# Dynamical phase transitions in quantum mechanics

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## Abstract

1936 Niels Bohr: *In the atom and in the nucleus we have indeed to do with two extreme cases of mechanical many-body problems for which a procedure of approximation resting on a combination of one-body problems, so effective in the former case, loses any validity in the latter where we, from the very beginning, have to do with essential collective aspects of the interplay between the constituent particles.*

1963: Maria Goeppert-Mayer and J. Hans D. Jensen received *the Nobel Prize in Physics for their discoveries concerning nuclear shell structure.*

State of the art 2011:

– The nucleus is an open quantum system described by a non-Hermitian Hamilton operator with complex eigenvalues. The eigenvalues may cross in the complex plane ('exceptional points'), the phases of the eigenfunctions are not rigid in approaching the crossing points and the widths bifurcate. By this, a dynamical phase transition occurs in the many-level system.

– The dynamical phase transition starts at a critical value of the level density. Hence the properties of the low-lying nuclear states (described well by the shell model) and those of highly excited nuclear states (described by random ensembles) differ fundamentally from one another.

– The statement of Niels Bohr for compound nucleus states at high level density is not in contradiction to the shell-model description of nuclear (and atomic) states at low level density.

– Dynamical phase transitions are observed experimentally in different systems, including $\mathcal{PT}$-symmetric ones, by varying one or more parameters.

References

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