Shape coexistence in neutron deficient mercury isotopes

Jacek Dobaczewski & Alessandro Pastore
University of York

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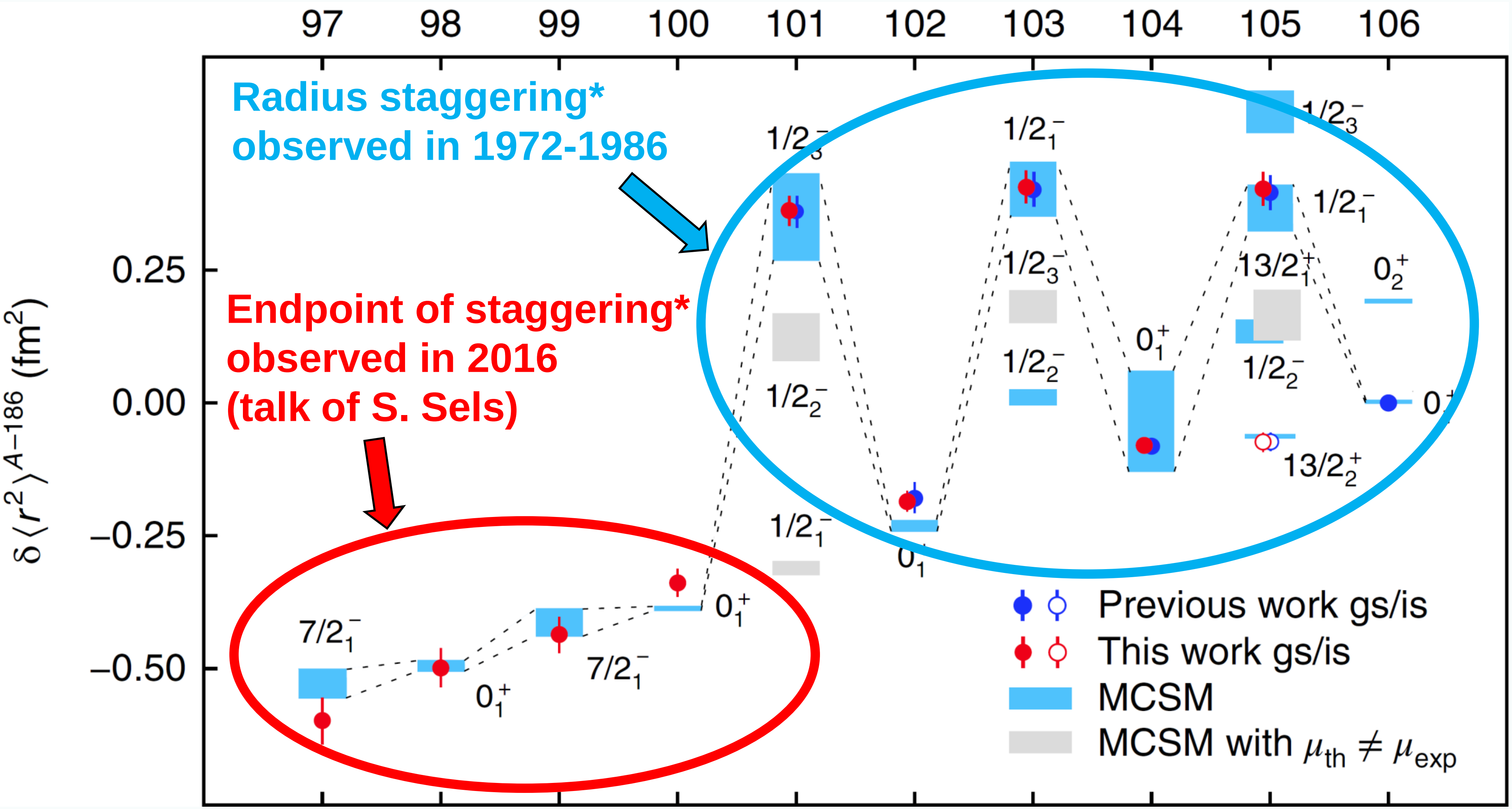


[1] B.A. Marsh et al. Nature Physics 14 (2018) 1163
[2] S. Sels et al., Phys. Rev. C 99 (2019) 044306

***A much weaker odd-even radius staggering is an ubiquitous phenomenon observed in most of the isotopic chains This talk is about a giant radius staggering observed only in the chain of light mercury isotopes.**

The physics of radius staggering in Hg

J. Bonn et al., Phys. Lett. B 38, 308 (1972).

“*The observation of the anomalous isotopic shift in ^{183,185}Hg points to the possible existence of a new region of strongly deformed nuclei only two units away from the closed proton shell.*”

