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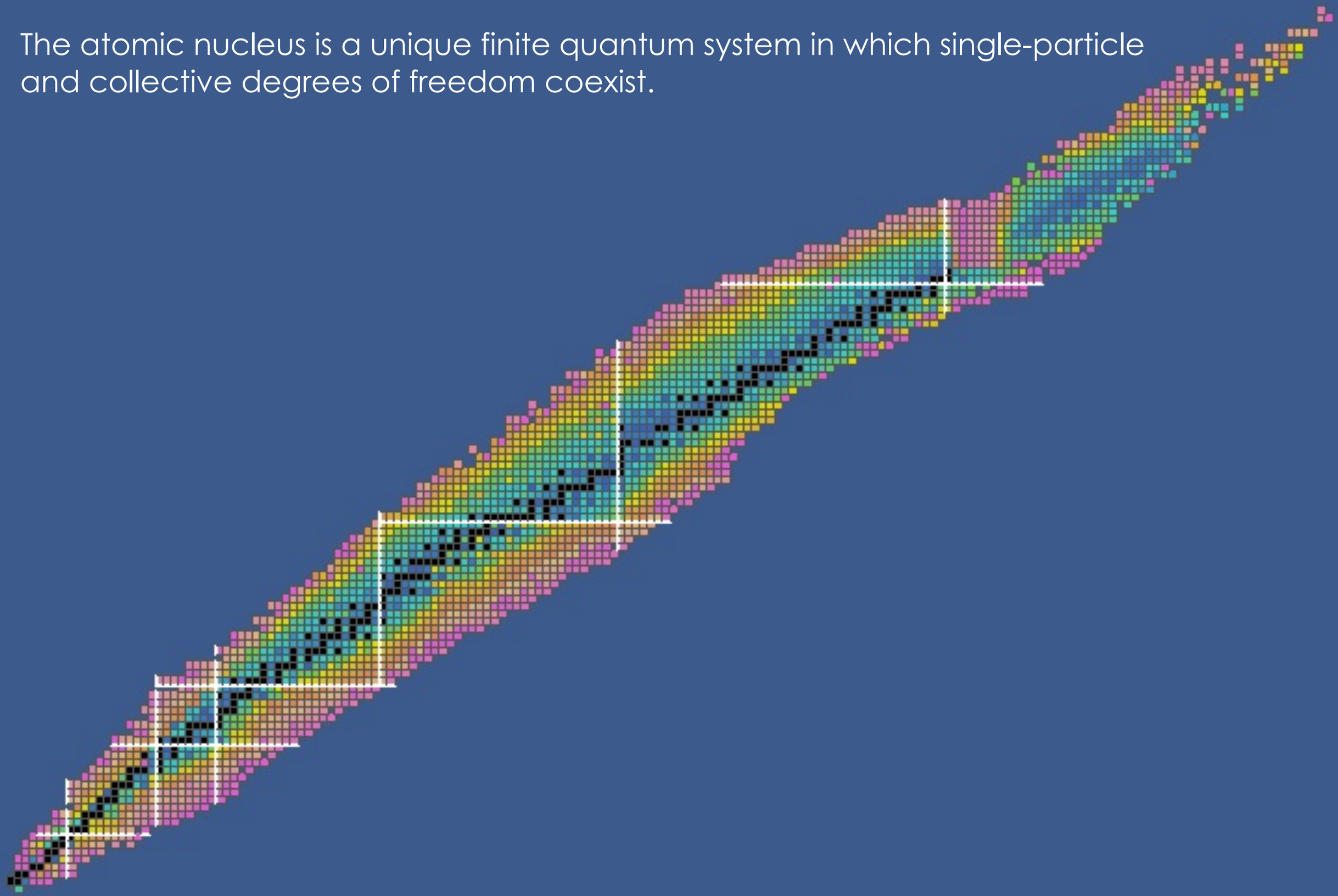

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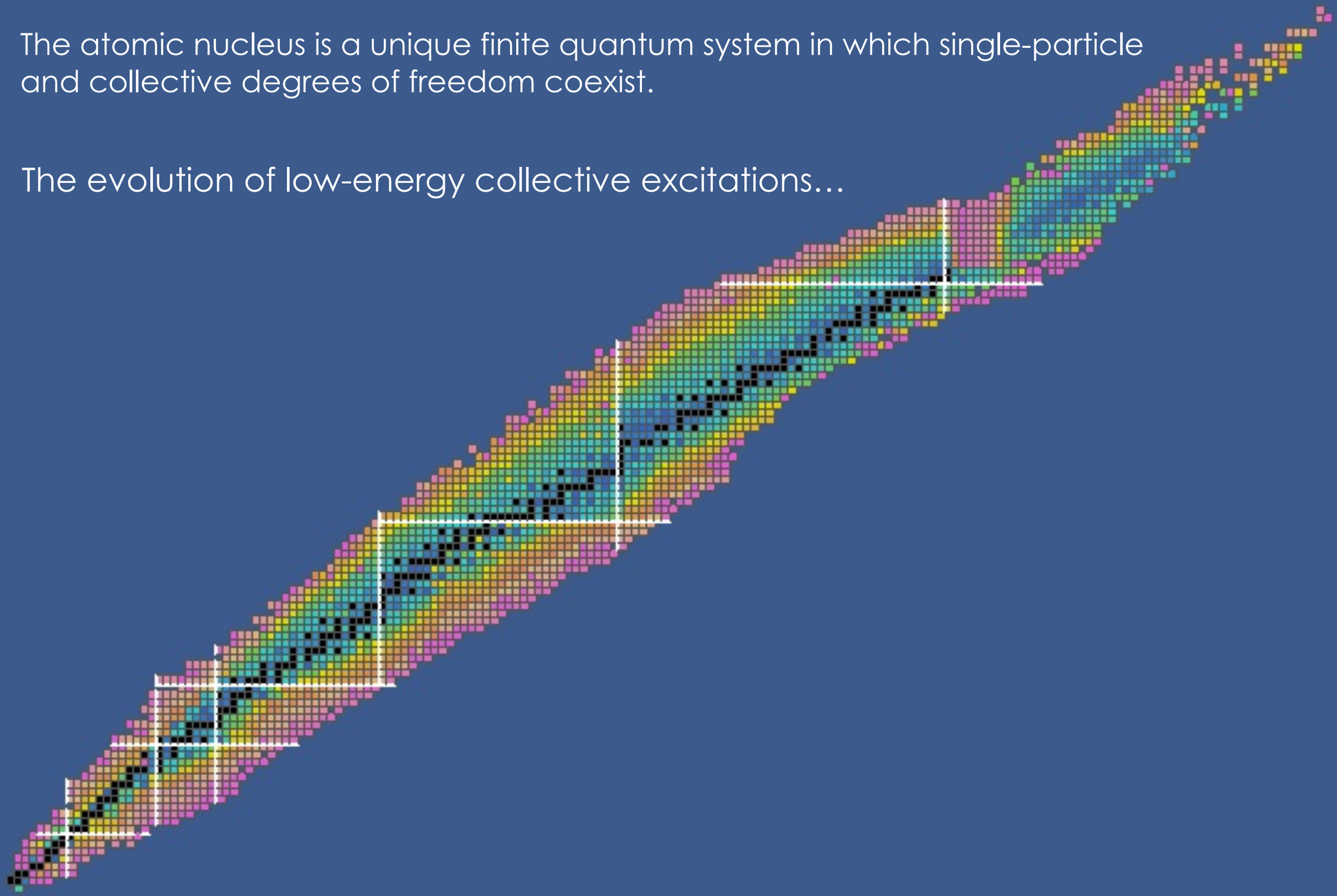

