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Quantum fluctuations and phase coherence in superconducting nanowires

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Quantum behavior of superconducting nanowires may essentially depend on the employed experimental setup. Here we investigate a setup that enables passing equilibrium supercurrent across an arbitrary segment of the wire without restricting fluctuations of its superconducting phase. The low temperature physics of the system is determined by a combined effect of collective sound-like plasma excitations and quantum phase slips. At $T = 0$ the wire exhibits two quantum phase transitions, both being controlled by the dimensionless wire impedance g. While thicker wires with $g > 16$ stay superconducting, in thinnest wires with $g < 2$ the supercurrent is totally destroyed by quantum fluctuations. The intermediate phase with $2 < g < 16$ is characterized by two different correlation lengths demonstrating superconducting-like behavior at shorter scales combined with vanishing superconducting response in the long scale limit.

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