Abstract Submitted
for the MAR10 Meeting of
The American Physical Society

Quantum computation in the ground state of interacting fermions

DAVID FEDER, University of Calgary, GORA SHLYAPNIKOV, LPTMS, Universite Paris-Sud — In measurement-based quantum computation (MBQC), an algorithm proceeds entirely by making projective measurements on successive qubits comprising some highly entangled 'resource state.' While two-dimensional cluster states are known to be universal resources for MBQC, it has been proven that they cannot be the unique ground states of any two-body spin Hamiltonian. We show that a particular ground state of non-interacting fermions (equivalent to a many-body spin system) is formally equivalent to a cluster state, though only capable of simulating a limited set of quantum operations. In the presence of two-particle interactions, however, the ground state becomes a universal resource for MBQC. This result suggests that arbitrary quantum algorithms could be simulated fault-tolerantly simply by measuring a cold gas of interacting fermions, such as ultracold atoms in optical lattices.

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Date submitted: 19 Nov 2009 Electronic form version 1.4