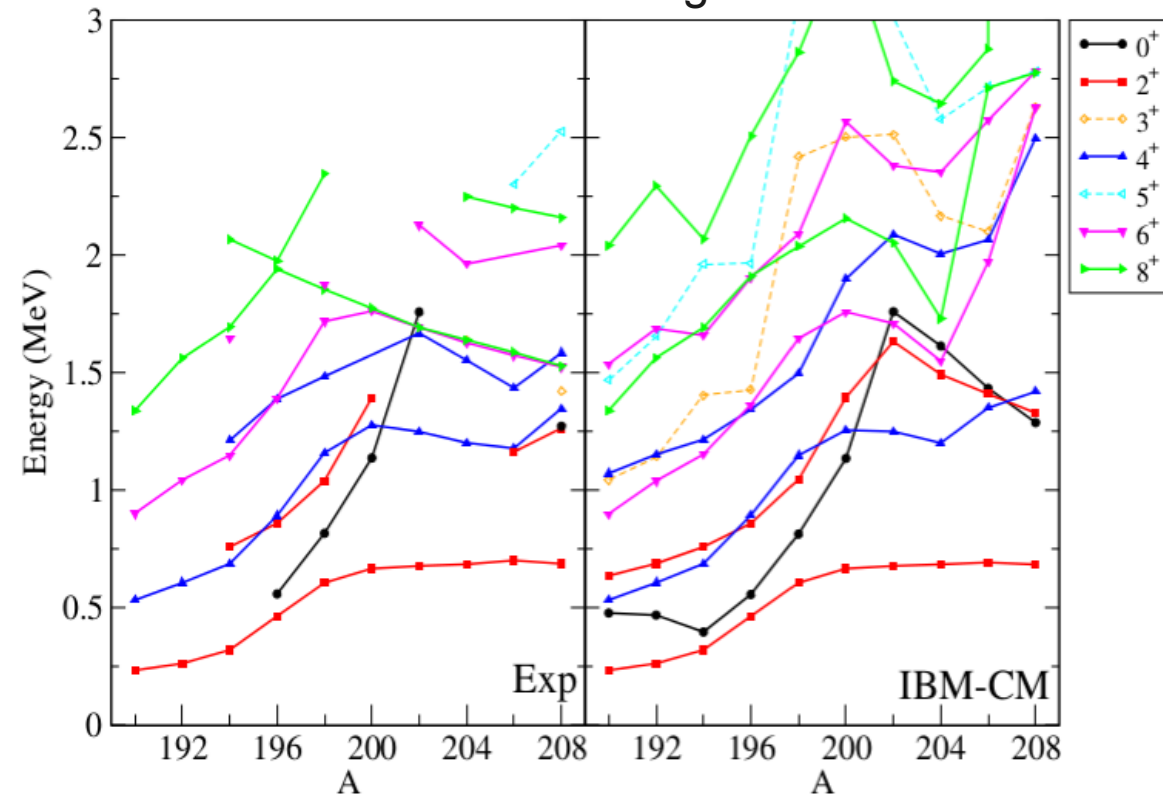
Error (keV)	States
$\sigma = 0.1$	2_1^+
$\sigma = 1$	$4_1^+, 0_2^+, 2_2^+$
$\sigma = 10$	$2_3^+, 3_1^+, 4_2^+, 6_1^+, 8_1^+$
$\sigma = 100$	6_2^+

+ all the known B(E2) transitions



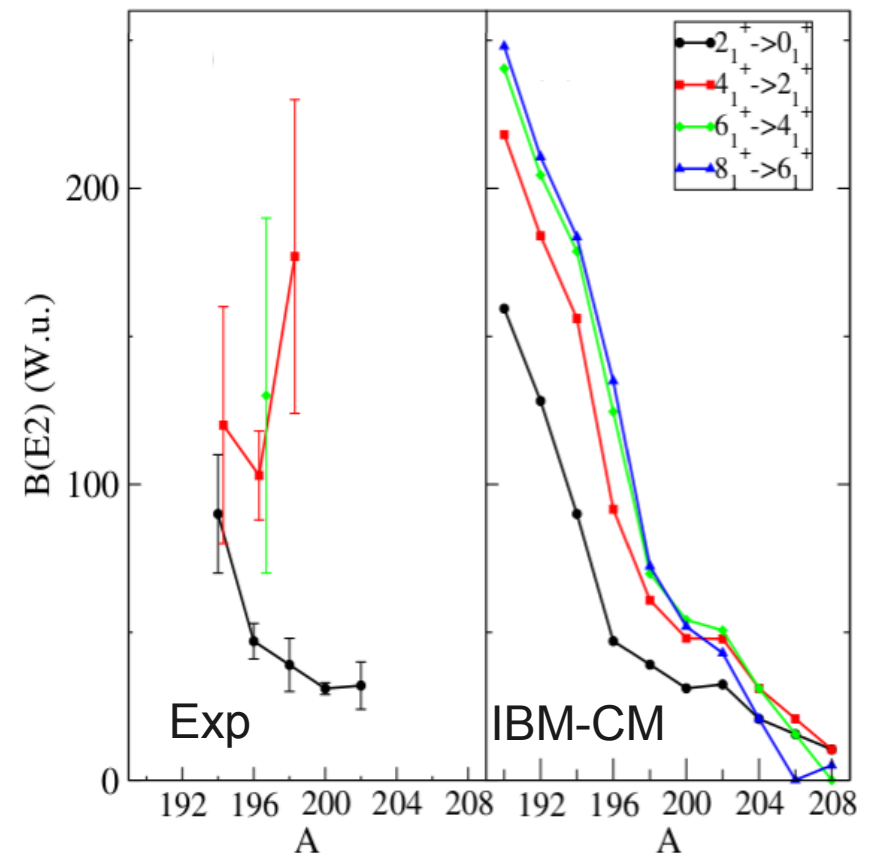
How the IBM results look like?

