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Superconductor-insulator quantum transition in extra-long, one-dimensional chains of Josephson junctions

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A quantum phase transition (QPT) represents a discontinuous change of the ground state of an extended, ideally infinite, system. Such transitions occur at zero temperature and they are driven by tuning a parameter in the Hamiltonian. If an effective Hamiltonian is such that it includes some temperature-dependent parameters, then a temperature-controlled quantum transition (TC-QPT) can be expected. Here we present a TC-QPT between superconducting and insulating regimes in a chain of weakly coupled superconducting islands. The transition appears at a temperature where the Josephson energy equals the effective Coulomb charging energy, defined by the electric capacitance between the islands. The insulating state is manifested by a resistance peak, characterized by an exponential growth of resistance with cooling, while the superconducting state is represented by an exponential drop of the resistance with cooling. A scaling analysis, which takes into account the temperature-dependent critical parameter of the observed TC-QPT, is presented. The temperature dependence of the QPT critical point comes about because the Josephson coupling energy depends on the BCS energy gap, which is temperature dependent.

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