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Preparing ground states of quantum many-body systems on a quantum computer

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The simulation of quantum many-body systems is a notoriously hard problem in condensed matter physics, but it could easily be handled by a quantum computer [4,1]. There is however one catch: while a quantum computer can naturally implement the dynamics of a quantum system — i.e. solve Schrödinger's equation — there was until now no general method to initialize the computer in a low-energy state of the simulated system. We present a quantum algorithm [5] that can prepare the ground state and thermal states of a quantum many-body system in a time proportional to the square-root of its Hilbert space dimension. This is the same scaling as required by the best known algorithm to prepare the ground state of a classical many-body system on a quantum computer [3,2]. This provides strong evidence that for a quantum computer, preparing the ground state of a quantum system is in the worst case no more difficult than preparing the ground state of a classical system.

References

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