



Conducting research for a changing society: This is what drives us at Forschungszentrum Jülich. As a member of the Helmholtz Association, we aim to tackle the grand societal challenges of our time and conduct research into the possibilities of a digitized society, a climate-friendly energy system, and a resource-efficient economy. Work together with around 7,500 employees in one of Europe's biggest research centres and help us to shape change!

The Peter Grünberg Institute for Quantum Control (PGI-8) at the Forschungszentrum Jülich specializes in novel optimization strategies for emerging quantum technologies. These emerging technologies aim to provide transformative changes to our society, including how we think about information, and unlocking vast calculations for the natural sciences, logistical problem solving, and high-performance computation. Our group has pioneered the application of quantum optimal control methods to quantum computation and many-body quantum systems. Moreover, we have been driving the development of tensor networks techniques for many-body systems, allowing to numerically manage quantum entanglement in a practical way. By their use, we explore synthetic quantum matter and we also benchmark the computational gain attainable via noisy intermediate-scale quantum devices.

The Peter Grünberg Institute for Quantum Control (PGI-8) is offering a

PhD Position – Efficient randomization methods for quantum applications

Your Job:

Random unitaries are a ubiquitous tool in quantum information and quantum computing, with applications in the characterization of quantum hardware, quantum algorithms, quantum cryptography and complexity theory, and in the chaotic dynamics of quantum many-body systems. Moreover, a breakthrough result in 2024 shows that random unitaries can often be constructed by short-depth quantum circuits, making these techniques particularly promising for early quantum applications. You will investigate techniques for the construction of random unitaries based on random quantum circuits and study their performance for a range of applications. A focus will lie on quantum algorithms for many-body systems, in particular on classical shadows. Here, you will also transfer results for qubits to fermions, which are highly relevant, for instance, in quantum chemistry. Your research will be embedded in international collaborations with renowned experts, offering plenty of opportunities for close cooperation. You will join the teams of Dr. Markus Heinrich at the Institute for Theoretical Physics of the University of Cologne and of Prof. Matteo Rizzi at PGI-8 at the Forschungszentrum Jülich. You may consult the

We look forward to receiving your application until 18.05.2025 via our **Online-Recruitment-System!**

Questions about the vacancy?

Get in touch with us by using **our contact form.**

Please note that for technical reasons we cannot accept applications via email.
www.fz-juelich.de

website of Dr. Markus Heinrich and the one of the Synthetic Quantum Matter division at PGI-8 for an impression of the relevant research. Your tasks in detail:

- Develop techniques for the efficient construction of random unitaries based on quantum circuits
- Transfer these efficient randomization techniques into applications, especially classical shadows
- Model and identify the effects of experimental errors, investigate error mitigation techniques
- Cooperate and actively work with international collaborators

Your Profile:

- Master's degree in physics, mathematics, or computer science
- Strong interest in both developing fundamental ideas and bringing them into applications
- Detailed knowledge of quantum mechanics and experience with quantum information theory
- Ideally first experiences with random unitaries and/or classical shadows
- Strong mathematical education, in particular in relation to linear algebra
- Programming experience is a plus
- Ability to effectively communicate in written and spoken English
- Ability to work autonomously and in close interaction within a team
- Most importantly: enthusiasm to explore uncharted territory, develop, and follow your own ideas

Our Offer:

We work on the very latest issues that impact our society and are offering you the chance to actively help in shaping the change! We offer ideal conditions for you to complete your doctoral degree:

- Opportunity to conduct research at the interface of theory and applications
- Work in a highly motivated research group as part of an international and interdisciplinary working environment with access to outstanding computing facilities and connections to the best research institutions around the world.
- Continuous scientific mentoring by your scientific advisor as well as feedback and wide-ranging expertise from the whole group in multiple facets of quantum technology and optimization.
- Opportunity of participating in (international) conferences and project meetings.
- Participation in overarching seminars including certificate.
- The skills that you will acquire during your PhD are in high demand both in academia and in high-tech companies: at present, there is significant government and private investment in the field of quantum technologies.
- Further development of your transferable skills via a structured program of continuing education and networking opportunities specifically for doctoral researchers via JuDocS, the Jülich Center for Doctoral Researchers and Supervisors: <https://www.fz-juelich.de/en/judocs>
- Targeted services for international employees, e.g. through our International Advisory Service

In addition to exciting tasks and a collaborative working atmosphere in Jülich, we have a lot more to offer: <https://go.fzj.de/benefits>

The position is for a fixed term of 4 years. The salary is in line with pay group 13 (75 %) of the Collective Agreement for the Public Service (TVöD-Bund). In addition, an annual special payment is granted ("Christmas payment"), which amounts to 60 % of the monthly salary. Further information on doctoral degrees at Forschungszentrum Jülich

including our other locations is available at: https://www.fz-juelich.de/gp/Careers_Docs

We welcome applications from people with diverse backgrounds, e.g. in terms of age, gender, disability, sexual orientation / identity, and social, ethnic and religious origin. A diverse and inclusive working environment with equal opportunities in which everyone can realize their potential is important to us.

Further information on diversity and equal opportunities: <https://go.fzj.de/equality>