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Statistics of superconductive-resistive switching in nanowires: An effective probe for resolving phase-slip events[1]

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Phase slips are topological fluctuation events that carry the superconducting order-parameter field between distinct current carrying states and impart a non-zero resistance to superconducting nanowires. They play a fundamental role in determining the fate of superconductivity in nanowires. Conversely, superconducting nanowires provide an ideal setting for accessing non-trivial fluctuations driven by thermal activation and—at low temperatures—by quantum tunneling of a one-dimensional field. However, this potential has not been fully realized because resistance measurements, on the one hand, are capable of capturing only the averaged phase-slip behavior, and on the other hand, are incapable of pinning down the low temperature phase-slip behavior, as the measured resistance values drop below the noise floor. On going beyond the linear-response regime, the I-V characteristics show a hysteretic behavior. As the current is ramped up repeatedly, the state switches from a superconductive to a resistive one, doing so at somewhat random current values below the depairing critical current. The distribution of these switching currents was studied recently [1]. In this talk, I will report on the rather counter-intuitive temperature dependence of the distribution and its theoretical understanding via a stochastic model developed in Ref [2]. I will show that although, in general, several phase-slip events are necessary to induce switching, there is an experimentally accessible temperature- and current-range for which a single phase-slip event is sufficient to switch the wire to the normal (resistive) state. I will conclude by arguing that switching-current statistics provide an effective probe to resolve individual phase-slip events and in addition offer unprecedented access to quantum phase-slip tunneling events.

[1] M. Sahu, M.-H. Bae, A. Rogachev, D. Pekker, T.-C. Wei, N. Shah, P. M. Goldbart, and A. Bezryadin, arXiv:0804.2251
[2] N. Shah, D. Pekker, and P. M. Goldbart, Phys. Rev. Lett. 101, 207001 (2008)

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