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Title: Quantum computing with electrons floating on liquid helium
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Abstract
We describe a quantum computer based on electrons supported by a helium film and localized laterally by small electrodes just under the helium surface. Each qubit is made of combinations of the ground and first excited state of an electron trapped in the image potential well at the surface. We identify the ground and first excited states of these electrons with the $|0\rangle$ and $|1\rangle$ analog of classical bits, respectively. Each qubit (quantum-bit) can be put in any linear superposition of the states $|0\rangle$ and $|1\rangle$ with a basis vector $a|0\rangle+b|1\rangle$; $a^2+b^2=1$. A quantum computer composed of N qubits has 2^N basis states (combinations of $|0\rangle$s and $|1\rangle$s for each qubit) which in the simplest form are products of the basis vectors of each of the N qubits. Operations use qubits in a superposition of many possible basis states and can, therefore, be equivalent to performing a large number of computations in parallel. The difficulty in utilizing this advantage arises from the fundamental nature of measurement in quantum processes, namely that measurement of the energy of an individual qubit will necessarily collapse the wave function so that the result can be only either $|0\rangle$ or $|1\rangle$ for each qubit. This requires algorithms that can yield definite answers to computations. We describe mechanisms for preparing the initial state of the qubit, operations with the qubits, and a proposed readout. This system is, in principle, capable of 10^4 operations in a decoherence time, the time in which the wave function collapses.