

Equation reveals the characteristics of quantum chaos

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Researchers have now succeeded in formulating a mathematical result that provides an exact answer to the question of how chaos actually behaves. The researchers have analysed chaotic states at the atomic level.

What does [chaos](#) look like in the smallest of worlds that we can imagine – inside atoms? The world in there behaves a lot differently to the world that we experience; the protons and neutrons in the nucleus are waves. In this microcosmos, the so-called quantum world, the normal rules of nature do not apply, but in terms of the state called chaos, there are universal features that are present, regardless of the level of existence.

In a new study, a research group including researchers from Lund University, has therefore set out to tackle the theory of quantum chaos, i.e. they have studied the chaotic state at quantum level. The theory of quantum chaos is about explaining the irregular movements of both electrons and nuclei, as well as the irregular movements of, for example, rays of light in optical instruments with complex geometries, or sound waves in a furnished room.

The researchers have analysed statistical properties at different [energy levels](#) in a quantum chaos state. Although the research is theoretical, it has practical applications. Chaos theory and the associated concept of random matrices are used in different contexts where there is an attempt to describe and analyse chaotic [states](#). These contexts include financial instruments, brain surgery and even the string [theory](#) for the universe.

"In chaotic quantum systems, the energy levels repel each other, and they affect each other even if they are far apart," states Vladimir Osipov, a researcher at Lund University's Faculty of Science and one of the authors of the new study.

He notes that it is difficult to make computer calculations for a specific [quantum](#) chaos state, as chaotic systems are extremely sensitive to the initial numbers entered in calculations. Small differences in initial values can produce large deviations in the final result of the calculation.

However, due to the results of the new study, it is possible from now on to use an exact, mathematical equation to predict the characteristics of chaos without such extensive number-crunching.

"Yes, we now have an exact equation. Personally, I am actually surprised that it was possible at all," says Vladimir Osipov.

More information: Roman Riser et al. Power Spectrum of Long Eigenlevel Sequences in Quantum Chaotic Systems, *Physical Review Letters* (2017). [DOI: 10.1103/PhysRevLett.118.204101](https://doi.org/10.1103/PhysRevLett.118.204101)

Provided by Lund University

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