



Endless oscillations



Destined never to relax: a theoretical study on quantum systems

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According to classical physics, the universe tends to equilibrium but the same does not apply to quantum systems, which are destined to shift constantly between different configurations without ever finding peace. A theoretical study conducted by SISSA and the University of Oxford illustrates this dramatic difference and explains that in order to be described correctly one-dimensional quantum systems should be thought of as being defined on discrete points in space.

A quantum system never relaxes. An isolated system (like a cloud of cold atoms trapped in optical grids) will endlessly oscillate between its different configurations without ever finding peace. In



practice, these types of systems are unable to dissipate energy in any form. This is the exact opposite of what happens in classical physics, where the tendency to reach a state of equilibrium is such a fundamental drive that it has been made a fundamental law of physics, i.e., the second law of thermodynamics, which introduces the concept of entropy.

This profound difference is the subject of a study published in *Physical Review A*, conducted with the collaboration of the International School of Advanced Studies (SISSA) of Trieste and the University of Oxford. Giuseppe Mussardo, professor at SISSA, together with Milosz Panfil, SISSA research fellow, and Fabian Essler from the University of Oxford carried out a theoretical analysis with which they demonstrated the peculiarity of one-dimensional quantum systems, as well as explaining the non-local nature of these systems.

"The main point of our work was not only realizing the dramatic difference between classical and quantum reality," explains Mussardo, "but also discovering the existence of quantum systems that are extremely robust with respect to any external stimulus, thanks to their specific laws of symmetry. These laws, in particular, demand not only the conservation of energy but also of innumerable other quantities, which maintain the same value over time as a result".

Mussardo and colleagues also made another discovery: to be able to predict the evolution of quantum systems and their statistical characteristics, we should think of them as being defined not by every point in space (and therefore continuous) but only by discrete points.

It is as if these systems lived "intrinsically" on a grid, explains Mussardo (who also adds that "this came as a big surprise"), "so that on a large scale we have to take into account non-local effects".

This study, as well as shedding light on some peculiar effects revealed by recent experiments on mixtures of cold atoms and spin chains, opens up interesting scenarios on the control of extensive quantum systems and their use for future memory architectures and quantum algorithms.

USEFUL LINKS:

- **Original paper in Physical Review A:** <https://goo.gl/5zP4CD>

IMAGES:

- **Credits:** Luc Viatour (Wikimedia commons: <http://goo.gl/AWyM1E>)

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