Abstract for APQC:

The performance of algorithms run on NISQ devices are severely restricted by short qubit coherence times. Entangling gate families parametrized by continuous parameters have recently gathered significant interest since they are typically shorter, using up a smaller fraction of the qubit coherence time available. Fast and efficient calibration of such shorter, high fidelity parametrized gates and the construction of optimal circuit synthesis schemes that leverage the richer gate set are open problems that we address in this talk.

Calibrating a high fidelity two-qubit gate is resource intensive because a number of control parameters need to be carefully tuned. We develop a novel gate calibration technique specially designed for parametric gates that is highly resource efficient in terms of both QPU time and classical post-processing time. It relies on building a faithful model for the gate Hamiltonian that includes the contribution of coherent error terms. The coherent errors are corrected purely in software. Our specialized compiler features a unitary synthesis algorithm that is able to use such gate definitions efficiently to construct circuits which have shorter depths and higher fidelity.

We demonstrate the power of this fully automated technique experimentally on cross resonance gates on IBM Quantum devices. We are able to add to the existing entangling gate set, shorter duration efficient gates by utilizing only 3 min of QPU time and 30s of classical post-processing time. Our algorithmic benchmarking of these techniques allows us to get up to 3 times higher success probability (compared to only using backend provided gates) in the quantum Fourier transform for up to 22 qubits. We also explore trotterized Hamiltonian simulations of the 1D Heisenberg model, where our technique gives better estimates of universal dynamical exponents.

*This work explores the usefulness of building faithful low-level physics models of quantum hardware, leading us towards a codesign of pulse level gates and compilation techniques.*