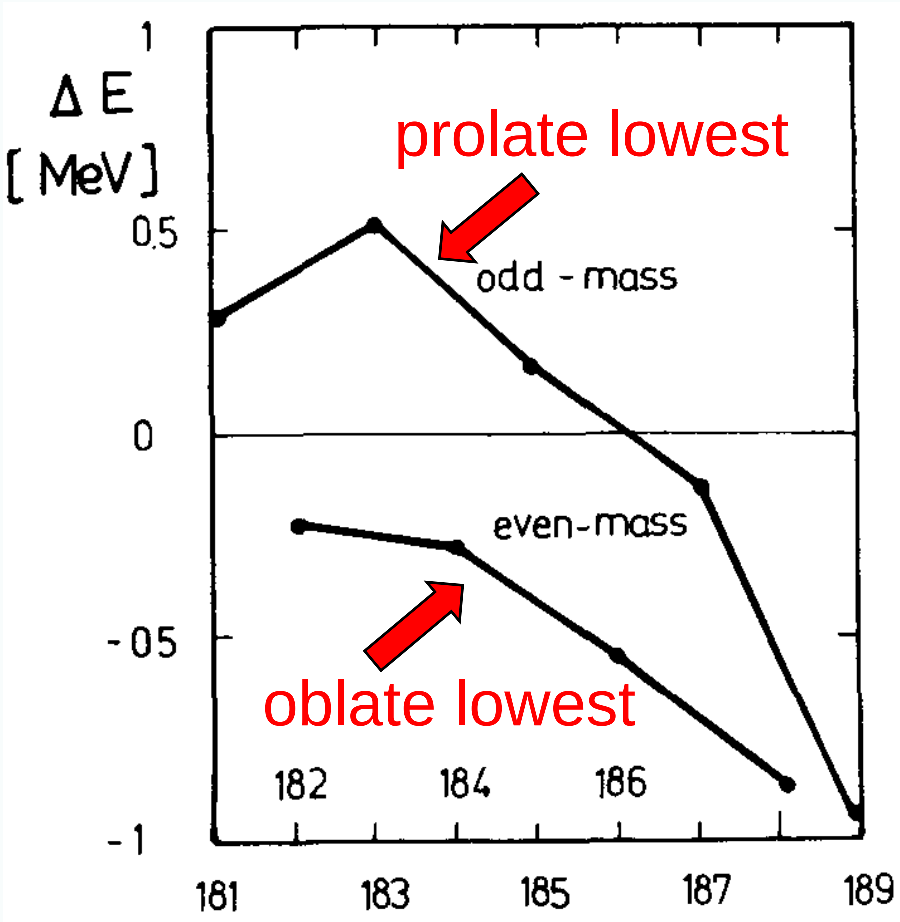
G. Ulm et al., Z. Phys. A: At. Nucl. 325, 247 (1986).

“*Now it is widely accepted that the light even Hg isotopes, as well as ^{185m}Hg, and those with A > 186 have a small oblate deformation, while the light odd isotopes ^{181}Hg, ^{183}Hg, and ^{185}Hg are strongly deformed and prolate.*”

Theoretical description of radius staggering in Hg

S. Frauendorf and V. V. Pashkevich, Phys. Lett. B 55, 365 (1975).

“A more critical point, however, is the proper choice of the strength of the pairing interaction because the energy difference between the two minima ΔE sensitively depends on this quantity. [...] Therefore it is very difficult to obtain ΔE with the required accuracy and we allowed for a certain adjustment of ΔE via the averaged proton gap.”

