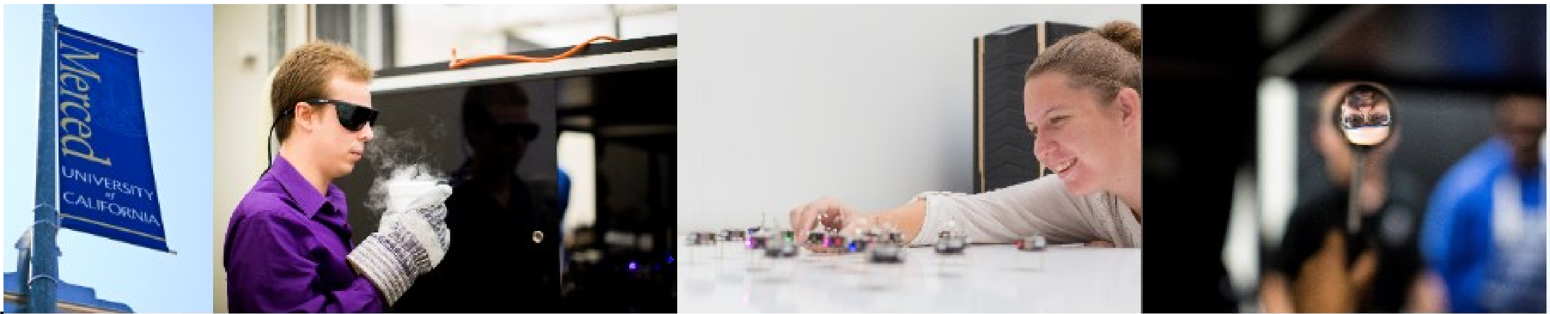

PHYSICS COLLOQUIUM:

Design of High-Order and Long-Range Interactions for Quantum Annealers

Date: **2/28/2020**

Time: **10:30–11:50 AM**

Location: **COB2 140**

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Abstract

Quantum annealing is a computational paradigm for solving combinatorial problems based on finding the ground state of a Hamiltonian. The common approach to quantum annealing is to encode problems using Ising spin Hamiltonians. A specific problem is encoded by appropriately setting the values of single spin biasing magnetic fields and spin-spin interactions strengths.

I will discuss our work on expanding the potential of quantum annealers based on the implementation of new types of interactions. This work is done in the context of quantum annealing based on superconducting quantum bits. Each spin in the Ising Hamiltonian is implemented using a quantum bit (two-state system) realized as the lowest two states of a superconducting electrical circuit with Josephson junctions.

In the first part of the talk, I will discuss the design of multi-spin interactions. Multi-spin interactions are relevant for efficient hardware embedding of specific annealing problems and for error correction. Many-particle interactions do not arise naturally. We implement them by designing suitable superconducting circuits connected to the qubits, where these many-body interactions arise as effective interactions. We use an approach, based on symmetry, to implement a tunable three-body interaction, while completely suppressing residual two-body interactions.

In the second part of the talk, I will present our work on the implementation of long-range interactions in a quantum annealer. The usual approach for implementation of spin-spin (qubit-qubit) interactions is based on the use of superconducting loops interrupted by a Josephson junction (RF-SQUIDs). This approach breaks down for coupling qubits at large distances. The coupler tree architecture is a proposal for implementation of long-range interactions between superconducting flux qubits using a network of coupled RF-SQUIDs. We present the results of experiments with two capacitively shunted flux qubits connected by a chain of RF-SQUIDs. We demonstrated propagation of a magnetic flux signal through the chain, a first step towards demonstration of long range qubit-qubit interactions. We will discuss future prospects for this work and other directions for implementation of long-range interactions.

About the Speaker

Adrian Lupascu received his PhD from Delft University of Technology, Netherlands in 2005, under the supervision of Professor J. E. Mooij. His PhD work involved the development of quantum measurements for superconducting qubits. He continued his research on quantum measurement and decoherence during a one year postdoctoral position in Delft.

In 2006, Lupascu became a Postdoctoral Fellow at Ecole Normale Superieure Paris, in the group led by Professor S. Haroche and Professor J. M. Raimond, supported by a Marie Curie fellowship. During this time, he did research on cold atoms and superconducting detectors.

Lupascu joined IQC and the Department of Physics and Astronomy at the University of Waterloo in March 2009 as an Assistant Professor. In 2011 he received a cross-appointment in the Department of Electrical and Computer Engineering. Lupascu became an Associate Professor in 2014.

Lupascu investigates the physics of superconducting devices. Current research topics include quantum annealing, quantum control, and strong light-matter interactions.

In 2011, Lupascu was the recipient of both the Alfred P. Sloan Research Fellowship award and Ministry of Research and Innovation Early Researcher award.