Excitation energies



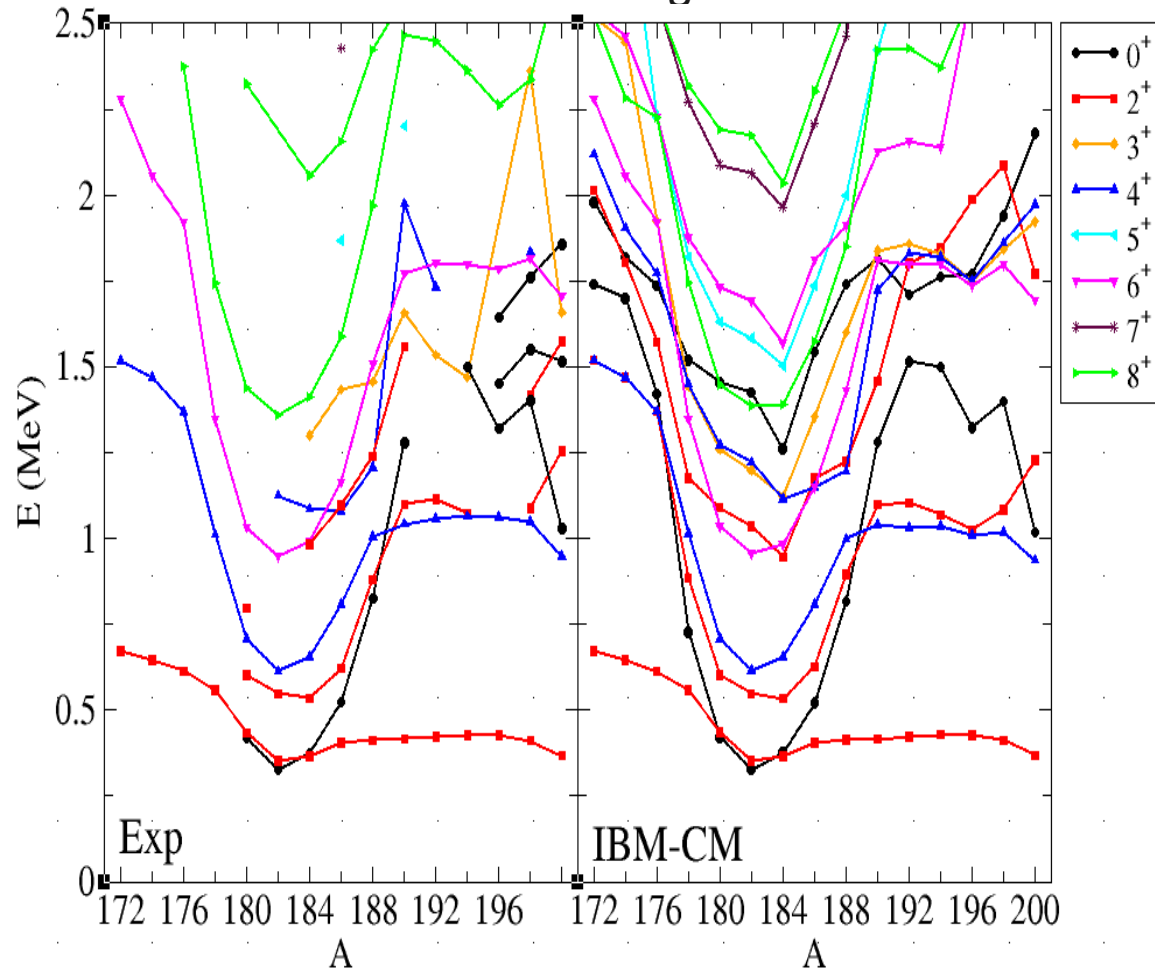
Po isotopes

B(E2)'s in the yrast band



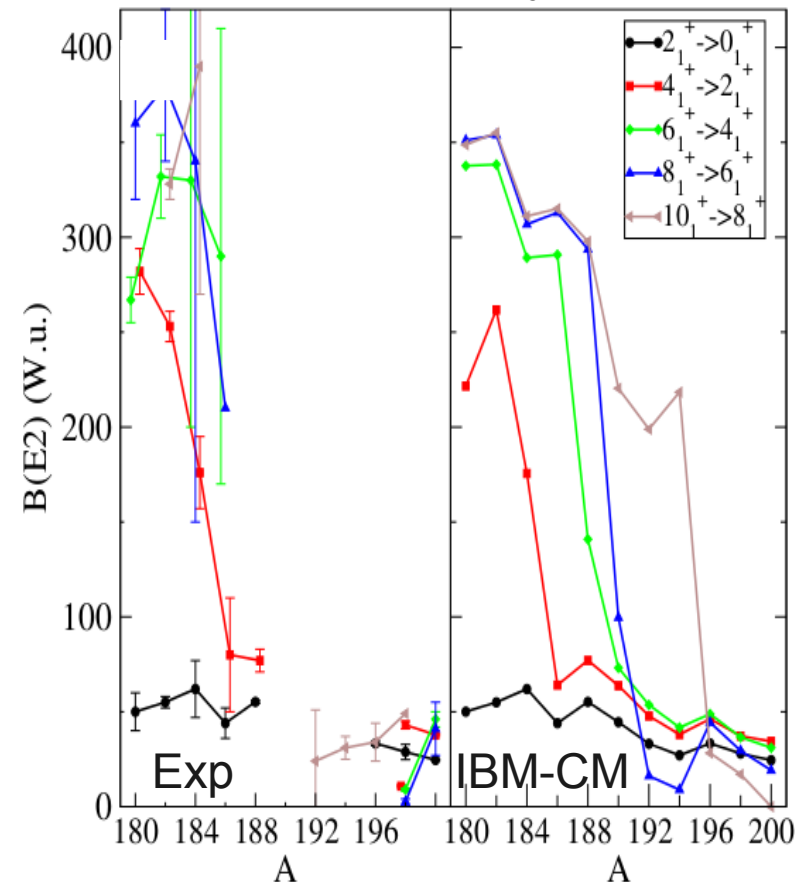
How the IBM results look like?

Excitation energies

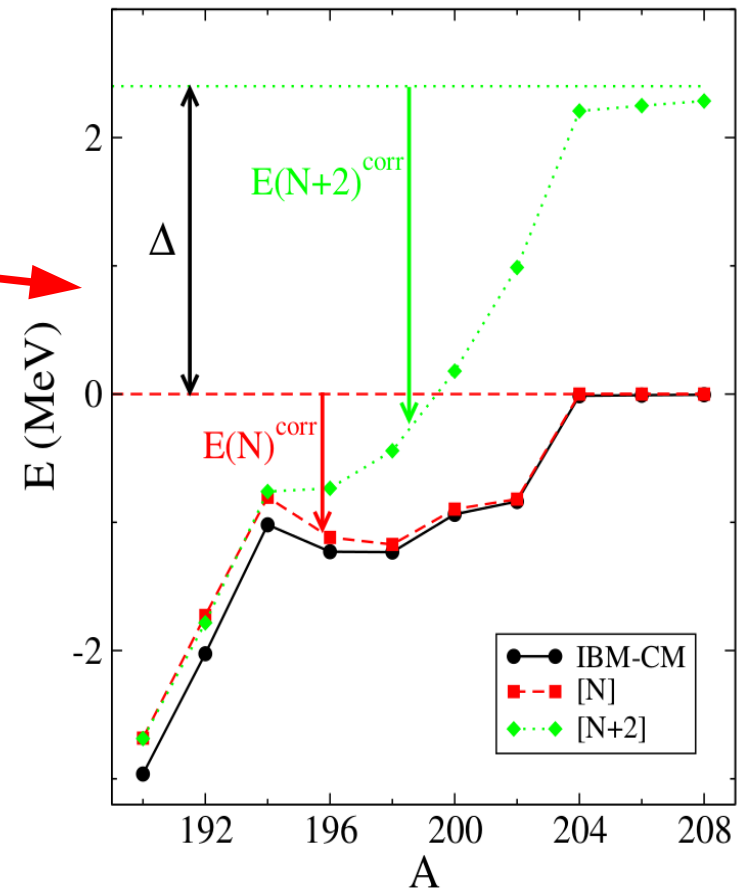
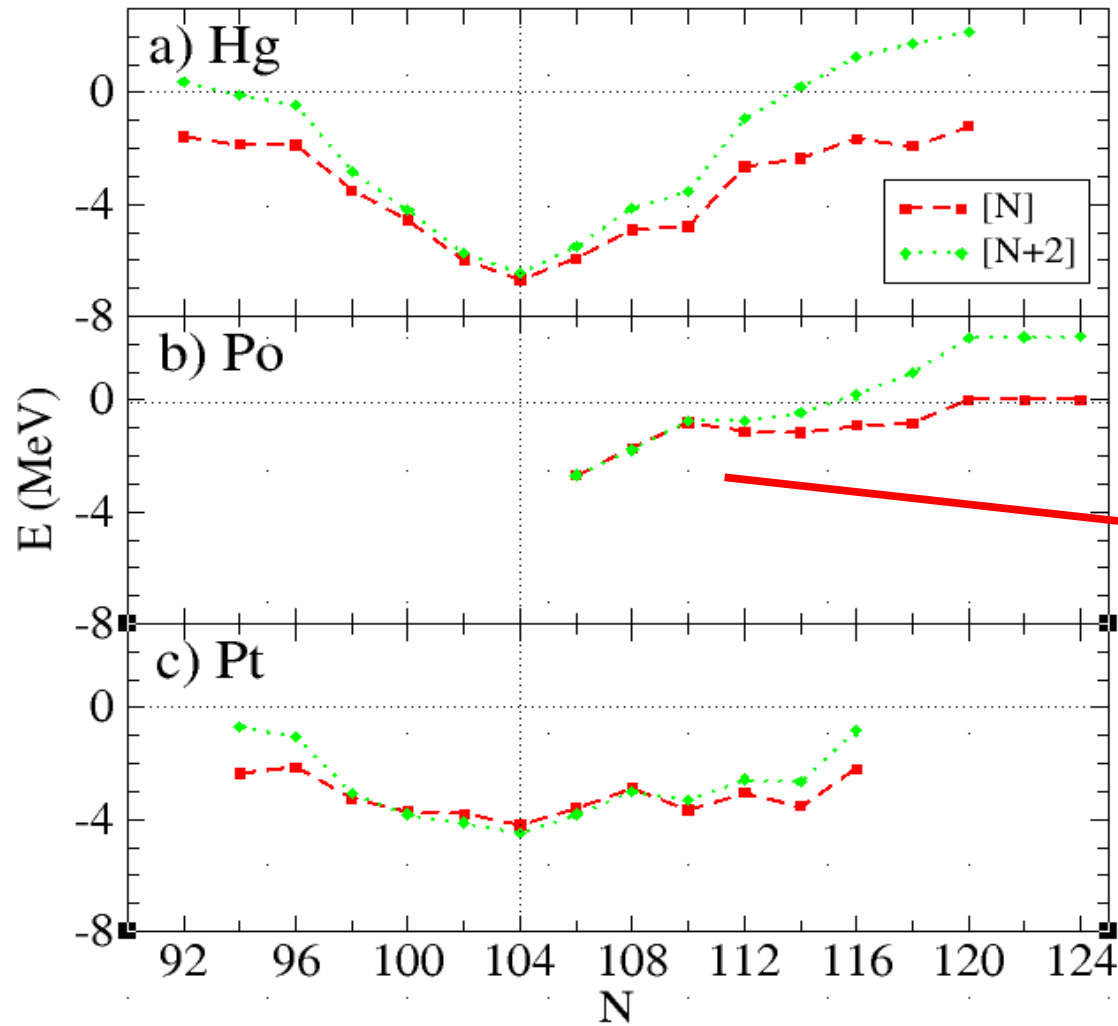


