Development of SQUID DC Magnetometer for a Top Loading Dilution Refrigerator Probe


Introduction

We have developed a SQUID (superconducting quantum interference device) DC magnetometer for a top loading dilution refrigerator [1]. The test results show that the base temperature at 25 mK increased ~ 1.6 % when the sample displacement was 3.2 cm with a speed of 3 cm/min. The moment of the test sample was successfully detected down to 50 mK. Improvement in coil balancing and shielding of the detection coil are planned.

Experimental Results and Discussion

A NbTi superconducting wire was wound on a G-10 tube (OD = 1.9 cm) to form a gradiometer and the superconducting wires coming out of the coil are tightly twisted and secured to the G-10 rod, which extends all the way to the 1 K pot cavity where the wires enter into the SQUID electronics. As a test sample 1.9 mg of the paramagnetic salt Gadolinium Sulfate (Gd$_2$(SO$_4$)$_3$•8H$_2$O) in powder form was mounted using a commercial straw. The moment of the test sample is expected to be in the order of $10^{-4}$ emu•G at 10 G and increases as the external magnetic field increases. Near base temperature at 25 mK, the heating effect due to the mechanical shaft moving was tested by continuously moving the shaft for ~ 3.2 cm with speed of 3 cm/min. The moving distance, 3.2 cm is similar to the height of detection coil. The temperature increased to 25.3 mK during the movement of mechanical shaft and shows plausible use for low temperature application. Figure 1(a) shows raw SQUID signals as the test sample moves through the detection coil near 500 mK as measured at the top of the mixing chamber. The overall SQUID amplitude increases as expected as the magnetic field increases and the noise level was less than the size of the data point. The SQUID signal was able to detect the test sample moment down to 50 mK, see Figure 1(b). The shape of the signal however, did not turn out to be symmetric around the center of the detection coil. This imbalance of signal is most likely due to the imbalance of coil winding or non homogenous temperature profile along the 3.9 cm of coil axis and requires future improvement.

![Figure 1](url)

Figure 1. Raw SQUID signals at different magnetic fields (a) and different temperatures (b) as the test sample (Gd$_2$(SO$_4$)$_3$•8H$_2$O) moves through the detection coil.

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References