Fast state preparation for variational quantum algorithms to outrace decoherence on near term quantum computers

Quantum simulation of chemical systems is one of the most promising near-term applications of quantum computers. Although fully error corrected devices would enable “approximation-free” algorithms like quantum phase estimation to provide arbitrarily accurate calculations of strongly correlated molecules, significant practical and theoretical challenges exist, making hardware realization not likely in the near future. In contrast, the Variational Quantum Eigensolver (VQE) is more robust to noise and errors, and has been experimentally demonstrated on current NISQ devices. Unfortunately, this increased robustness comes at the cost of the introduction of approximations in the form of an ansatz. This defines the key tradeoff with VQE: longer circuits permit higher accuracy, while shorter circuits minimize problems from device noise and errors. In this talk, I will present two distinct families of quantum algorithms that our collaborative team have recently designed, demonstrating that they make significant improvements over the existing approaches.