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From Exotic Symmetries to Exotic Isomers in Both Stable and Exotic Nuclei

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We discuss selected results of a large scale exotic symmetry research project addressing even-even nuclei with Z, N > 10, including exotic and super-heavy nuclei – calculations performed in multidimensional deformation spaces. In the presentation we focus on realistic nuclear mean-field theory results for two types of nuclear isomers: yrast-trap and K-isomers in axially symmetric nuclei, cf. recent refs. [1,2], as opposed to nuclear shape-isomers generated by exotic shape-symmetries. In the present terminology, shapes which are neither quadrupole prolate, oblate or triaxial nor pear-shape octupole deformed are referred to as exotic.

We employ our phenomenological mean field Hamiltonian with its universal parametrisation. The term 'universal' refers in the present context to the fact that the parameter set used is common for all the nuclei in the nuclear mass table. There are no further parametrisation adjustments e.g. depending on the experimental context.

Our microscopic calculations of the nuclear potential energies - in particular 2D projections usually called potential energy surfaces - involve applications of the Inverse Problem Theory to stabilise the predictive power of the new parametrisation of the Hamiltonian and of the Graph Theory to address multidimensional shape analysis. Predictive power of this new parametrisation has been tested in recent ref. [3]. Both techniques are well known in the domain of applied mathematics. We employ Group Representation Theory to address point-group symmetries, in particular to construct experimental identification criteria of newly predicted, exotic symmetries.

Presentation, while focussing on new applications of the powerful mathematical tools, addresses mainly experimental nuclear-structure audiences; we use in particular selected unpublished material of our collaboration [4].

Relating specifically to exotic-shape isomers, we wish to discuss in particular the properties of the newly predicted, so-called molecular symmetries D_{3h}, D_{2v} and D_{2d} together with their experimental identification criteria, as well as a new mechanism referred to as 'isomer bands' – a new property of nuclei in their tetrahedral, T_d, and/or octahedral, O_h symmetry configurations, the latter recently discovered in subatomic physics, cf. ref. [5].

References:

[1] C. Hornung et al., Phys. Lett. B802 (2020) 135200
[2] S. Beck et al., Phys. Rev. Lett. 127 (2021) 112501
[3] A. Gaamouci, I. Dedes, J. Dudek, A. Baran, N. Benhamouda, D. Curien, H. L. Wang and J. Yang, Phys. Rev. C103 (2021) 054311
[4] J. Yang, J. Dudek, I. Dedes, A. Baran, D. Curien, A. Gaamouci, A. Gozdz, A. Pedrak, D. Rouvel, H. L. Wang and J. Burkat; submitted for publication
[5] J. Dudek et al., Phys. Rev. C97 (2018) 021302(R)

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