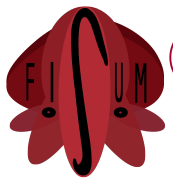
Hg isotopes

B(E2)'s in the yrast band



Correlation energy (IBM-CM)

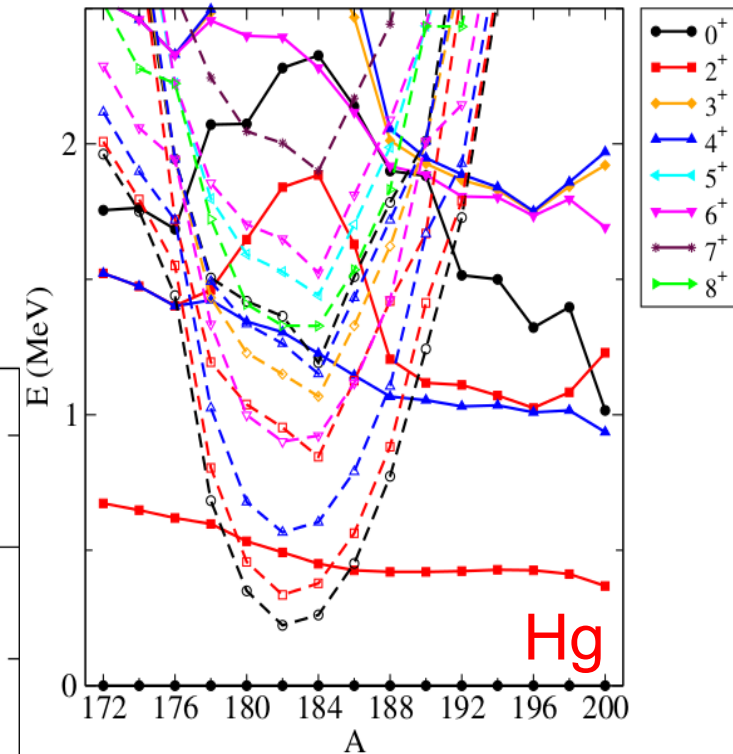
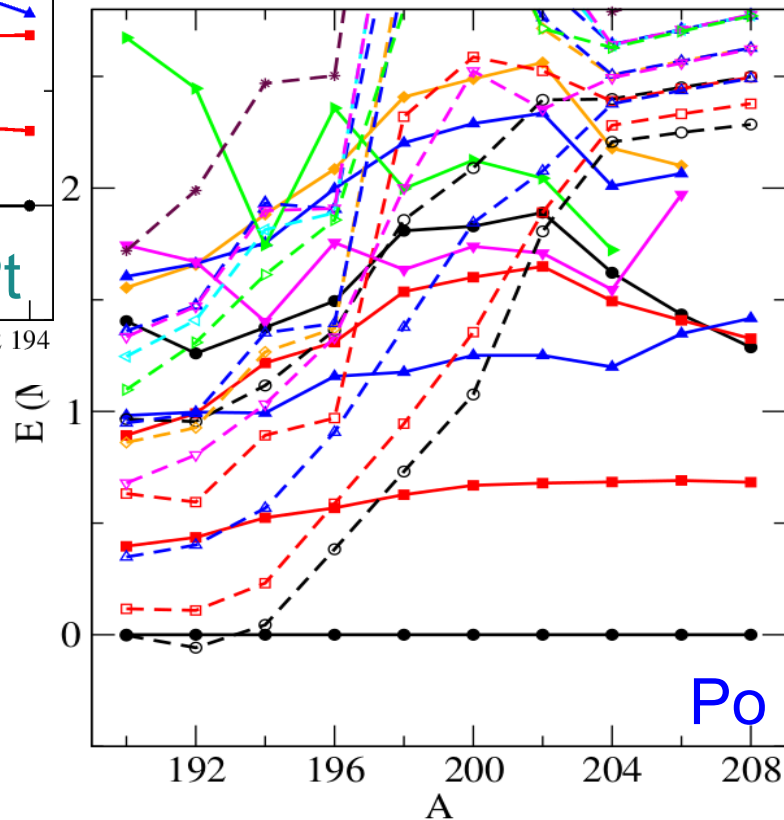
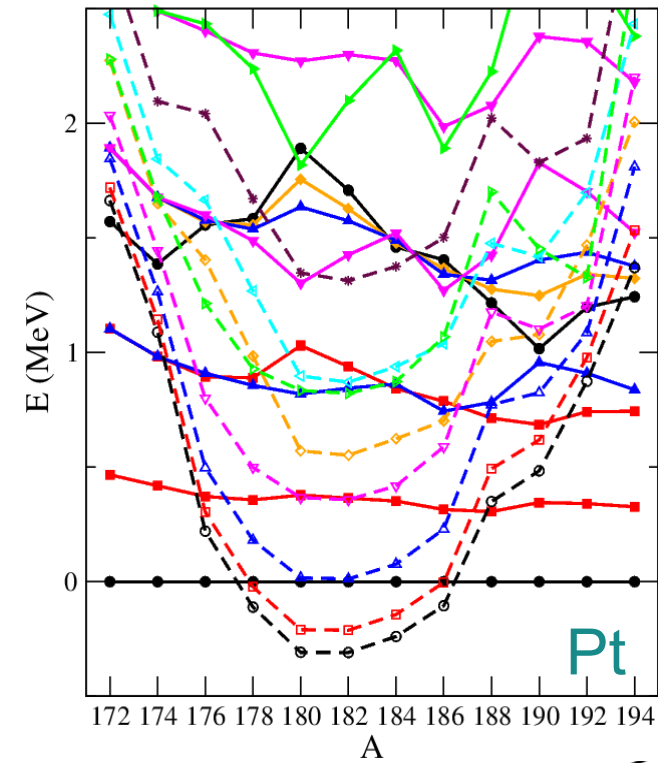




