MPMS Application Note 1014-823

Improvements in Magnet Hysteresis Charging Mode

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1. Summary

An improvement in the hysteresis mode magnet controls implemented in MultiVu Rev. 1.53 will enable users to collect data with better magnetic field resolution resulting in less scatter in the data points, especially when crossing zero field.

2. Discussion

In the MPMS, hysteresis loops measurements are typically performed using the "hysteresis" magnet charging mode[1]. Although the fields are set less accurately (typical resolution ~ 1-2G) than in oscillate or no-overshoot mode (resolution ~ 0.1-0.2 G for H<5000 G) the field settings in hysteresis mode are set much more rapidly, enabling the user to perform a greater number of loops in a given amount of time.

In hysteresis mode, the field charges directly to the set target field specified by the user. The control PC keeps the magnet power supply turned on, so that current flows to the magnet and the persistent switch heater remains warm. The current output from the power supply is based upon the magnet calibration factor (i.e. H/I ~1550 G/A for a 5 T system) to reach the desired field:

$$H_{target} = I_{PowerSupply} * (H/I)$$

[1] See *MPMS MultiVu Application User's Manual* page 6-12.

Once the current is set, the PC uses the voltmeter card (inside the model 1822) to read the voltage across the 0.1 Ω current sensing resistor[2] to compute the current in the magnet and thus the actual field in the sample space.

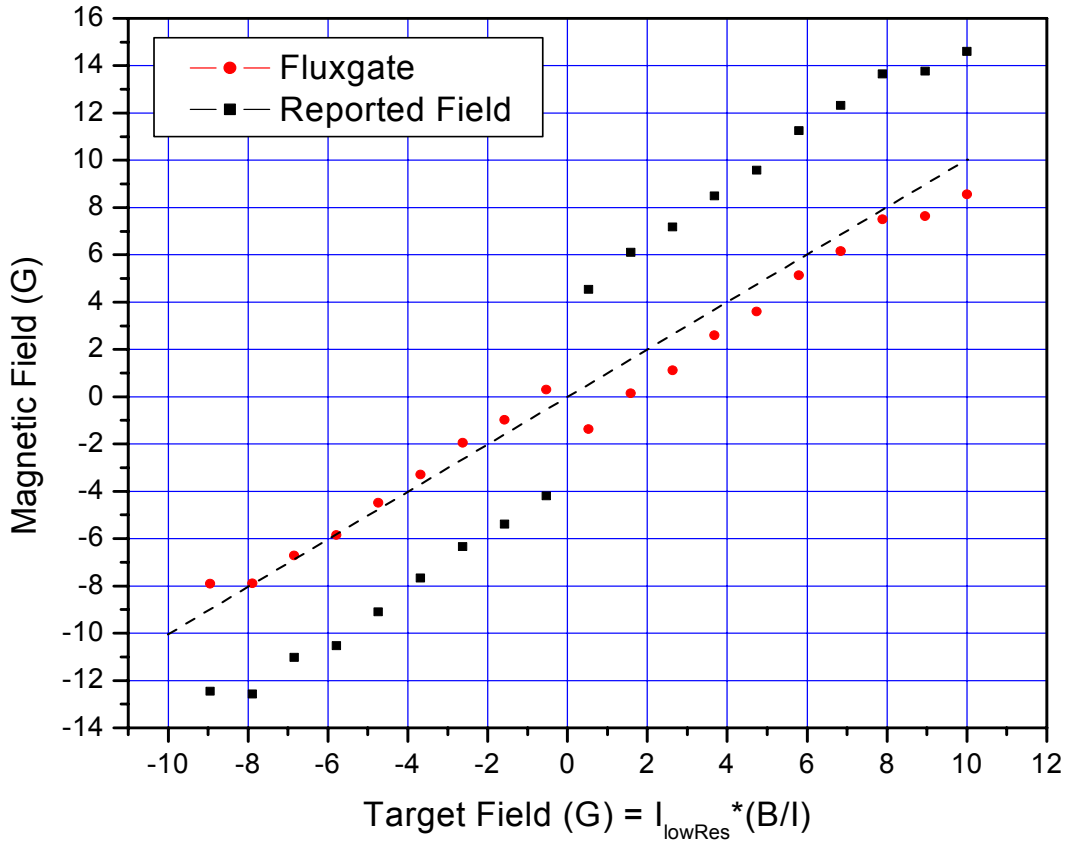

Figure 1. Reported magnetic fields with digitizer gain = 1V.

