« Atelier sur l'information quantique et mécanique statistique quantique »
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Approximation algorithms for quantum many-body problems

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We discuss classical algorithms for approximating the largest eigenvalue of quantum spin and fermionic Hamiltonians based on semidefinite programming relaxation methods. First, we consider traceless 2-local Hamiltonians H describing a system of n qubits. We give an efficient algorithm that outputs a separable state whose energy is at least a $1/O(\log n)$ fraction of the maximum eigenvalue of H. We also give a simplified proof of a theorem due to Lieb that establishes the existence of a separable state with energy at least a 1/9 ratio of this maximum.

Secondly, we consider a system of n fermionic modes and traceless Hamiltonians composed of quadratic and quartic fermionic operators. We give an efficient algorithm that outputs a fermionic Gaussian state is at least a $1/O(n \log n)$ ratio of the maximum eigenvalue. Finally, we give a simple family of Hamiltonians for which Gaussian states vastly outperform Slater determinant states commonly used in the Hartree-Fock method.

This is joint work with Sergey Bravyi, Robert Koenig, and Kristan Temme.

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