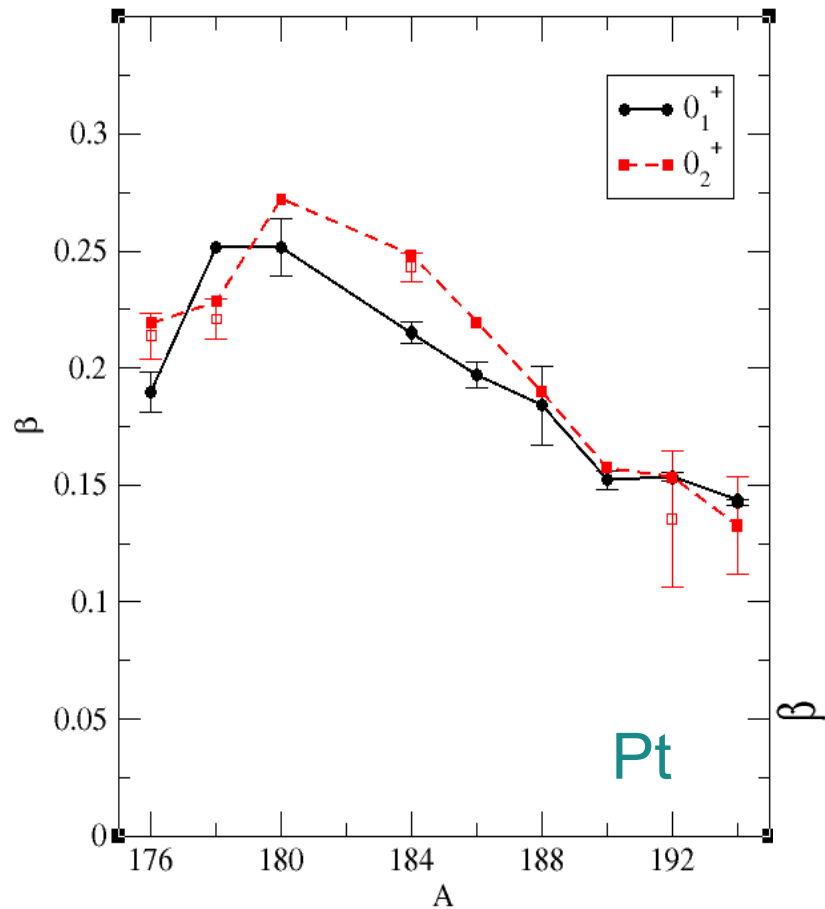
Universidad
de Huelva

www.uhu.es/gem

Unperturbed energies (IBM-CM)

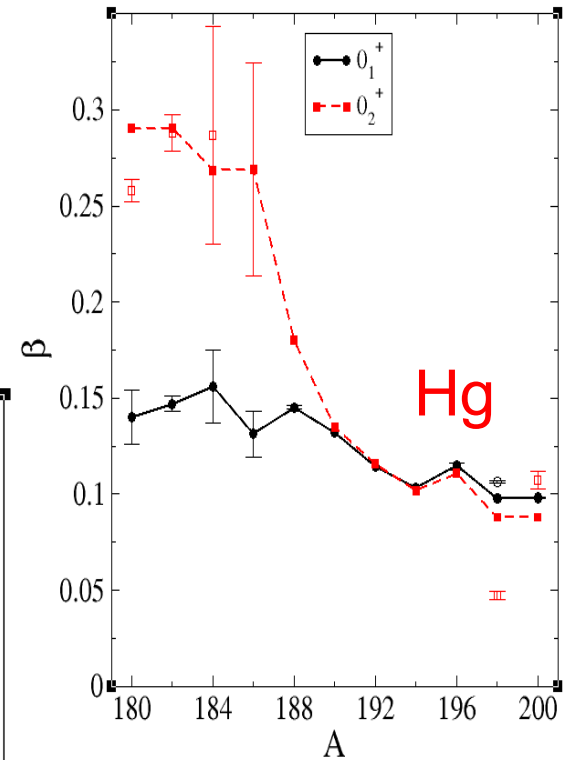
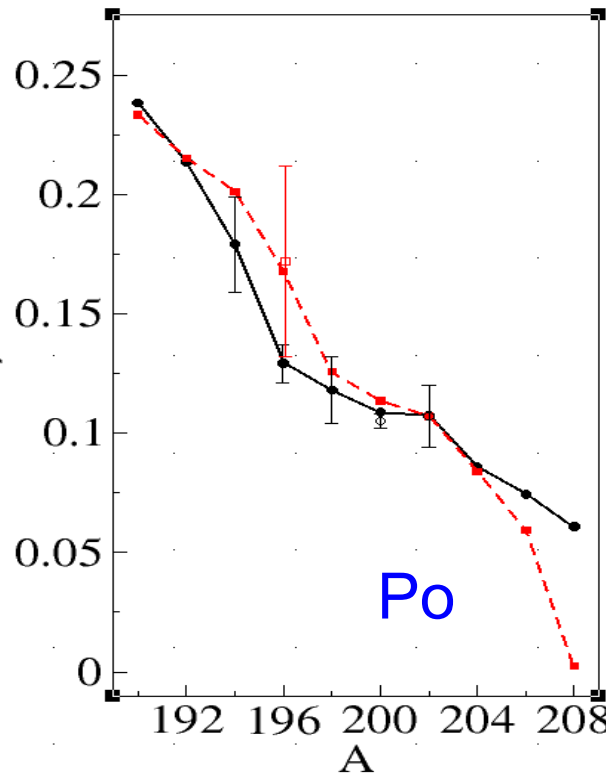


