Electrical Control of a Flying Charge Qubit

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Electron interference in an open structure usually suffers from a complicated multi-path interference bound to time reversal symmetry. We study electron transport through a hybrid system of an Aharonov-Bohm (AB) ring connected to tunnel-coupled quantum wires whose connection is varied between the adiabatic and non-adiabatic regimes. The non-adiabatic regime is realized when the inter-wire coupling is sufficiently weak that electrons injected from the AB ring to the coupled wire oscillate between the two wires, and the interference is characterized by a pure two-path interference without backscattering. This is in contrast with the one in the conventional adiabatic regime where the inter-wire coupling is so strong that the coupled-wire is equivalent to a single wire or lead connected to the AB ring.
The unique two-path interference is used to electrically control a flying qubit state defined by the presence of an electron in either part of the coupled-wire. We demonstrate full electrical control of the qubit with an operation frequency v_F/L of order of 100 GHz. Long coherence length of over 100 μm, more than 2 order of magnitude longer than the length required for each quantum operation, is also confirmed. This flying qubit opens a new avenue for fast and coherent control and transfer of a quantum information.