How to measure temperature by flipping a coin?

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Thermometry is a key in studies of thermodynamics - discipline investigating heat flows arising from difference in temperature between two bodies. In our pioneering experiments we employ a superconducting weak link (Fig.1) to measure rapidly changing electron temperature in a long superconducting nanowire with nanosecond resolution [1]. Investigation of thermal properties in nanoscale is much less common than corresponding electrical and magnetic studies. Partially it is because of the lack of fast thermometers that would be able to trace thermal transients appearing when electrical circuit is driven out of equilibrium due to, say, rapidly changing current responsible for Joule heating or photons absorbed in the bolometer. Yet, a proper understanding of thermal processes is essential for failure-free functioning of quantum circuits, involving design of nanoscale calorimeters and bolometers. In our quest to measure temperature even faster we utilized the ability of current-carrying superconducting weak link to instantaneously switch from superconducting to normal state. This switching depends on temperature, thus providing a feature required for a temperature sensor. The ease of integration, true nanometer size and simplicity make our thermometer a good candidate for exploring thermodynamics of low temperature quantum circuits. The method can prove to be very attractive in determination of vanishingly small heat capacities and studying heat exchange mechanisms involving real-time visualization of hot electron diffusion in nanostructures and calorimetric counting of single microwave photons.

References

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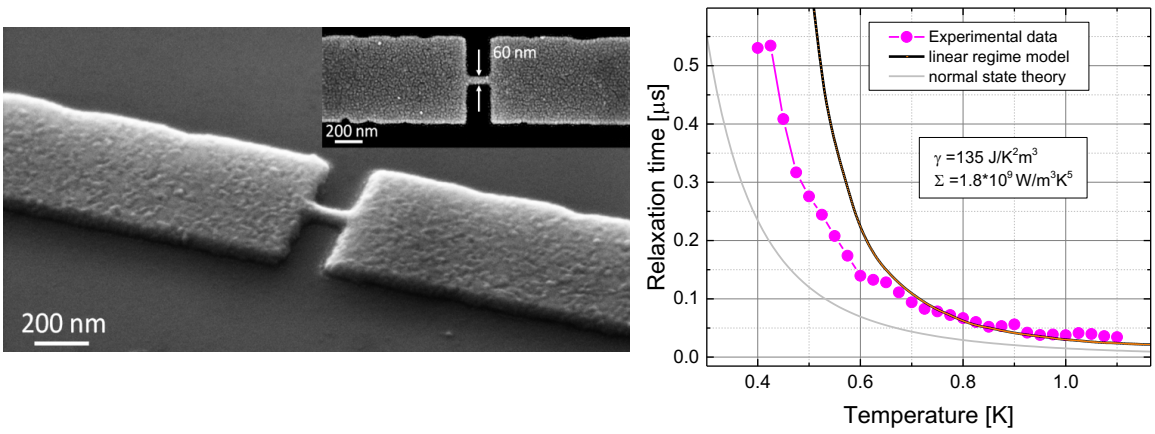

Fig.1. SEM image of the nanoscale thermometer and measured thermal relaxation times of a superconducting nanowire.