Recently[3] a gap in the magnetic field resolution was reported in low field hysteresis measurements. As a result of the investigation into this report, a slight voltage offset was discovered in the magnet charging circuit when $I_{PowerSupply} = 0$ A. The voltage was found to depend upon the voltmeter gain setting and I/O controller card in the model 1822. **Figure 1** compares the magnetic field values reported by MultiVu while charging the magnet in hysteresis mode with values read from a 10 G fluxgate inserted in the

[2] For the magnet current control schematic see Figure 6-1 in the *MPMS Hardware Reference Manual* Page 6-2.
[3] M. Boegel, c/o LOT-GmbH & Co KG, Germany, private communication.

sample chamber (p/n 4049-102). The data shows that the values computed from digitizer voltages across the sensing resistor and reported from the software are consistently higher than the fields in the sample chamber for positive fields and consistently lower than fields in the sample chamber for negative fields. An offset voltage of the order of 400 μV in the charging circuit of this MPMS system was found to be responsible for the error in the reported magnetic fields. The offset was found experimentally to vary from system to system from a few microvolts to few hundred microvolts.

The effect of the voltage offset upon low field hysteresis loops is more dramatic and somewhat more convoluted. **Figure 2** shows data of two isothermal (T= 100 K) hysteresis loops acquired in hysteresis charging mode of a dysprosium-oxide (Dy_2O_3)

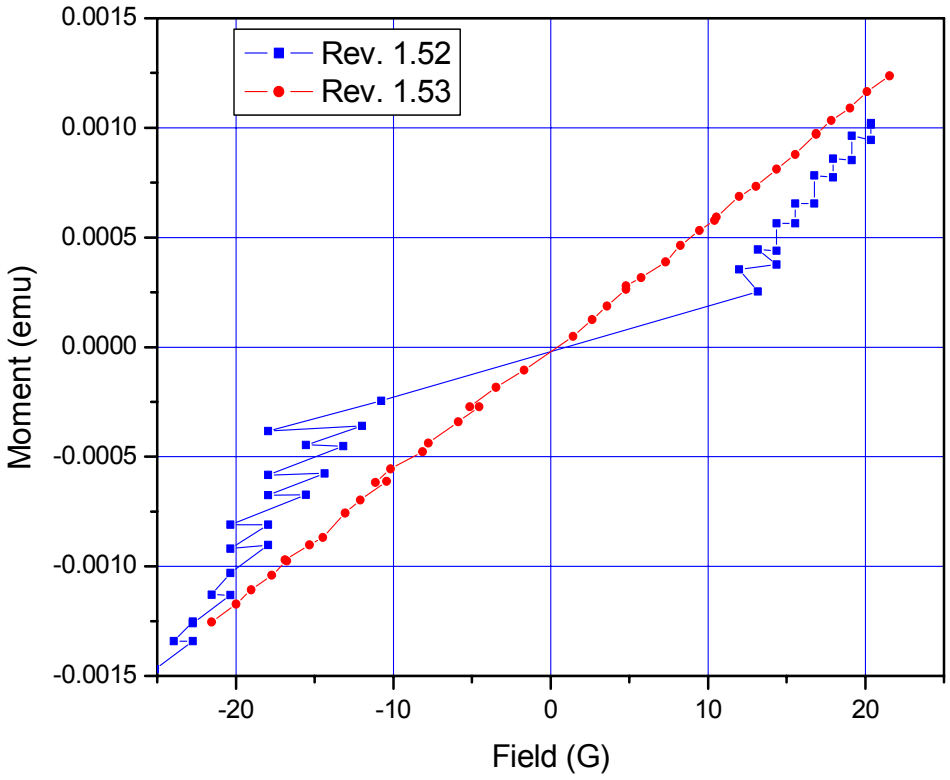

Figure 2. Hysteresis loops for Dy_2O_3 sample at 100 K.

sample using two versions of MultiVu software. In the revision 1.52 the magnetic field reported is not corrected for a voltage offset of 900 μV present in this MPMS system. The data shows a wide gap near zero field as a result of the accumulation of the voltage offset to voltmeter readings across the current sensing resistor. In addition, the data shows a somewhat high degree of scatter due to improper voltmeter auto ranging as a result of the offset. In the MultiVu revision 1.53 software, the voltage offsets are recorded (in the voltmeter.ini file) for $I_{PowerSupply} = 0$ A for all the voltmeter gain settings. The magnetic field reported is then computed from charging current readings which take into account the voltage offset of the circuit at the correct voltmeter gain. As a result, the data crosses smoothly through zero with much less scatter in the data.

3. Conclusion

MultiVu revision 1.53 correctly records and takes into account the voltmeter zero current offset voltages. This improvement in the magnetic hysteresis control will considerably improve the ability for making low field hysteresis loops with minimal offsets at zero field.