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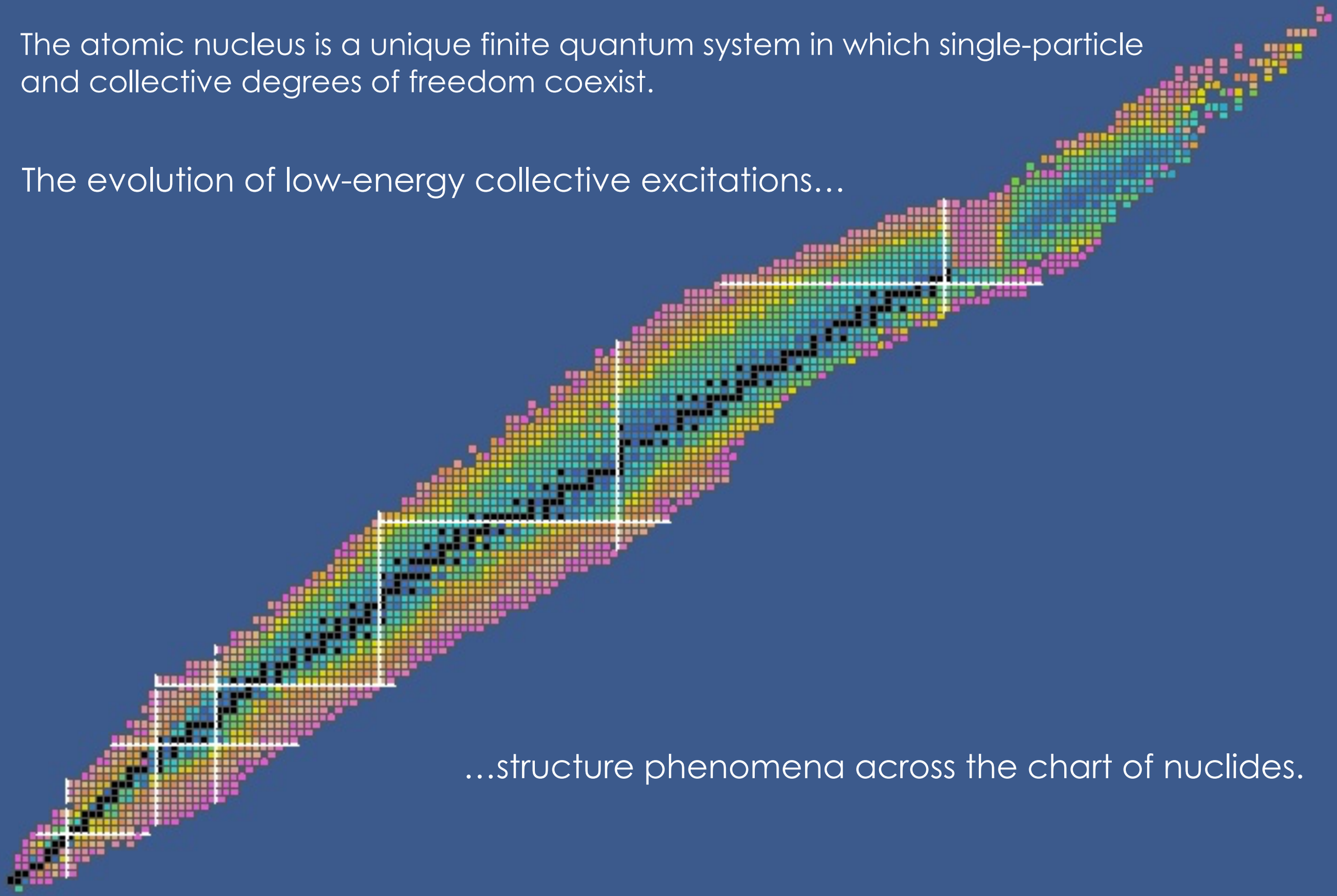

…structure phenomena across the chart of nuclides.

Nucleonic matter supports a variety of nuclear shapes:

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Evolution of shell structure with nucleon number and/or angular momentum.

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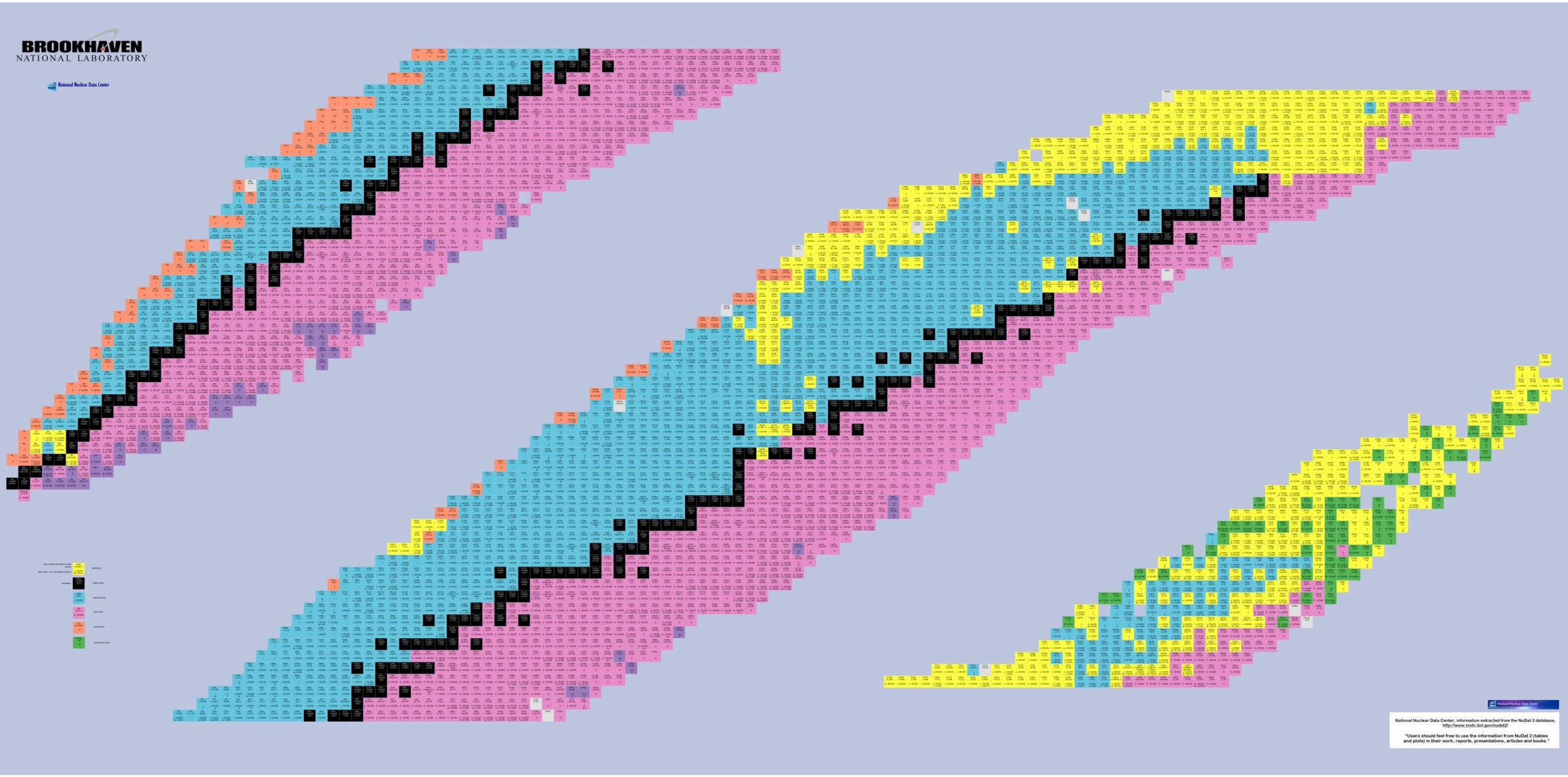
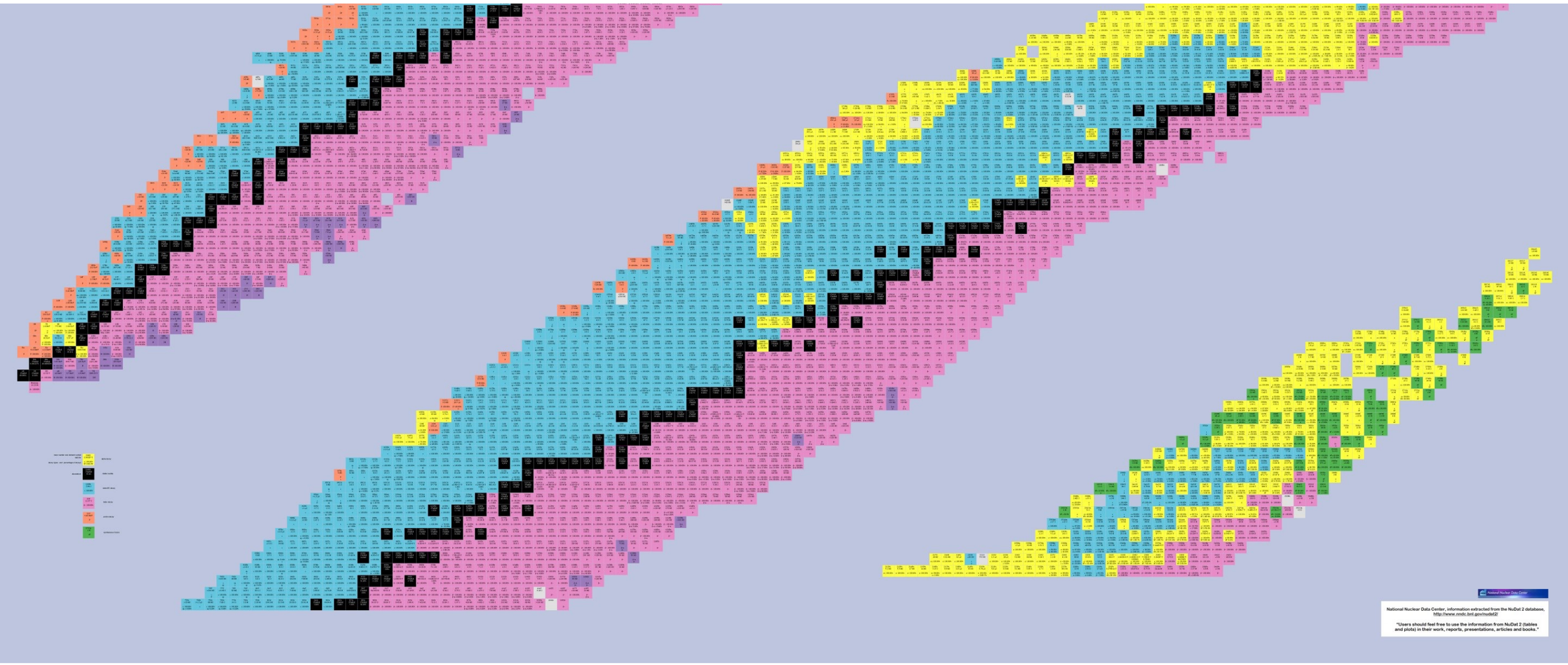
Universal theory framework:  Nuclear Energy Density Functionals