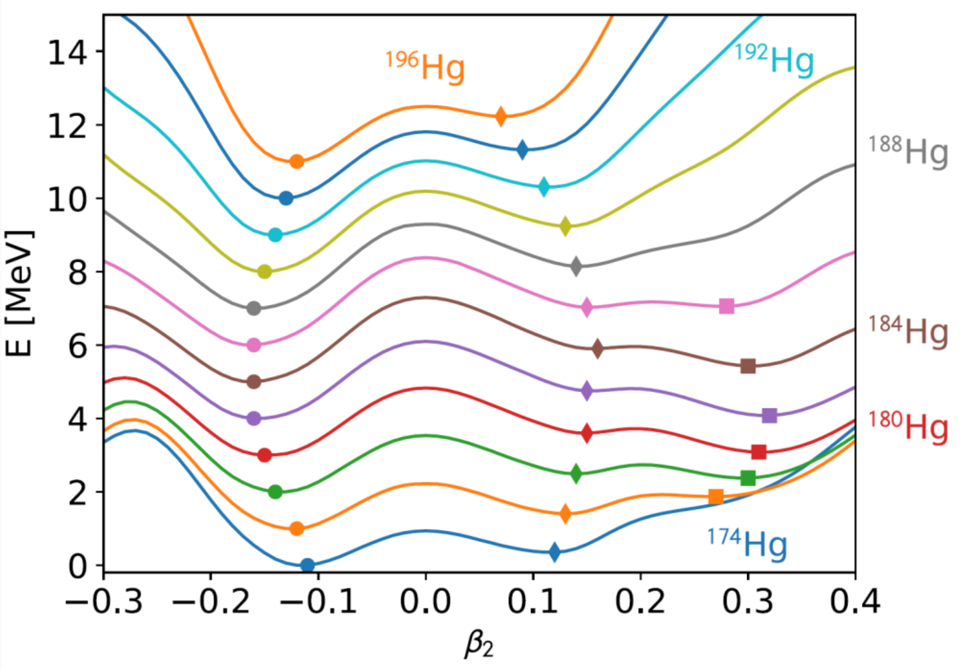


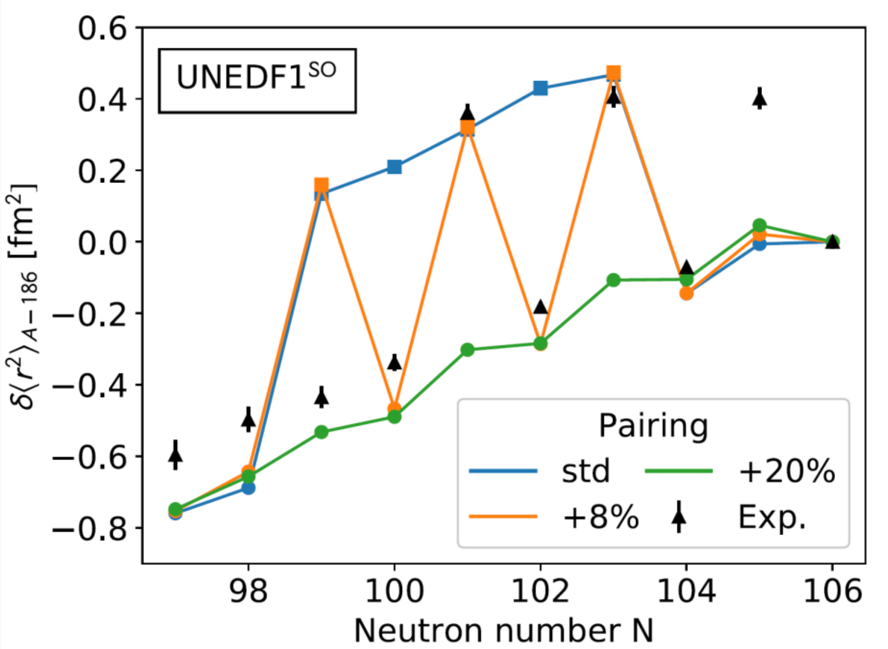
Nuclear DFT description of radius staggering in Hg

