Supercurrent flow in semiconductor quantum dots

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Abstract:

A zero-resistance supercurrent can flow between two weakly coupled superconductors due to the Josephson effect. The microscopic origin of this supercurrent depends on the nature of the weak link. I shall discuss the experimental realization of Josephson junctions formed by an individual semiconductor nanowire bridging two aluminum-based superconducting electrodes. Two distinct situations will be discussed: 1) The supercurrent is carried by the diffusive, but coherent, transport of correlated pairs of electrons across the nanowire. In this case the critical current can be tuned by a gate voltage acting on the carrier density in the nanowire. 2) An interacting quantum is defined in the nanowire by means of local gate electrodes. Due to Coulomb blockade, the transfer of a Cooper pair occurs by subsequent and correlated co-tunneling of the constituent electrons through the discrete energy levels of the quantum dot. For certain charge states of the dot, this transport mechanism results in a π-shift in the Josephson current-phase relation, i.e. a "negative" supercurrent.