# Energy Density Functionals



# Energy Density Functionals

✔ the nuclear many-body problem is effectively mapped onto a ***one-body problem*** without explicitly involving inter-nucleon interactions!



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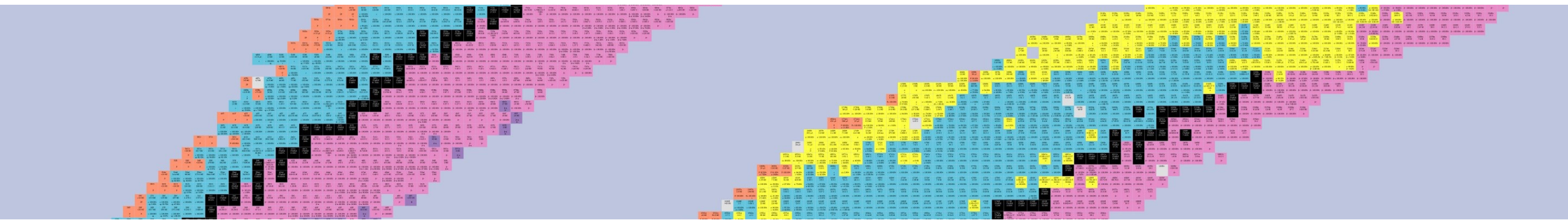
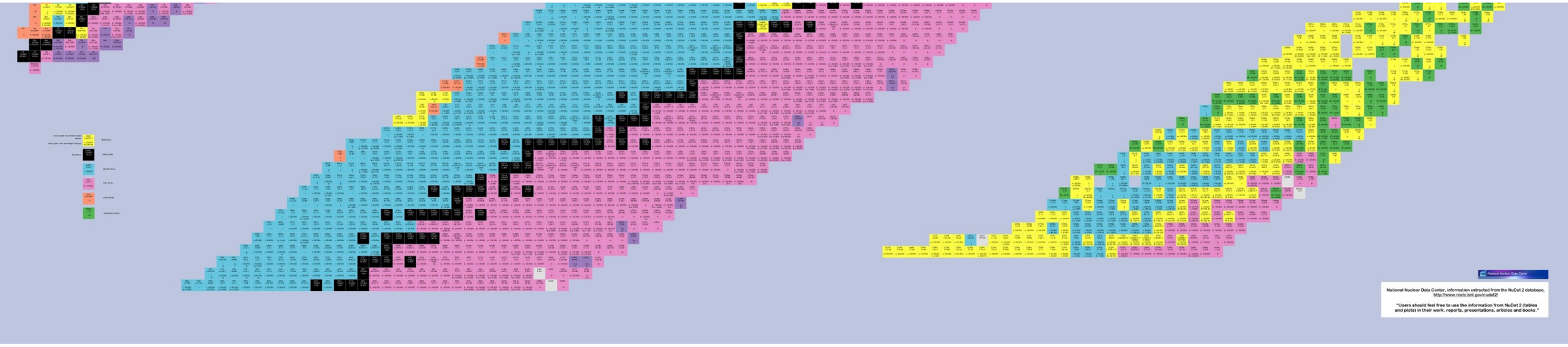


✔ the exact density functional is approximated with ***powers and gradients of ground-state densities and currents.***



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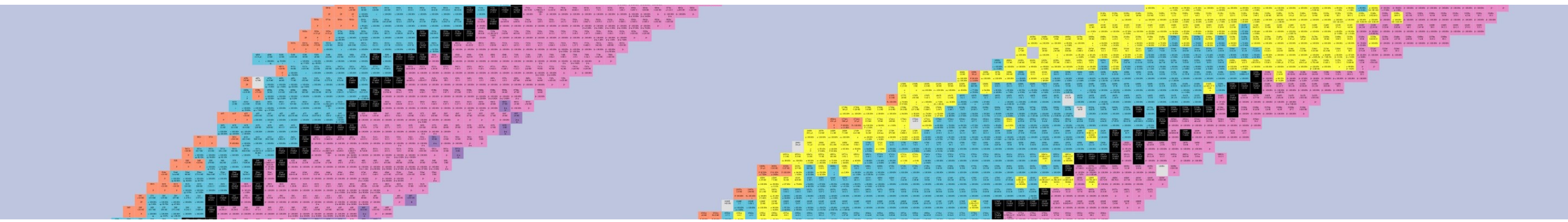