Deformation

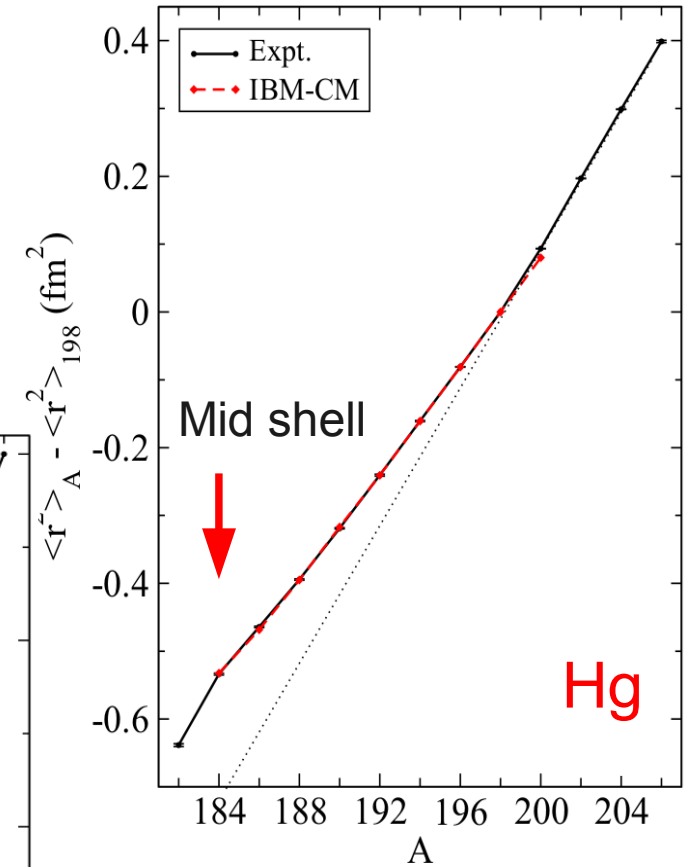
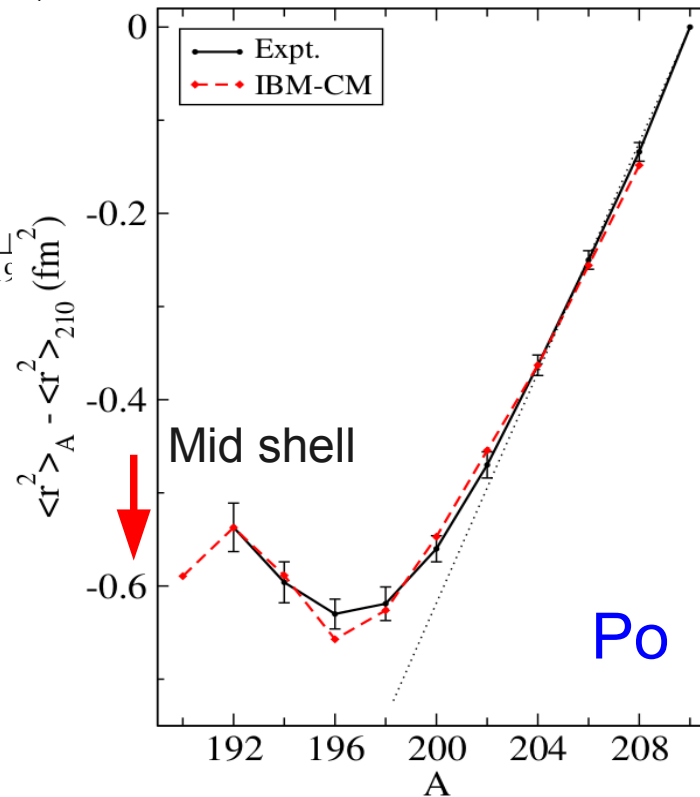
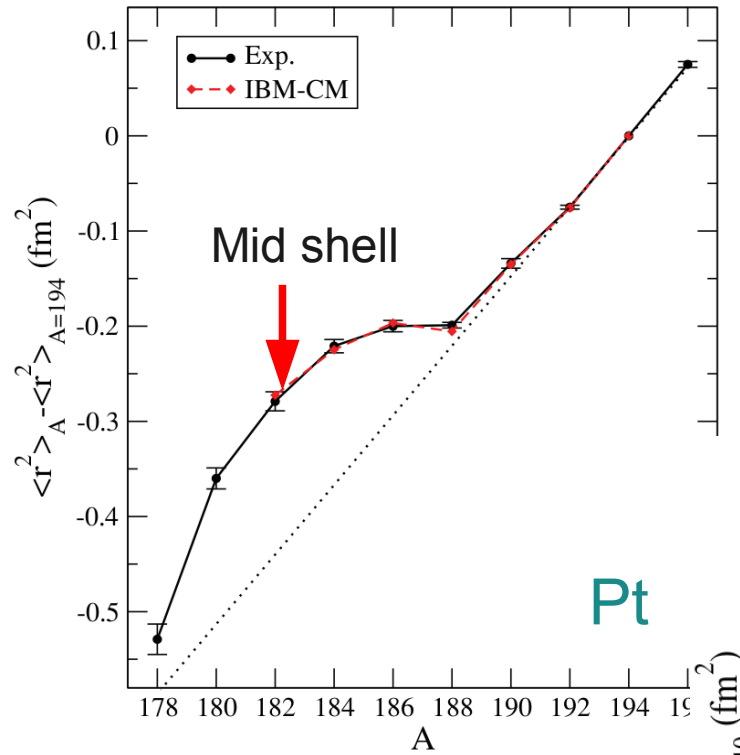


Beta's from $B(E2)$ values

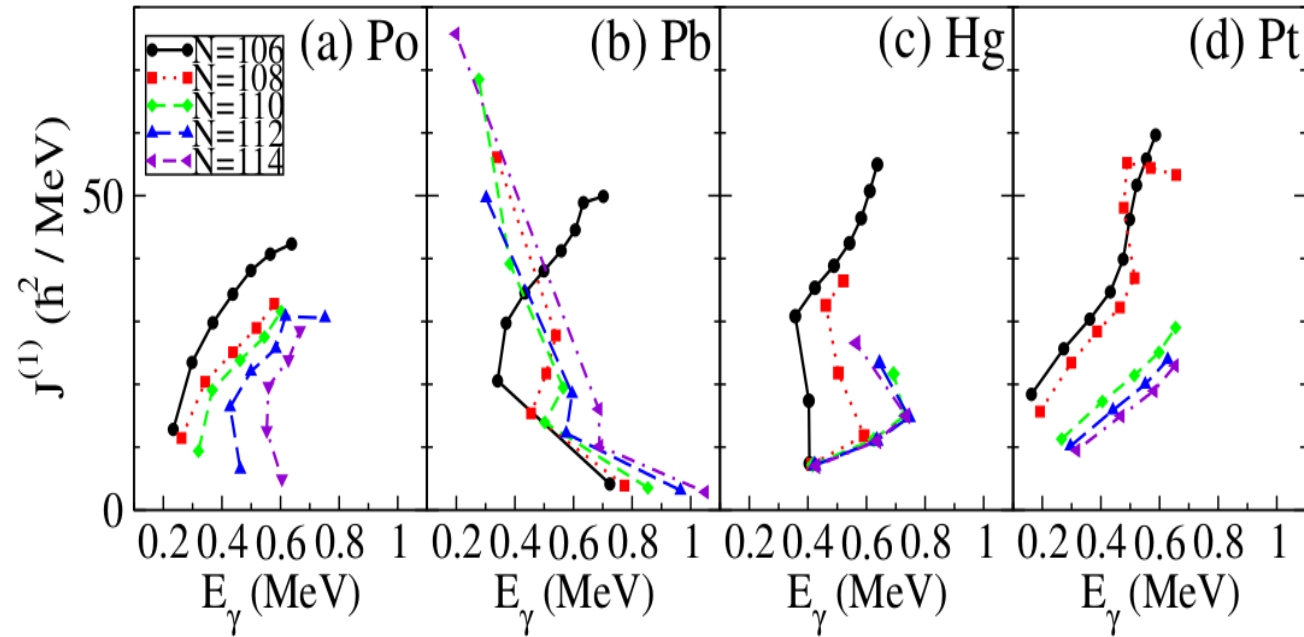
$$\beta = \frac{4\pi \sqrt{B(E2; J \rightarrow J-2)}}{3Ze r_0^2 A^{2/3} \langle J020 | J-20 \rangle}$$



