

PhD Project: Scientific Machine Learning for Quantum Many-Body Dynamics and Quantum Chaos

Project Overview

Quantum many-body systems exhibit some of the most fascinating phenomena in modern physics, including quantum chaos, information scrambling, thermalisation, many-body localisation, and dynamical phase transitions. Understanding these processes is crucial for future quantum technologies, yet their theoretical and computational description remains exceptionally challenging because of the exponential complexity of quantum systems.

This PhD project will develop novel scientific machine-learning approaches for the simulation and analysis of complex quantum systems. The research will combine ideas from quantum physics, statistical mechanics, machine learning and high-performance computing to tackle problems that are beyond the reach of conventional computational methods.

Possible research directions include: * Machine-learning approaches to overcome sign and phase problems in quantum simulations, * Analysis of quantum chaos, thermalisation and emergent collective behaviour in interacting many-body systems, * Identification of phase transitions and critical phenomena using data-driven approaches, * Extraction of physical observables from noisy quantum computing and quantum simulation experiments, * Development of interpretable and uncertainty-aware machine-learning methods that provide genuine physical insight rather than acting as black-box predictors.

The successful candidate will receive broad interdisciplinary training in quantum many-body theory, computational physics, scientific machine learning, modern numerical methods and research software development. The project is expected to contribute new computational methodologies, open-source software, and publications in leading international journals.

Research Environment

The student will join the Theoretical Physics research activities within the Department of Physics at the University of Warwick and work under the co-supervision of **Professor Rudolf Roemer and Dr Amos Chan**. The project sits at the interface of condensed matter physics, quantum information science, statistical physics and machine learning.

The candidate will benefit from collaborations within Warwick's quantum science community and from links to national and international research partners working on quantum computation, quantum simulation and many-body physics.

Candidate Profile

We are looking for an enthusiastic and highly motivated student with:

- A First Class or strong Upper Second Class undergraduate degree, or a Master's degree, in Physics, Mathematics, Theoretical Physics or a closely related discipline.
- A strong mathematical and analytical background.
- An interest in quantum physics, theoretical physics and interacting many-body systems.
- Some experience in scientific programming (e.g. Python, C/C++, Julia/Mathematica or similar) is desirable but not essential.
- An interest in machine learning, data science or computational methods applied to physical sciences.

Applicants from both physics and mathematics backgrounds are encouraged to apply.

Funding

This project is intended for support through the Doctoral Landscape Award (DLA) programme. Funding eligibility and terms will follow the relevant UKRI and University of Warwick regulations in force for the competition year.

How to Apply

Applications should be submitted through the University of Warwick postgraduate admissions system. Applicants should indicate their interest in the project **"Scientific Machine Learning for Quantum Many-Body Dynamics and Quantum Chaos."**

Application materials will normally include:

- Curriculum Vitae (CV)
- Degree transcripts
- Personal statement
- Contact details for academic referees

Informal Enquiries

Informal enquiries are welcome and encouraged before applying.

Professor Rudolf Roemer

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Prospective applicants are encouraged to contact Professor Roemer with a brief CV and a short statement outlining their interests and relevant background.