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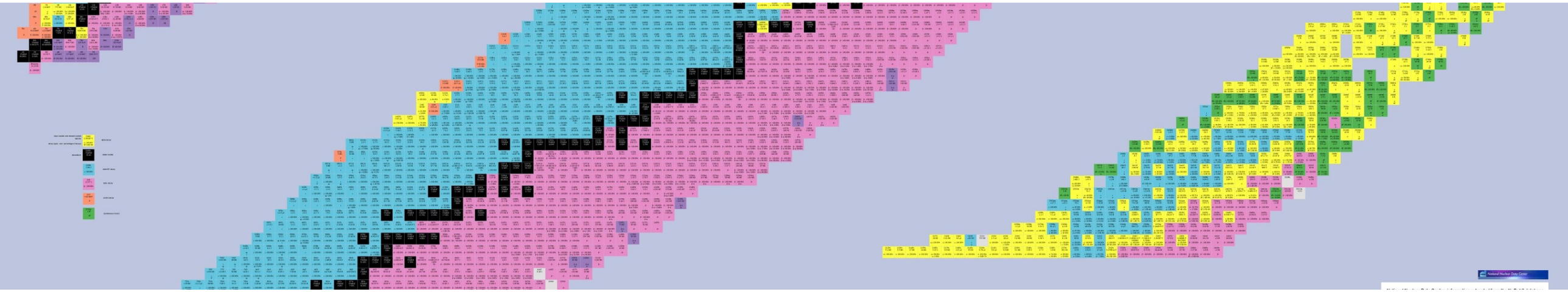

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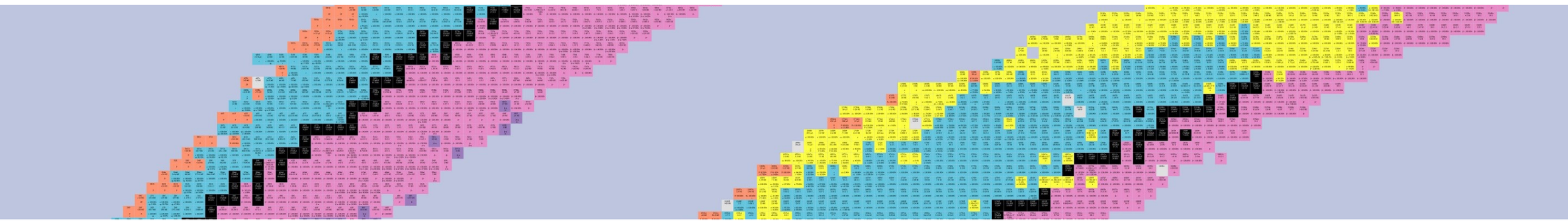

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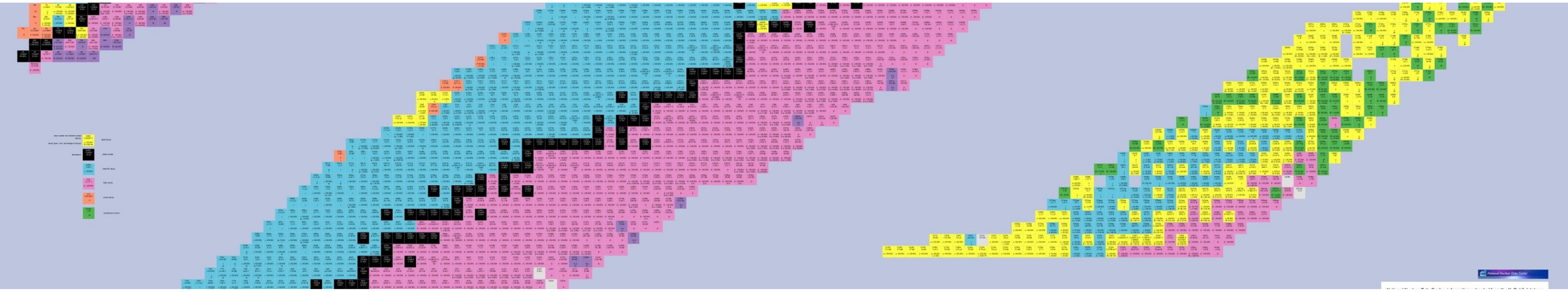

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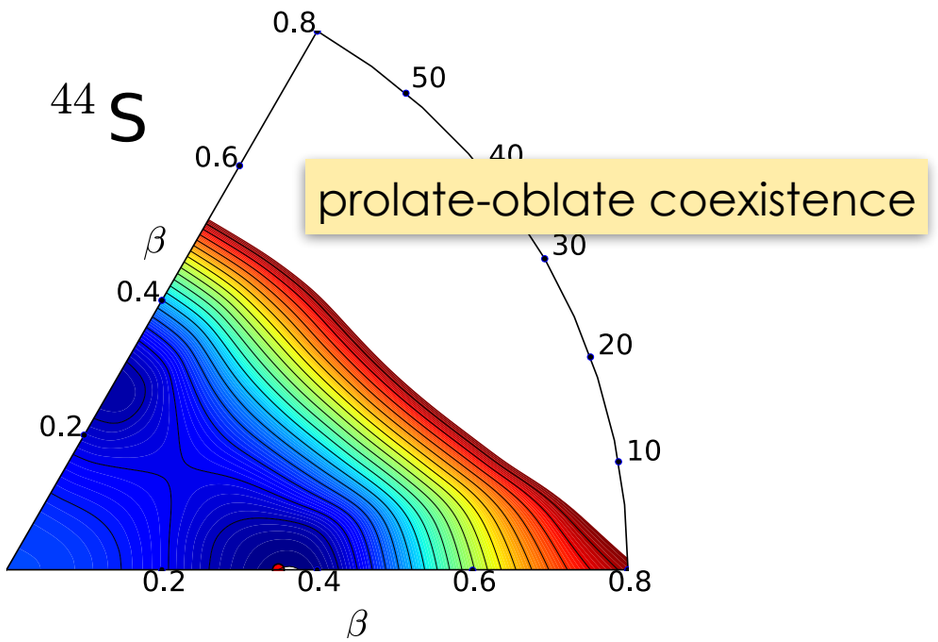
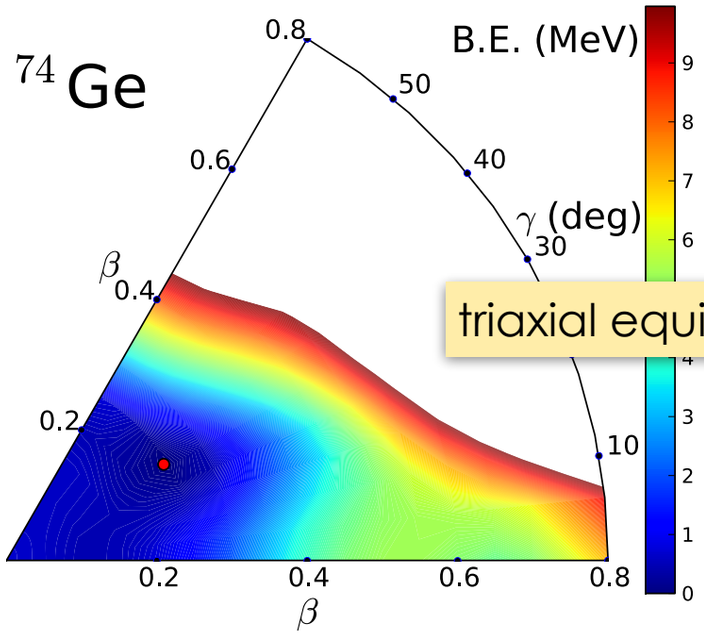
Important for extrapolations to regions far from stability!

