Quantum computing with FQHE quasiparticles

D. V. Averin and V. J. Goldman
SUNY-Stony Brook, USA

``Topological" quantum computation using anyons, quasiparticles of two-dimensional (2D) systems with non-trivial exchange statistics, has been suggested as a way of solving the decoherence problem in quantum computation. Motivated by this suggestion, and by the recent progress in experiments on transport of individual fractional quantum Hall effect (FQHE) quasiparticles in the antidot systems, we propose the possibility of practical implementation of anyonic quantum computation in multi-antidot structures in the 2D electron liquids in the FQHE regime.

The proposed qubits and logic gates are based on the adiabatic transport of abelian FQHE quasiparticles in antidot structures. The qubit is the system of two tunnel-coupled antidots, with the information represented by the state of one quasiparticle in this system. The basic two-qubit gate is the controlled-phase gate, obtained by intertwining two quasiparticles in the course of their propagation through the gate structure. We estimate the decoherence rates in these systems, and parameters required for their operation. Advantages of our approach over other semiconductor-based proposals of quantum computation include energy gap in the FQHE liquid that suppresses decoherence, and the topological nature of statistical phase that makes it possible to entangle two qubits without their direct dynamic interaction.