Noise Thermometry at Low Temperatures: MFFT Measurements in the Temperature Range From 1.6 K to Below 1 mK

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At low temperatures, reliable thermometry is a complicated task. Recently, we have developed a dc SQUID-based noise thermometer, the so-called magnetic field fluctuation thermometer (MFFT), for practical thermometry in the low temperature range[1]. Its operational principle is based on the Nyquist theorem ensuring a linear characteristic over a wide range of temperatures. This makes the MFFT a thermometer capable to replace a variety of secondary thermometers which are normally required to cover the whole temperature range of the International Temperature Scale PLTS-2000 from 1 K to 0.001 K.
Here we describe a fast, compact, and easy to use MFFT system comprising a metallic temperature sensor with a SQUID gradiometer, a data acquisition unit and a software package. For measurements at very low temperatures, the MFFT setup is specially designed to have a high signal level and, at the same time, a sufficiently high bandwidth for fast measurements.
For the first time, we report on MFFT measurements over more than 3 decades in temperature from about 1.6 K down to below 1 mK. The deviations from a high accuracy realization of the PLTS-2000 are found to be $\leq 1\%$.

[1]J. Engert, J. Beyer, D. Drung, A. Kirste, M. Peters, Int. J. Thermophys. **28**, 1800 (2007).