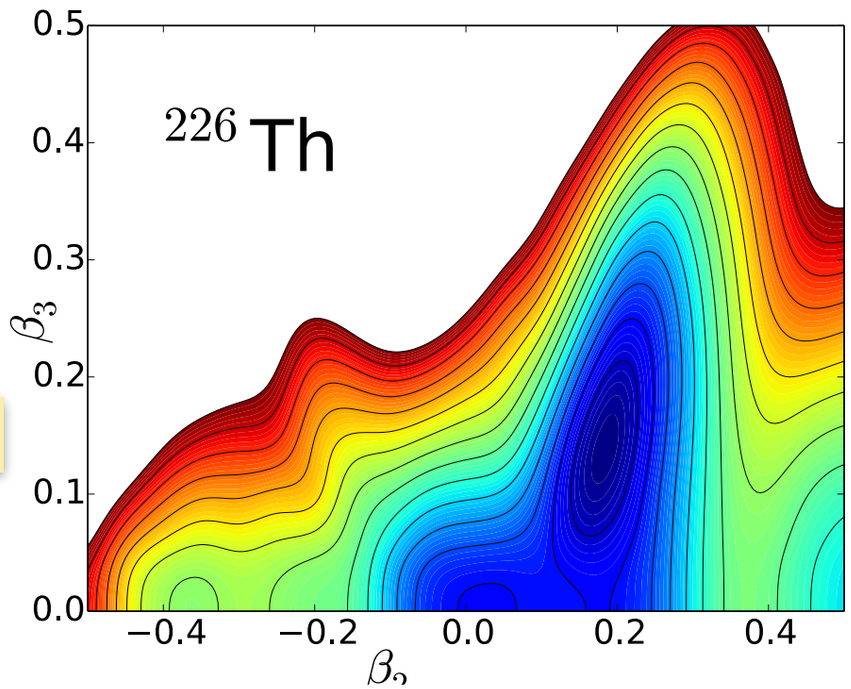
Basic implementation: the self-consistent mean field method → produces semi-classical energy surfaces as functions of intrinsic deformation parameters.




prolate-oblate coexistence




triaxial equilibrium shape




octupole deformation

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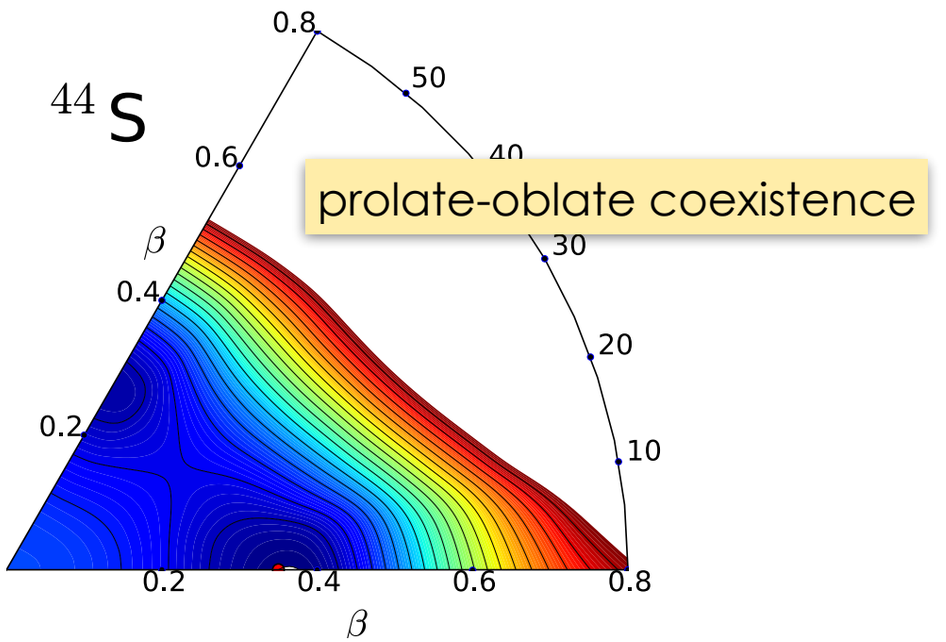


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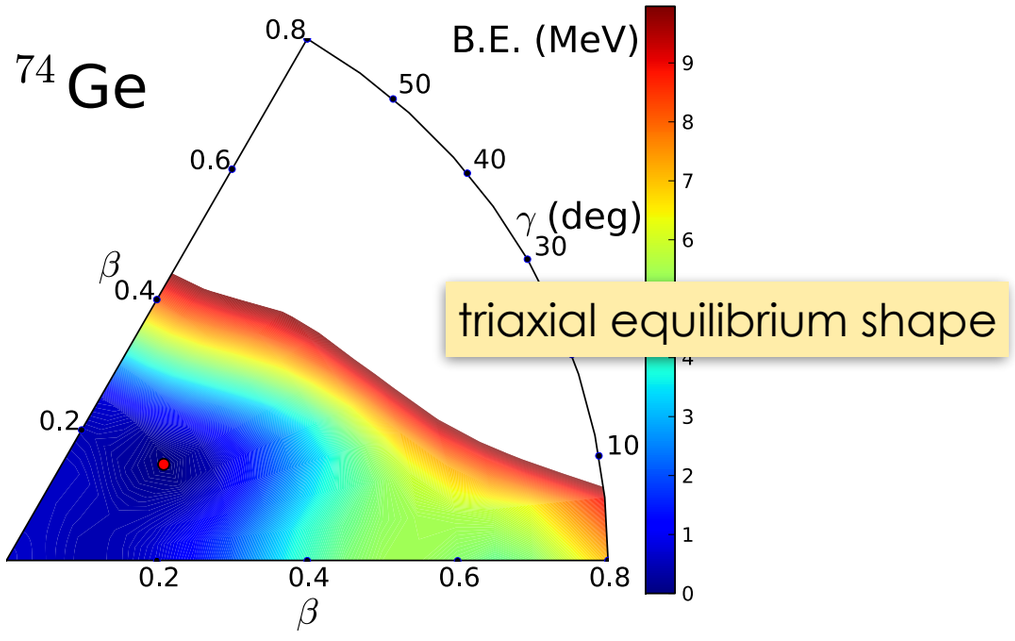


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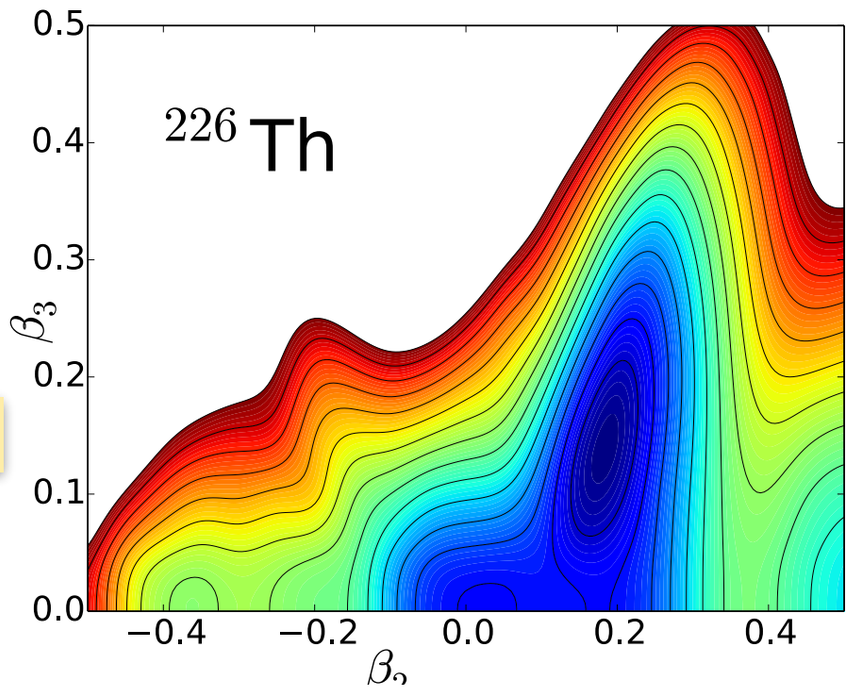


