Simulating extreme plasma physics on a quantum computer

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Quantum computers promise significant speedups and memory saving when simulating physical systems. However, they are naturally applicable only to a certain kind of problems, that can be expressed in a form equivalent to the linear Schrödinger equation. In the last few years many new algorithms have been designed to map problems that do not strictly satisfy this condition to a quantum circuit. Current general public-access quantum computers only allow for ~15 qubits at a time and short circuit depths (~100 gates before results get corrupted by decoherence). This has restricted simulation capabilities on real quantum computers to testing toy models for most of the problems of interest. Variational algorithms are promising for the near-term quantum computers as they present three main advantages: their circuits are shorter than in regular Hamiltonian simulation, they allow for reconstruction of the wavefunction at each timestep and they can be extended to nonlinear dynamics. While quantum algorithms have been successfully applied in areas such as quantum chemistry and quantum field theory, their study in plasma physics is still at its infancy. In this work we apply quantum computing techniques to extreme plasma physics, which is inherently nonlinear in its nature.

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