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Quantum Simulation Algorithms for Many Fermion Systems in First Quantization

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In this work, we compare the quantum simulation of a pionless effective field theory using the first and second quantization frameworks, as well as evaluate the performance of various algorithms within the first quantization framework. We demonstrate that using the first quantization formalism can yield an exponential advantage over second quantization as the lattice size increases. However, this advantage comes with a trade-off of polynomially worse scaling in the number of particles. Consequently, we show that for scattering processes and simulations that require being "far" from the boundaries, the first quantization framework is likely the more suitable choice. We show that this is the case when considering a simple Hamiltonian with two and three-body contact interaction.

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