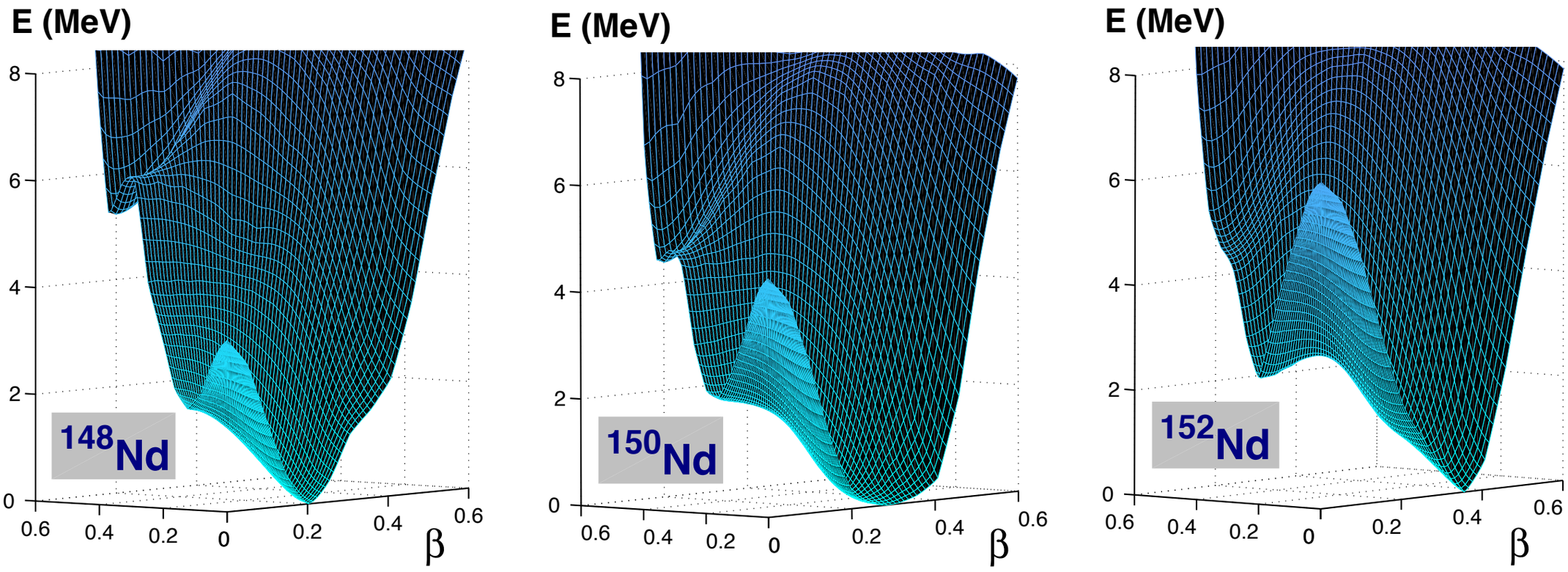

octupole deformation

→ include static correlations: deformations & pairing

→ do not include dynamic (collective) correlations that arise from symmetry restoration and quantum fluctuations around mean-field minima

# Shape Quantum Phase Transitions

…evolution of nucleonic shells ⇒ phase transitions in equilibrium shapes (QPT)

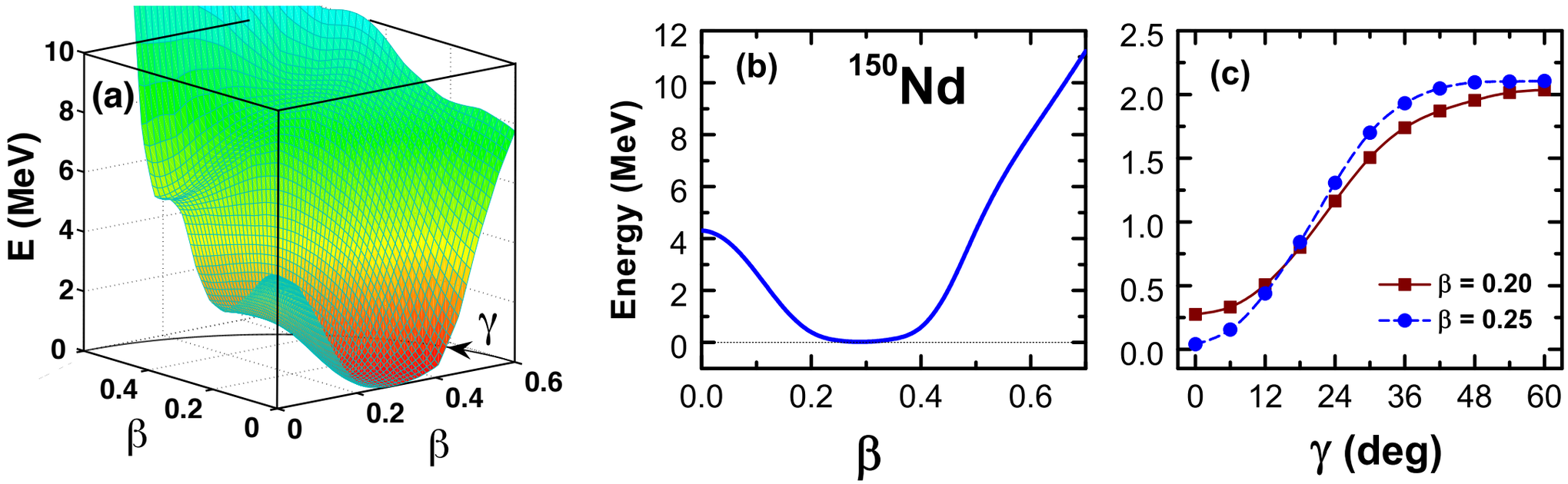



Nuclear Quantum Phase Transitions:

⇒ the physical control parameter - nucleon number - integer values!

⇒ order parameters - expectation values of operators that as observables characterize the state of a nuclear system.

Nuclear QPT ⇒ Landau theory based on potential energy surfaces:



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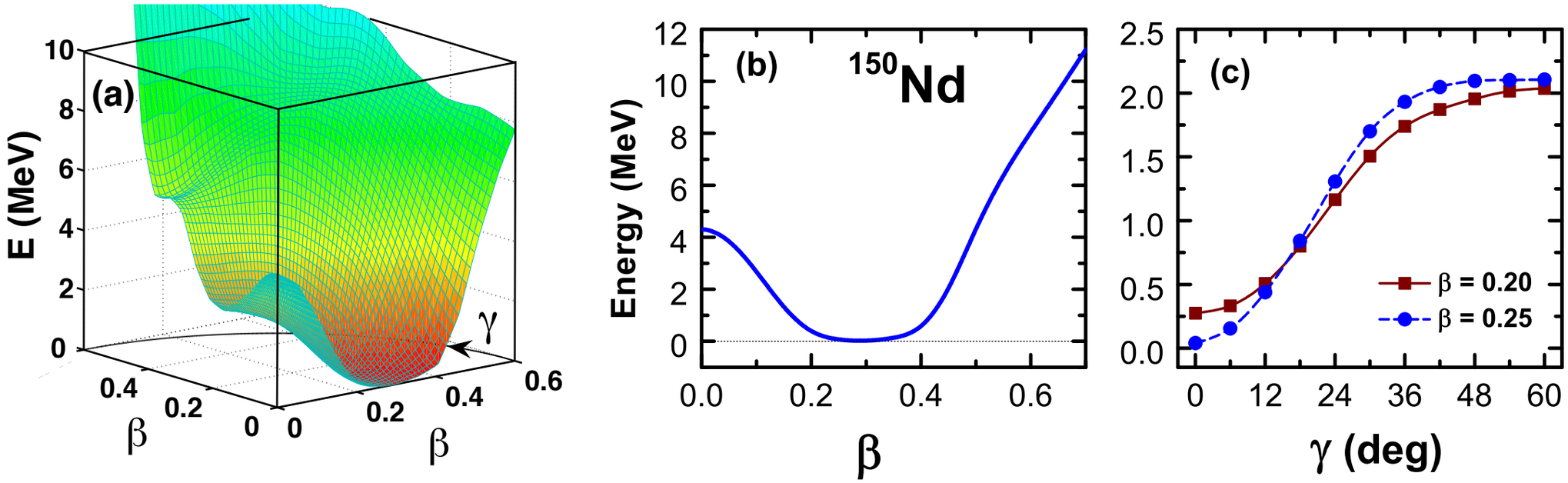


