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Manipulating superconducting fluctuations in ultrasmall loops and quasi one-dimensional wires of Al[1]

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Superconducting fluctuations and the control of these fluctuations have been a problem of long-standing interest, with recent impetus provided by its relevance to the pursuit of very high temperature superconductivity through the engineering of global phase coherence. In quasi one-dimensional superconductors, fluctuations due to thermal or quantum processes lead to phase slips, and the appearance of a finite electrical resistance. We found that the critical current in mesoscopic quasi one-dimensional wires of Al is influenced by the bulk measurement electrodes, and in fact increases with magnetic field at low fields, suggesting that the phase slips are suppressed by the loss of superconductivity in the bulk electrodes. Manipulation of superconducting fluctuations is also possible in ultrasmall loops, where the strength of the fluctuations is controlled by the loop's size in comparison with ξ and the enclosed flux. For ultrasmall loops with a circumference $\sim \pi\xi(0)$, de Gennes predicted more than three decades ago that superconductivity could be completely destroyed near half-integer-flux quanta even to zero temperature. Furthermore, the resulting destructive regime, likely dominated by quantum fluctuations at low temperatures, was predicted to be suppressed with the addition of a superconducting side branch. We observed this Little-Parks-de Gennes effect in ultrasmall Al loops prepared by e-beam lithography and we found that the addition of a superconducting side branch restores the lost phase coherence. We will present our most recent data and discuss the implications of our experimental observations.

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