Benchmarking of Quantum Control in ESR

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Quantum Computing, University of Waterloo — Quantum error correction is es- 
sential for realizing scalable quantum computation. Key ingredients for quantum 
error correction are highly polarized ancilla qubits and high-fidelity quantum con- 
trol. While NMR quantum processors have demonstrated high control fidelity, the 
requirement to prepare highly polarized spin qubits on demand is a major chal- 
lenge. Electron-nuclear hyperfine coupled spin systems provide a possible solution: 
electrons can be fully polarized at accessible fields and temperatures, and their po- 
larization is typically reset much faster than nuclei by spin relaxation. This makes 
open system cooling methods, such as heat bath algorithm cooling, possible. In 
this talk, I will describe our recent efforts to improve the precision of microwave 
control in a custom electron spin resonance spectrometer. In particular, we use ran- 
donized benchmarking of quantum gates to quantify control errors, and carefully 
take into account the resonator transfer function in correcting pulses. Moreover, we 
implement a protocol that distinguishes coherent and incoherent errors, which gives 
deeper insight into the nature of the remaining control imperfections and how to 
address them.

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