

The research group
High-Energy Physics

has the honor to invite you to the public defence of the PhD thesis of

Maxim Pavlov

to obtain the degree of Doctor of Sciences

Title of the PhD thesis:

**Quantum chaos and quantum complexity in
quantum resonant systems**

Supervisor:

Prof. dr. Ben Craps (VUB)

Co-supervisor:

Prof. dr. Oleg Evnin (VUB)

The defence will take place on

Thursday, October 22, 2026 at 4 p.m.

VUB Etterbeek campus, Pleinlaan 2, Elsene,
Promotiezaal D2.01

The defence can be followed through a live
stream: contact [Maxim](#) for more information.

Members of the jury

Prof. dr. Sophie de Buyl (VUB, chair)

Prof. dr. Christoph Uhlemann (VUB)

Prof. dr. Stijn Buitink (VUB)

Prof. dr. Wojciech De Roeck (KU Leuven)

Prof. dr. Leticia F. Cugliandolo (Sorbonne
Université, FR)

Curriculum vitae

Maxim Pavlov obtained his MSc in Physics from the University of Antwerp in 2020. He then started his PhD at the VUB in the theoretical physics division of the High-Energy Physics group, under the supervision of Prof. dr. Ben Craps and co-supervision of Prof. dr. Oleg Evnin.

His research, supported by an FWO PhD Fellowship from 2022 onward, focused on quantum chaos and quantum complexity in quantum many-body systems, with numerical methods playing a central role. In addition, he also studied entanglement entropy in 2D string theory. In total, he co-authored four scientific papers.

Abstract of the PhD research

Since the early days of quantum mechanics, it has been unclear how chaos manifests itself in the microscopic world. Classical definitions do not apply to quantum systems, so new probes had to be introduced. The growing importance of quantum many-body systems across different areas of physics has further stimulated research into the nature of quantum chaos in such systems.

Closely related to quantum chaos is the notion of quantum complexity. Observing that the growth of complexity in chaotic quantum circuits resembles the growth of the volume behind a black hole horizon has made it possible to study properties of black holes through quantum complexity. However, extending complexity from quantum circuits to many-body systems is difficult. Nielsen's geometric approach redefines complexity as the shortest distance in a complicated space, and finding this distance is highly non-trivial.

This thesis studies quantum chaos and complexity in the novel context of quantum resonant systems (QRS). These systems give controlled approximations to the dynamics of weakly nonlinear systems and possess attractive features such as a block-diagonal Hamiltonian. Below, we describe how QRS have shed new light on different problems in quantum chaos and quantum complexity.

First, we formulate an upper bound on Nielsen's complexity by restricting the minimization to a fixed infinite set of curves. Applied to QRS and fermionic models, the bound is lower for integrable systems than for chaotic ones, successfully displaying one of the main expected dynamical properties of quantum complexity.

Second, we study the Husimi distributions of energy eigenstates of weakly interacting bosons in a 2D harmonic trap, an example of a QRS. The classical system has special solutions that restrict dynamics to a low-dimensional manifold, and the eigenstates related to these solutions are localized on that manifold.

Finally, we address the long-standing problem of level spacing statistics in systems transitioning from integrability to chaos. Our simple random-matrix model reproduces the non-universal level spacing distributions during the transition. Their shape is set by the distribution of the perturbation's matrix elements in the unperturbed eigenbasis. Surprisingly, these matrix-element distributions exhibit a universal power-law form in a variety of systems.