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SQUID-based noise thermometer for sub-millikelvin refrigerators

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The magnetic-field fluctuation thermometer (MFFT) is a high-accuracy SQUID-based noise thermometer suitable for sub-Kelvin thermometry. It consists of a highly sensitive low-Tc SQUID magnetometer and a metal body in contact with the temperature stage to be measured. The SQUID is used to inductively detect magnetic field fluctuations that arise from the thermal motion of electrical charges in the metal body. For fixed geometry and constant electrical conductivity of the metal the spectral shape of the magnetic flux noise sensed by the SQUID is temperature independent, and the detected "magnetic"Johnson noise is directly proportional to the temperature. Hence, a reference measurement at one known temperature suffices for calibration. A complete MFFT thermometer system for the temperature range of ca. 4 K down to <10 mK is commercially available [1]. We have now developed an integrated MFFT with an extended range of operation down to <1 mK. For this purpose the sensitivity of the SQUID sensor has been increased, the metal body geometry modified and the magnetic shielding of the MFFT module improved. These modifications make it possible to obtain a thermometer noise temperature of <10 μK. We discuss the rationale for our MFFT configuration for ultra-low temperatures and present details of numerical simulations and experimental results.

[1] http://www.magnicon.com/fileadmin/download/datasheets/Magnicon_MFFT-1.pdf

Primary author: Mr SCHMIDT, Marco (Physikalisch-Technische Bundesanstalt)

Co-authors: BARTHELMESS, Henry J. (Magnicon GmbH); Dr BEYER, Joern (Physikalisch-Technische Bundesanstalt); Dr ENGERT, Jost (Physikalisch-Technische Bundesanstalt); Mr ALIVALIOLLAHI, Sassan (Magnicon GmbH)

Presenter: Mr SCHMIDT, Marco (Physikalisch-Technische Bundesanstalt)

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