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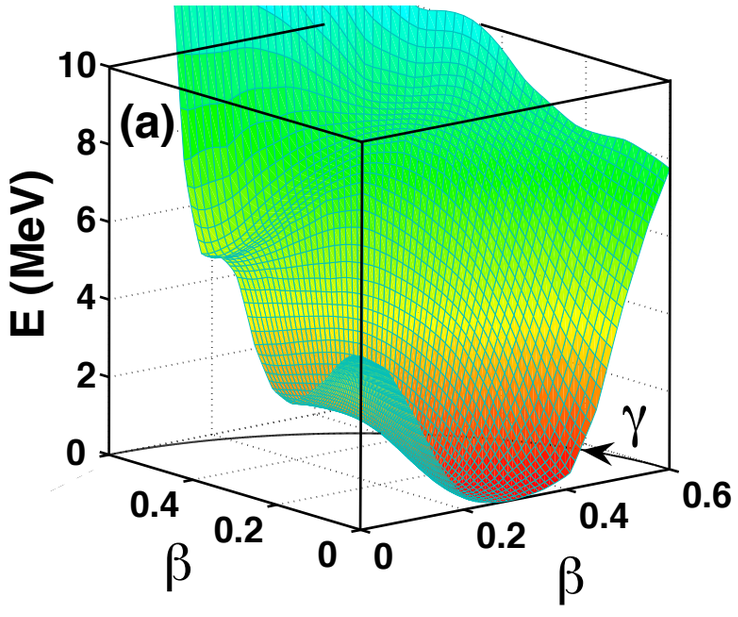


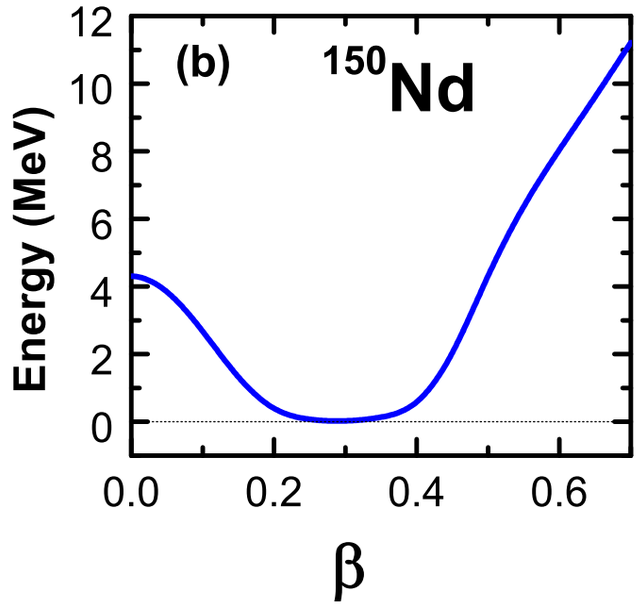


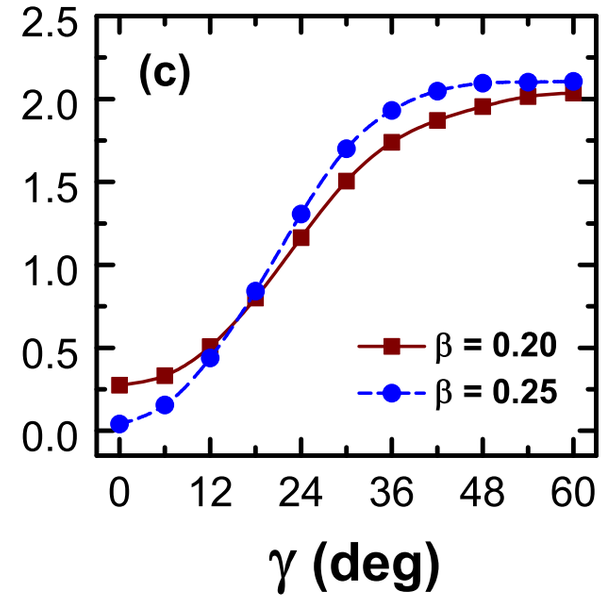


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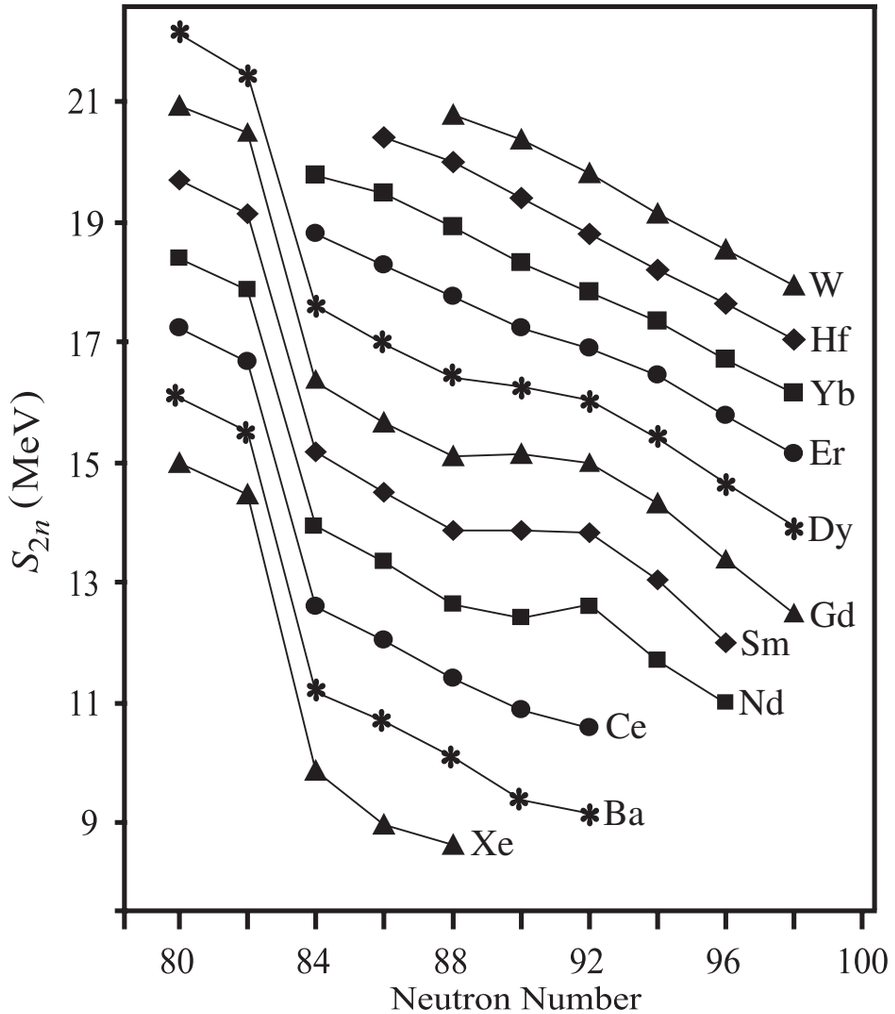

