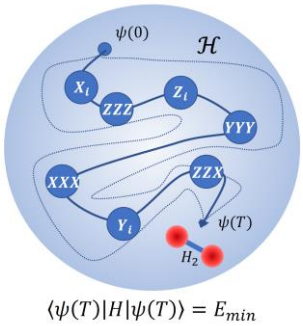
Scientific Area	Quantum Electronics
Topic title	Multi-qubit gates for the efficient exploration of Hilbert space with superconducting qubit systems
Main host institution	IBM Research – Zurich https://www.zurich.ibm.com (collaboration: Walther-Meißner-Institute, Germany)
Supervisor/institution	Stefan Filipp https://researcher.watson.ibm.com/researcher/view.php?person=zurich-sfi
Co-Supervisor/institution	tbd
Mentor[1]/institution	Alexej Ustinov https://www.phi.kit.edu/ustinov.php
Secondment institution	Alexej Ustinov https://www.phi.kit.edu/ustinov.php

Topic description



This project explores the potential of multi-qubit gates for quantum computing on a superconducting qubit platform. The main goal is to develop superconducting architectures and control methods to efficiently generate multi-qubit states going beyond the current paradigm of decomposing all state manipulations into single and two-qubit gates. We design and realize parametric couplers [McKay et al., Phys. Rev. Applied 6 (2016)] connecting multiple superconducting qubits and investigate multi-qubit operations that allow us to entangle multiple qubits at the same time. We explore multi-qubit entangling interactions and evaluate the maximally possible number of qubits coupled to a single coupler. The final goal is to address the question if there is an advantage in using multi-qubit gates over traditional two-qubit gates in practical experiments. To this end we assess the efficiency of multi-qubit gates in an algorithmic context targeting, e.g., a quantum chemistry problem, such as determining the ground state and energy spectrum of a small molecule using the variational quantum eigensolver (VQE). The devices and methods developed in this project will enhance the scalability of superconducting qubit platforms and the efficiency of quantum algorithms. This project is carried out in collaboration with the TU Munich/Walther-Meißner-Institute in Germany.

Recommended applicant's profile

The candidate should have a solid background in the experimental control of quantum systems, ideally with a focus on superconducting circuits. The candidate must be curious to learn or expand his expertise in micro- and nanofabrication, quantum circuit design, microwave engineering, signal processing, low-temperature physics, instrumentation, control and measurement automation, data analysis and/or coding. Good knowledge of Python is desired.

[1] Mentor: The primary role of the mentors will be to identify and facilitate specific training objectives, advise on any problems faced by the ESR, including career matters with an external perspective and provide mediation in the case of disputes.

The QUSTEC programme has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement number 847471.