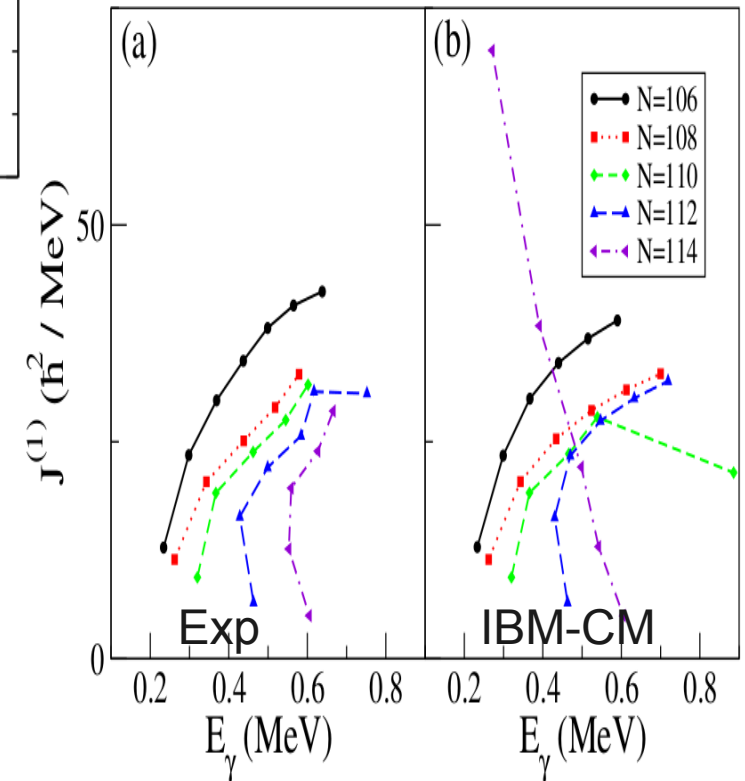
Radii

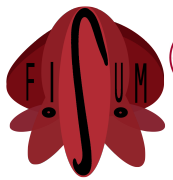


Kinematic moment of inertia



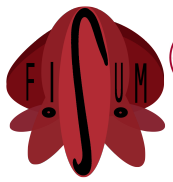
$$J^{(1)} = \frac{\hbar^2}{2} \left(\frac{dE}{d(J(J+1))} \right)^{-1} \approx \frac{\hbar^2(2J-1)}{2E_\gamma(J \rightarrow (J-2))}$$





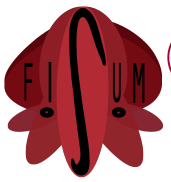
Summary and conclusions

- We have presented a detailed description of even-even Pt-Po-Hg isotopes using the interacting boson model including configuration mixing: excitation energies, BE2's, deformation, radii, ...
- In Po isotopes the effect of the coexistence is shown in the 0^+ and 2^+ states as in Pt, anyhow configuration mixing is somehow *concealed*. In Hg the presence of intruders is selfevident as in the case of Pb.
- Shape coexistence all through the nuclear mass region, is a very general phenomenon, except in few cases where the spherical shell gaps indeed block the development of deformed states.



Universidad
de Huelva
www.uhu.es/gem

Thank you

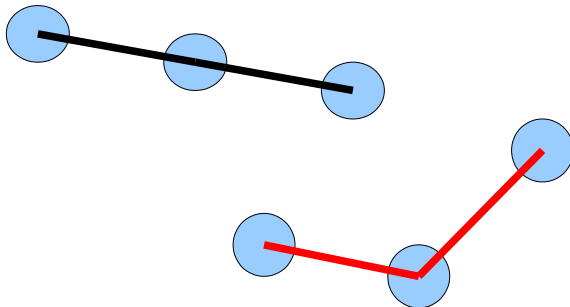


What is shape coexistence?

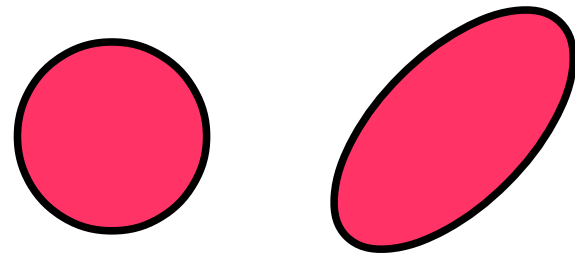
It appears in quantum systems where eigenstates with very different shapes coexist.

Therefore, it is implicit the existence of a geometric interpretation.

