Quantum Design

SVSM Application Note 1500-009

Mounting Samples Loosely Causes Moment Noise in VSM Measurements

Precise VSM measurements require smooth sinusoidal motion of the sample within the pickup coils. Deviations from this ideal motion will produce artifacts in the measured magnetic moment of the sample. This can occur in the following cases:

- A sample is not held tightly in the sample holder and subsequently it rattles.
- A powdered sample is not packed tightly and the material shakes within the sample holder.
- A glue or screw joint on the sample rod is loose so that the sample holder slips.

Figure 1 shows magnetic moment vs. temperature data from a nickel sphere 2 mm in diameter, measured in a magnetic field of 1 tesla. The moment is very large (~3.5 emu) and at temperatures below about 290 K its behavior is noisy and erratic, based on the following observations:

- The moment data exhibits significant noise and jumps.
- The quadrature signal "M Quad. Signal", which describes any moment pickup that is not in phase with the expected signal based on the motion of the motor, is a significant fraction (~5%) of the moment signal.
- The standard error "M. Std. Err.", which describes the uncertainty in the reported moment value, exhibits large scatter.

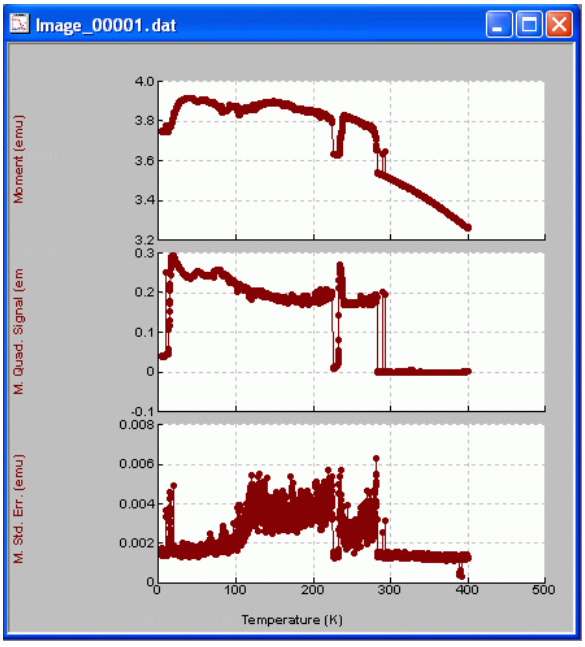

Figure 1. Magnetization vs. temperature data for nickel, with sample rattling in the sample holder below 290 K

In contrast, at temperatures above 300 K the moment data is smooth, and the quadrature signal and standard error are both less than 0.5% of the sample moment.

The noisy data is explained by the fact that the sample was not moving sinusoidally with the motor, but was instead rattling around in the sample holder. A significant quadrature component arose because the loose sample lagged behind the motion of the motor.

Differential thermal contraction of materials is a common cause of loose joints between parts, and it could explain why the noise in this data only appeared at temperatures below 290 K.

Figure 2 is a photograph of an oscilloscope trace of the signal for the same sample used above. The signal was taken from the BNC monitor ("MONITORS JF-5"), which is located on the front panel of the SQUID CM-F module, during the measurement. Note the jagged distortion of the signal, which appears strongest during a particular part of the cycle.

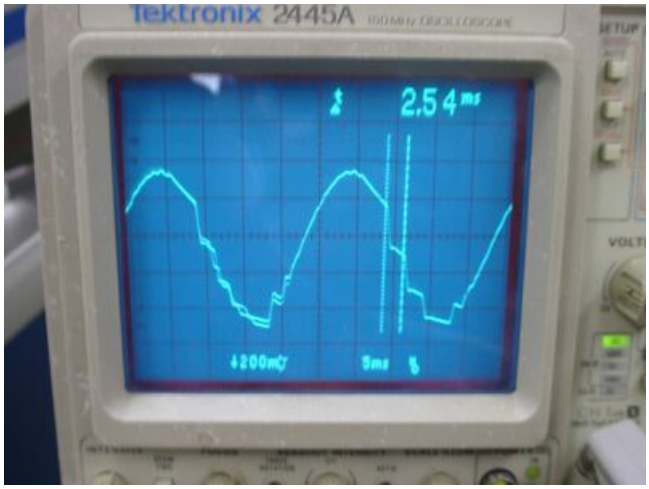

Figure 2. Oscilloscope trace of the sample signal, measured at the BNC on the SQUID module. Note the jagged distortion of the signal, which would be smooth and sinusoidal for a well-mounted sample.

The following suggestions should help prevent problems due to sample mounting.

1. Verify that the sample is rigidly mounted in the sample holder, keeping in mind that the accelerations during VSM measurements are very high!

   Noting that acceleration

   $$a = A\omega^2 = A(2\pi f)^2$$

   for a VSM peak amplitude A of 5 mm and a frequency f of 14 Hz, the acceleration is as high as 39 m/s^2, or ~ 4 g during each cycle.

2. Use an adhesive to hold the sample, if possible. Examples of recommended low-temperature adhesives are GE 7031 varnish or Devcon Duco cement. These are both soluble in common laboratory solvents: a toluene/alcohol mixture in the case of the GE varnish, and acetone in the case of the Duco cement.
3. Inspect all glue and screw joints on the sample rod and sample holder for loose connections.
4. Verify that powdered samples are packed tightly so that they are immobilized.