Magnetic Johnson-noise thermometry at milli-Kelvin temperatures and below

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The thermally driven voltage fluctuations of an electrical resistor can be described by the fluctuation-dissipation theorem, providing a fundamental relation between temperature and independently measurable quantities — one of the prerequisites for primary thermometry.
We present a setup for Johnson-noise thermometry at mK and sub-mK temperatures that uses a commercially available dc-SQUID as preamplifier. The noise to be measured is generated by the thermal motion of electrons in a bulk sample of a high purity metal such as gold or copper. These random currents cause fluctuations of magnetic flux in a superconducting pickup coil which is connected to the input coil of a current-sensor dc-SQUID. To characterize the performance of such thermometers we compared prototypes based on different noise source materials to each other and to a superconducting standard reference device (SRD1000) calibrated against the temperature scale PLTS-2000. The thermometer is easy to use, fast and rather insensitive to typical sources of parasitic heating even at lowest temperatures. We present results and discuss general design considerations as well as the dependence of the temperature uncertainty on measurement time.

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