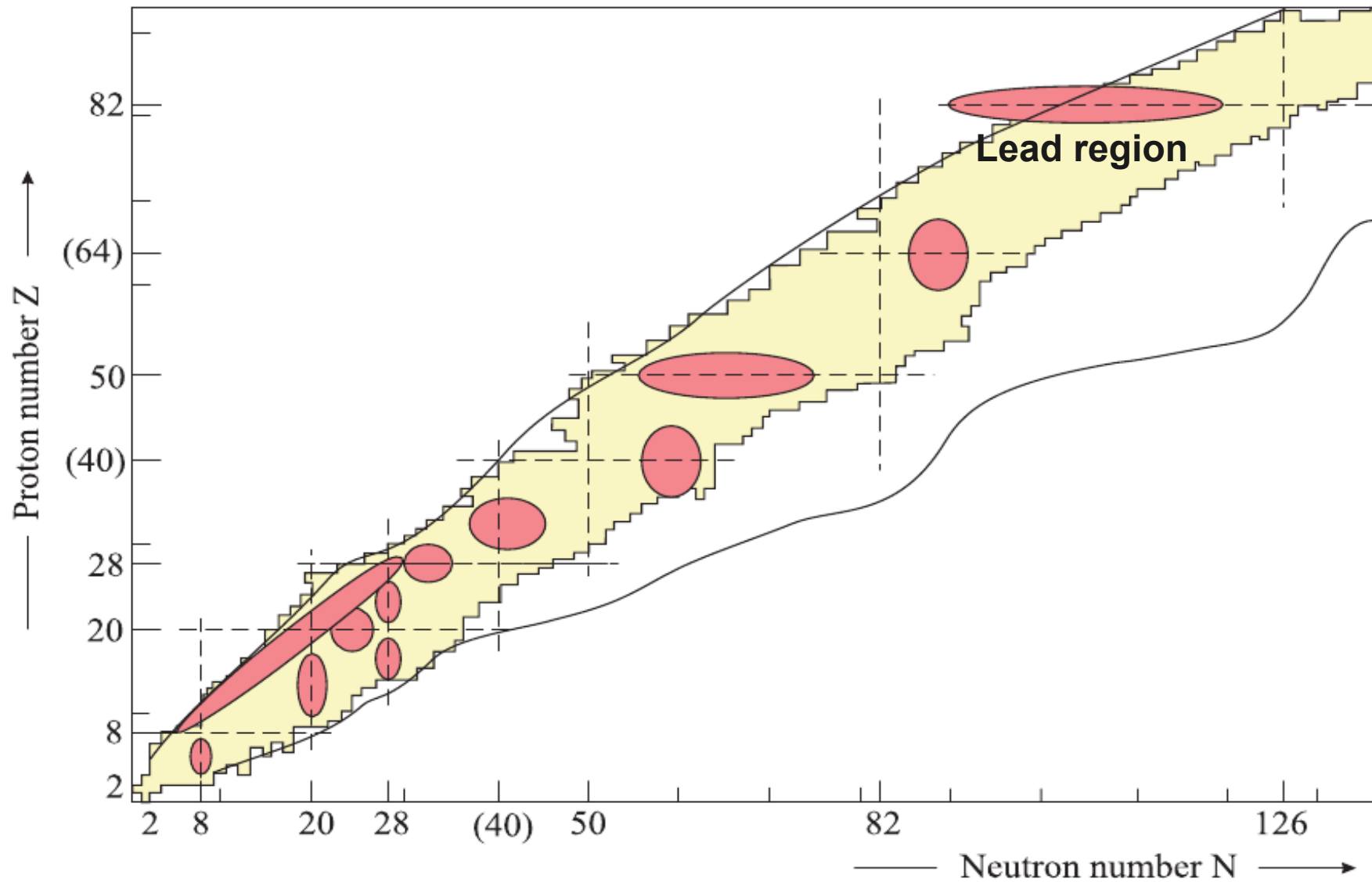
Molecules



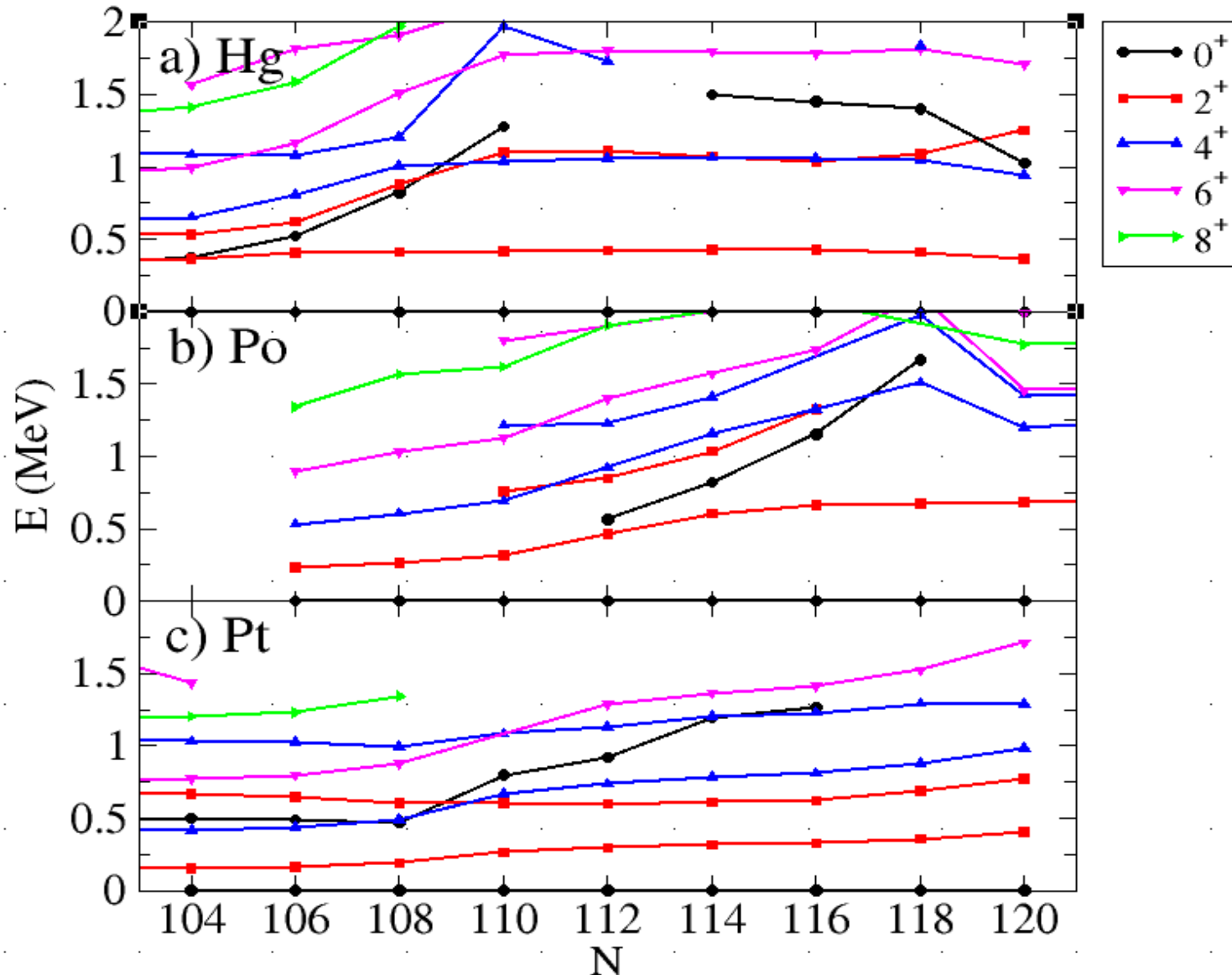
Nuclei

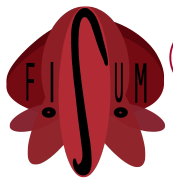


Many regions to understand



Excitation energies (exp)