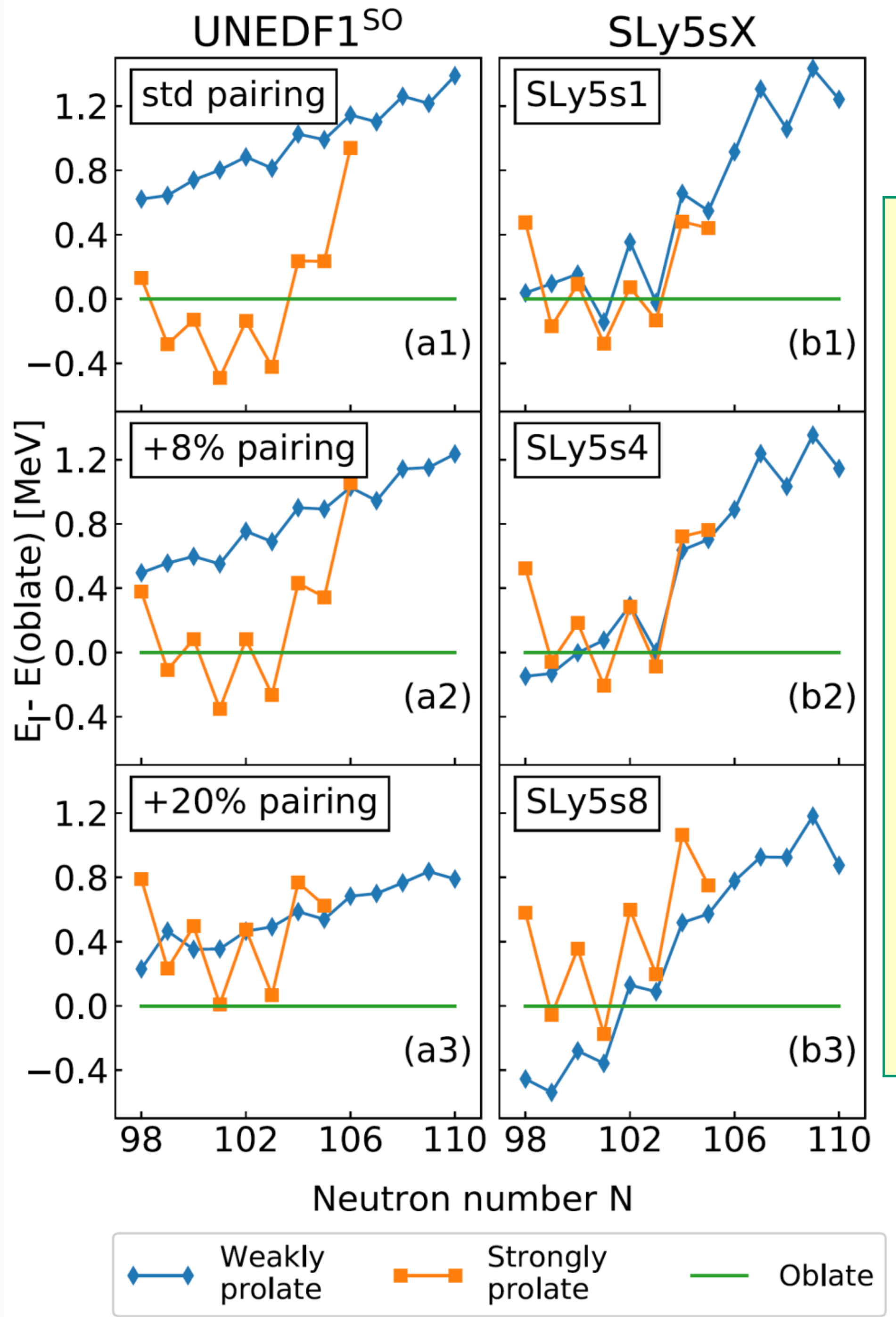
[1] S. Sakakihara and Y. Tanaka, Nuclear Phys. A 726, 37 (2003).
[2] J. M. Yao et al., Phys. Rev. C 87, 034322 (2013).
[3] J. M. Boillos and P. Sarriguren, Phys. Rev. C 91, 034311 (2015).
[4] V. Manea et al., Phys. Rev. C 95, 054322 (2017).
[5] S. Sels et al., Phys. Rev. C 99, 044306 (2019).

In [5] we say:

"*Early DFT calculations for both even- and odd-mass isotopes mercury isotopes […] achieved a reproduction of the odd-even radius staggering for N > 100 by fitting the pairing strength to the one-particle separation energy of these isotopes [2]. In Ref. [3] the shape coexistence in the region was confirmed as a mechanism for the observed radius staggering. […] As explicitly noted in Ref. [4], the precise staggering pattern depends sensitively on the details of the effective interaction.*"







S. Sels et al., Phys. Rev. C 99, 044306 (2019).

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University of Warsaw

Conclusions

1. Fantastically precise laser spectroscopy measurements have revealed spectacular phenomenon of a **giant charge radius staggering in three odd mercury isotopes** ^{191}Hg, ^{193}Hg, and ^{195}Hg, whereas all other isotopes between A=177 and A=126 follow a typical, fairly smooth behaviour.
2. Already in 1975, this phenomenon was correctly associated and properly described in terms of the **quadrupole shape staggering** between weakly oblate and strongly prolate deformations. This interpretation still holds today.
3. Numerous later DFT studies and the latest tour-de-force MCSM study have **confirmed this interpretation**.
4. Detailed description of energies of the competing shapes would require an **unprecedented and unrealistic precision** of modelling below 100 keV. This level of precision is possible only by an extreme fine-tuning of model parameters.

Thank you

MCSM description of radius staggering

B.A. Marsh et al., Nature Physics 14 (2018) 1163

"This work represents the largest ever MCSM calculations, performed on massively parallel supercomputers, including the K computer in Kobe, Japan. Exploiting the advantages of quantum Monte-Carlo, variational and matrix-diagonalization methods, this approach circumvents the diagonalization of a > 2×10^{42}-dimensional Hamiltonian matrix. Using the doubly-magic ^{132}Sn nucleus as an inert core, 30 protons and up to 24 neutrons were left to actively interact in an exceptionally large model space as compared to conventional CI calculations. Single-particle energies were set to be consistent with single particle properties of ^{132}Sn and ^{208}Pb with smooth changes as functions of Z and N. All nucleons interact through effective NN interactions adopted from the frequently-used ones."