2024 GQL IRTE Projects

These projects are available for undergraduate students for summer 2024 as part of the Global Quantum Leap International Research Training Experience. Applicants must be Juniors or Seniors with prior research experience studying at a US University. Applicants must be able to spend at least 10 weeks at their host institution.

Projects are located at the National Institute for Materials Science in Tsukuba, Japan and at RWTH Aachen University, Aachen, Germany. You can find descriptions for the German program below while more detailed descriptions for the Japan program will be released soon.

You can learn more about the program by visiting the Student Experiences Page or look at past year's technical reports.

If you are interested, please request an application from program staff at jschwed@umn.edu. Please address any questions to jschwed@umn.edu.

Applications are due Nov. 22, 2023

Project 1 (Germany): XXZ Model Temperature Dynamics

Project Supervisor: Dr. Dante Kennes, Group Leader, Center for Free-Electron Laser Science (CFEL), Max Planck Institute for the Structure and Dynamics of Matter, RWTH Aachen.

Scope and Purpose: We want to re-examine the infinite temperature dynamics of the quantum Heisenberg "XXZ Model" building on recent work in the literature. In this project, IBM's quantum computer will be explored for its capability of representing purification (for the temperature ensemble average) as well as simulating the subsequent magnetization dynamics. A comparison to state-of-the-art tensor networks will be given.

Project 2 (Germany): Spin Qubit Shuttling and Disorder Mapping

Project Supervisor: Dr. Lars Schreiber, RWTH Aachen University, Institute for Quantum Information.

Scope and Purpose: This project involves shuttling of spin qubits and mapping of potential disorder and valley splitting in Si/SiGe. The student will learn the pre-characterization of our quantum chips at 4 K by electrical low-noise transport-experiments. The student will be engaged in programming the automatization of its workflow. Selected devices are cooled down to 10 mK and the student will help within a team to perform spin-qubit shuttling experiments. This technique can be used to map potential disorder and valley splitting in the device.

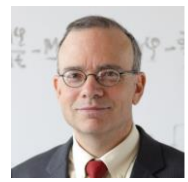
Project 3 (Germany): Spin Qubits in Graphene Quantum Dots

Project Supervisor: Dr. Christoph Stampfer, Head of the 2nd Institute of Physics A at RWTH Aachen University.

Scope and Purpose: We aim to assess the potential of bilayer graphene quantum dots as hosts for valley and spin qubits. The goal of this project is the characterization of spin and valley relaxation rates. For that purpose, time-resolved state detection will be performed on our state-of-the-art bilayer graphene quantum dot devices with integrated charge sensors.

Project 4 (Germany): Theory of Novel Photon Forms

Project Supervisor: Dr. David di Vincenzo, Director of the Institute of Theoretical Nanoelectronics at the Peter Grünberg Institute FZ Jülich and Professor at the Institute for Quantum Information at RWTH Aachen University.



Scope and Purpose: This internship will explore the theory of photons which do not have a specific frequency, even approximately. In current solid-state quantum computer systems, these may be created by sub-nanosecond electrical pulses. We will determine the applicability of these novel forms of photons in protocols for quantum information transfer.

Project 5 (Germany): Multi-Valley Quantum Dot Electron States

Project Supervisor: Dr. Hendrik Bluhm, Leader of the Quantum Technology Group & co-director of the JARA Institute for Quantum Information.

Scope and Purpose: The goal of this project is to carry out an analytical and numerical study of the energy spectrum of one and two electrons confined in a quantum dot (QD). We consider QDs formed in Si/SiGe heterostructures, and thus the effects of the valley multiplicity will be relevant. The student will learn about valley disorder in Si/SiGe quantum dots and how this affects the dynamics of confined electrons. They will work on a model to predict energy level crossings and valley states splittings from measured parameters.

Projects 6-8 (Germany): Müller Group Quantum Computing Projects

Project Supervisor: Dr. Markus Müller, RWTH Aachen University Institute for Quantum Information.

Dr. Müller has three potential projects related to quantum computing. These projects require a solid understanding of quantum mechanics, and so students should have previously taken courses on quantum computing, information and/or algorithms. Programming knowledge (e.g. in python, Matlab, C++) is also helpful.

Project 6: Topological Quantum Error Correction

In this theory internship project, you will first familiarize yourself with the basics of quantum error correction, and then implement and numerically benchmark the performance of a quantum error correcting code and decoder that is suitable for a realistic experimental implementation of logical qubits.

Project 7: Quantum Neural Networks and Machine Learning

In this theory internship, you will first familiarize yourself with the basics of quantum neural networks and machine learning. You will then implement a quantum neural network based on a quantum Hopfield, multi-layer, or quantum cellular automaton network architecture, and investigate and benchmark its performance.

Project 8: Scalable Quantum Computing with Rydberg Atoms

In this theory internship, you will first familiarize yourself with the basics of quantum computing and algorithms. You will then develop and numerically implement protocols for quantum gate operations between Rydberg atoms and investigate their expected performance under realistic conditions and noise sources, as building blocks of more complex quantum algorithms.

Projects 9-12 (Japan): National Institute for Materials Science Quantum projects TBA.

Project Supervisors: TBA.

We expect to have 4 projects available at NIMS, Japan. However, the project descriptions are not available as of 11/1/2023. In 2023, NIMS hosted 3 projects (2 experimental and 1 theoretical). The 2023 projects involved control of electron spins in diamond, fabrication of moiré superlattice devices in 2D materials, and theory and simulation of nano-patterned 2D materials. We expect similar topics for the 2024 program, and will provide the detailed project descriptions as soon as they are available.