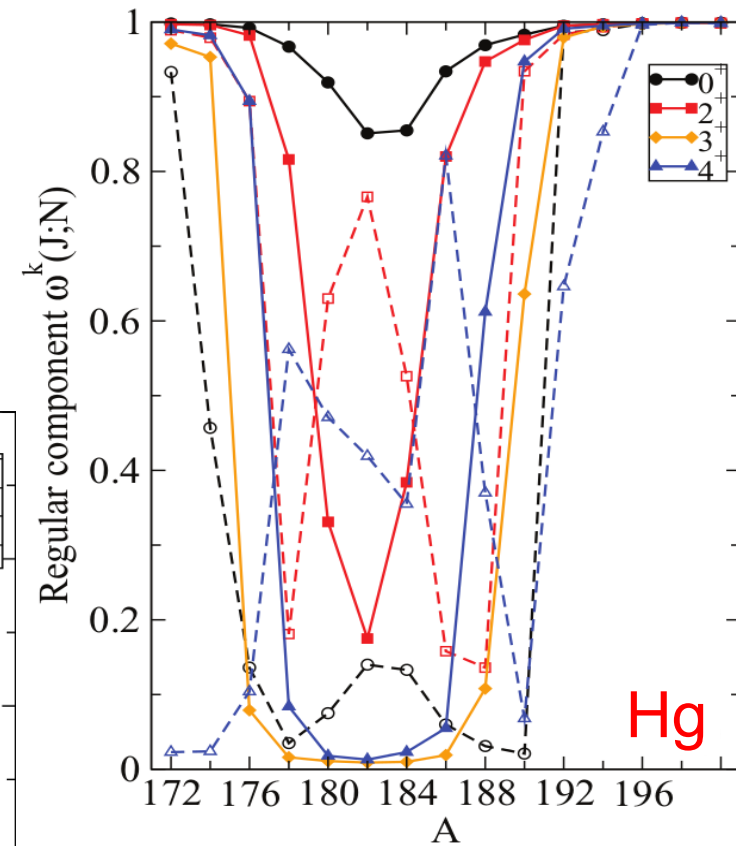
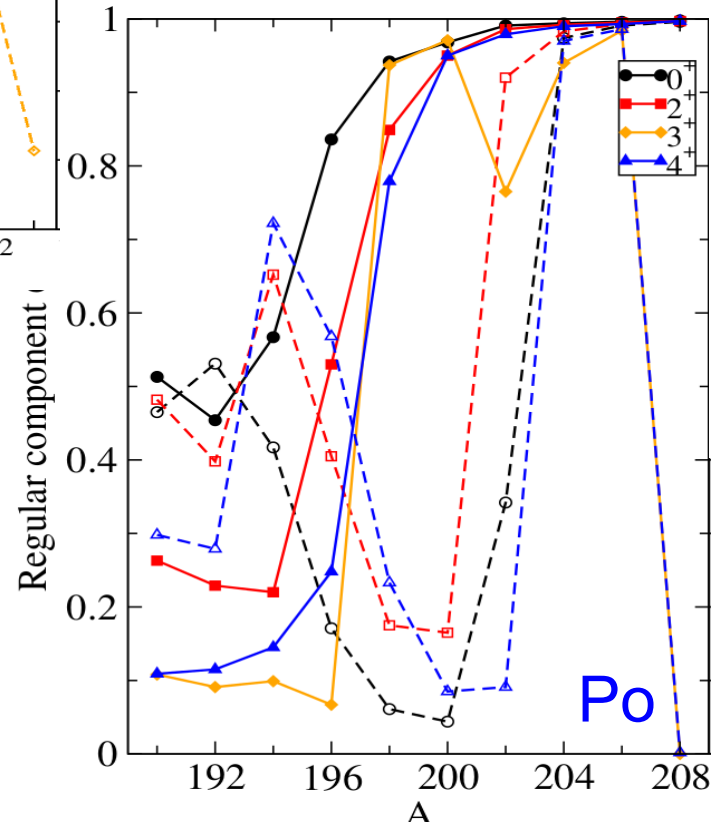
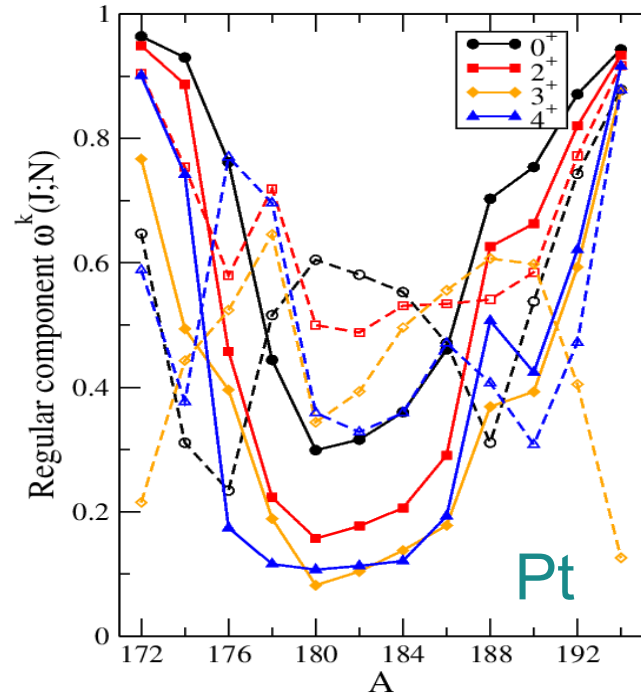




Universidad
de Huelva

www.uhu.es/gam

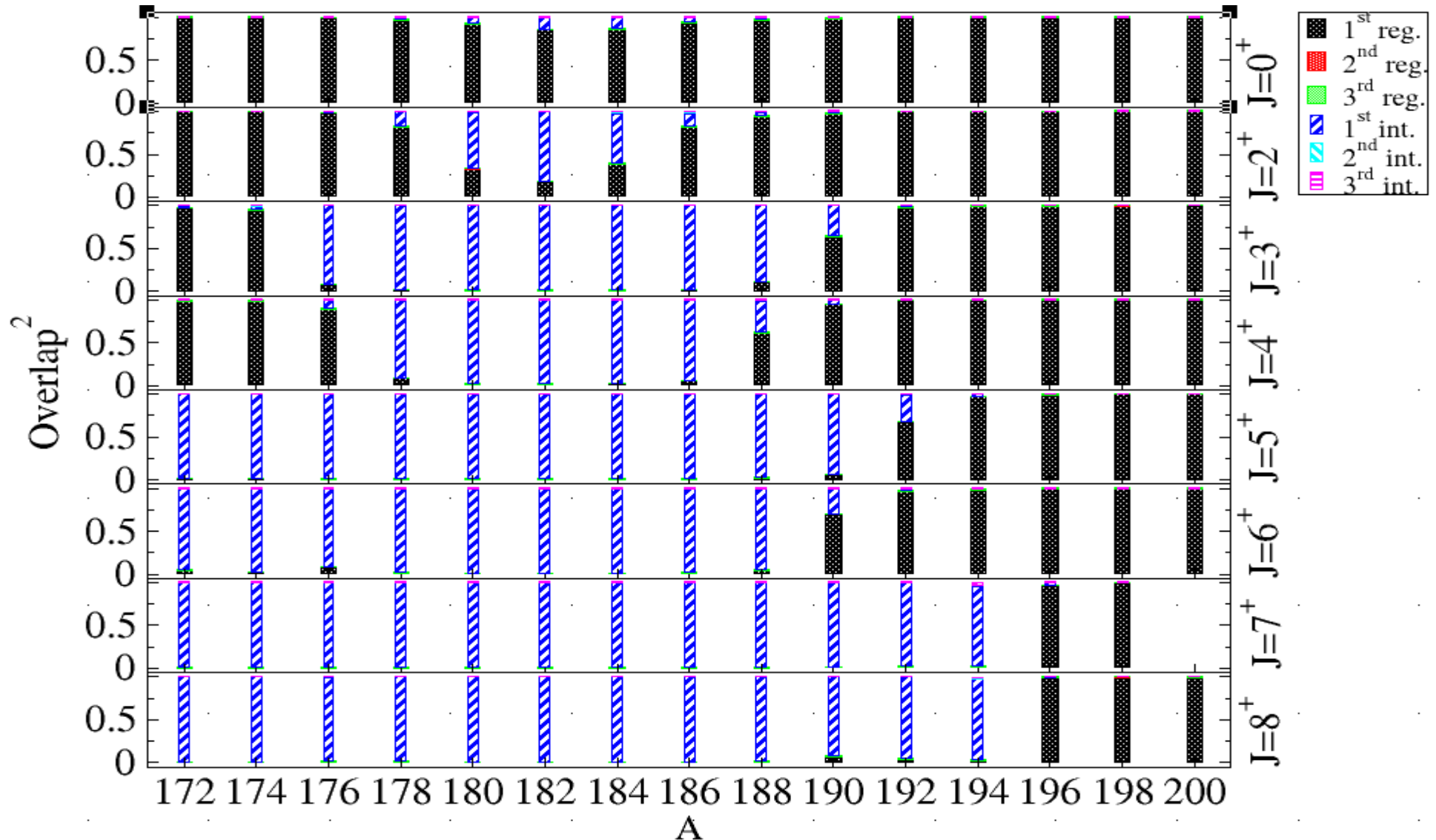
Wave functions (IBM-CM)





Decomposition in an intermediate basis (Hg)

First state



IBM-CM energy surfaces