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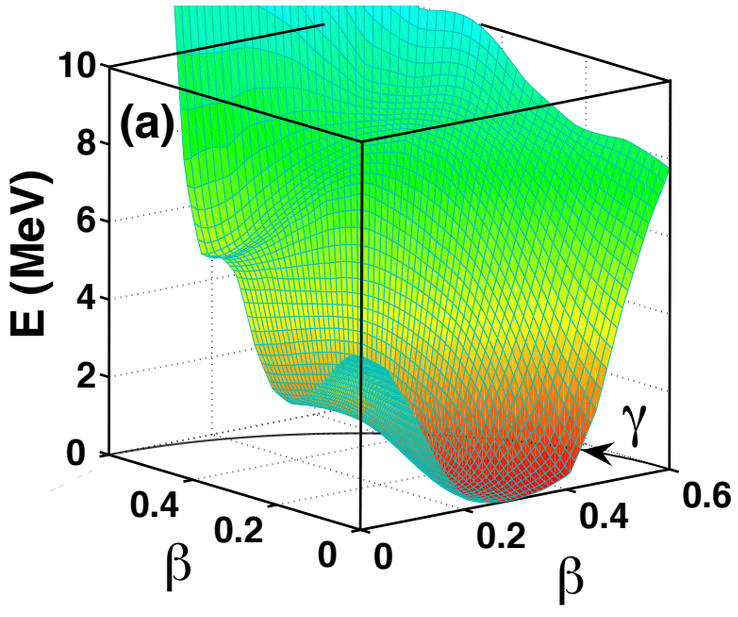


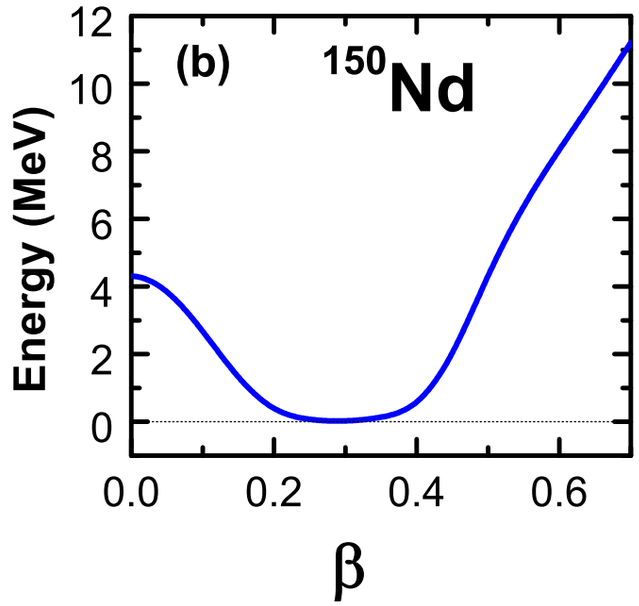


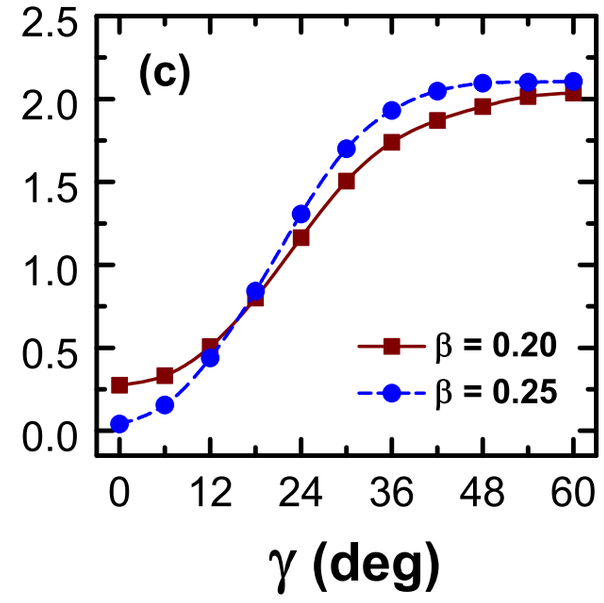


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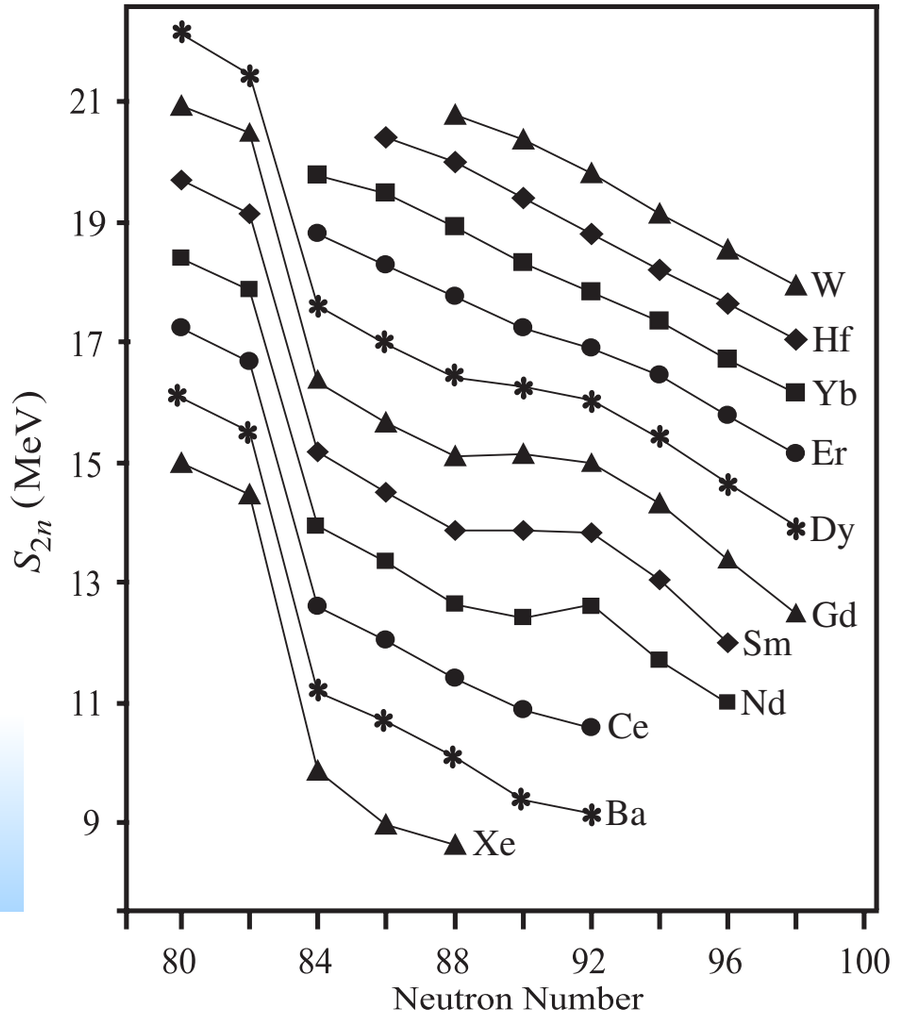


Both methods can be combined in a microscopic beyond-mean mean-field approach!

# DFT-based Description of Nuclear QPTs

✔ ***mean-field*** approach based on microscopic EDFs ➔ intuitive interpretation of QPTs in terms of ***intrinsic shapes*** and ***single-particle states.***

✔ ***collective models*** based on EDFs (symmetry restoration, fluctuations around the MF minima) ➔ parameter-free calculation of ***order parameters*** in the full model space of occupied states.

✘ discrete integer values for the control parameter - ***nucleon number*** ➔ how precisely can a QPT point be assigned to a particular nucleus and the importance of ***particle number projection*** in the mean-field approach?

✘ identification of ***order parameters***? Accuracy of the EDF-based collective models used to calculate excitation spectra and transition rates?

✘ ***odd-A nuclei*** - influence of the unpaired fermion on the location and nature of the phase transition.