Dilation Experiments in a Single Turn Coil Magnet to 150T

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Introduction

$LaCoO_3$ and $SrCu_2(BO_3)$ are interesting magnetic systems that show spin transition effects and magnetic superstructure, respectively, in magnetic fields that exceed 70T, and are expected to show additional effects in fields exceeding 100T. Detection of phase transitions in pulsed magnetic fields to 100T was previously accomplished with an optical fiber Bragg grating technique. [1,2]

Experimental

A series of proof-of-principle magnetostriction measurements using a new high-speed Fiber Bragg grating (FBG) dilation approach were successfully executed on the single-turn coil magnet NHMFL system to 150T. In these experiment crystals of $LaCoO_3$ and $SrCu_2(BO_3)$ epoxied to single FBG sensors were observed using a novel 100 MHz fiber Bragg interrogation method. Briefly, the approach relies on using an ultrafast coherent optical time-domain spectrometer. A schematic of the approach is shown in Fig.1. Femtosecond pulses from a mode-locked Er fiber laser are coupled into single mode fiber integration system comprised of an optical circulator, 1-mm long uniform FBG sensor, chromatic dispersion element, erbium-doped fiber amplifier (EDFA), 35 GHz photodetector (Newport 1474-A), and a fast transient waveform digitizer (20 GHz, 50 GSamp/sec, Tetronix DPO 72004C). The laser source (Menlo Systems Inc. T-Light Laser) operates at 1560 nm and provides a continuous 100 MHz train of pulses to interrogate the FBG. The optical bandwidth content of the pulse extends from 1510 nm to 1610 nm. Each laser pulse samples the FBG sensor and the narrow band reflection pulse spectrum is returned to the optical circulator before being temporally stretched in a 50-km (or 100 km in double pass mode) long spool of single mode optical fiber (Corning SMF 28e) with a chromatic dispersion constant of 16.7 ps/(nm-km). The time delay observed in the pulses can be then recorded and converted to FBG reflection frequency, which is converted to strain with a calibration factor based on the physical characteristics of the grating.

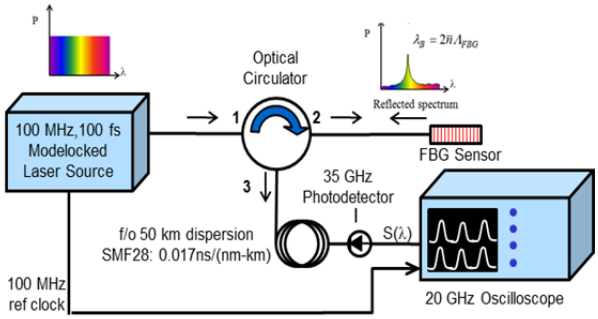

Figure 1: schematics of the setup used for magnetostriction experiments in the single tur coil magnet

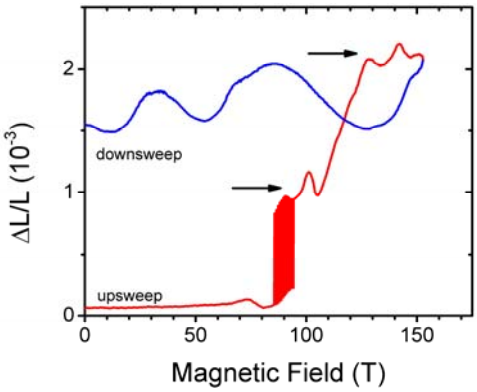

Figure 2: magnetostriction vs field for $LaCoO_3$

Results and Discussion

Figure 2 shows the first observed magnetostriction to 150T in a single crystal sample of LaCoO3, that shows a sharp transition in the 80-90 T region, consistent in magnitude with a transition previously observed in a 100T repetitive magnet at 60-70 T[1]. Efforts are under way to adjust the clock between experiment to berify if this difference is due to time difference between magnetic field and strain measurements. A second transition is observed in the 110-125T region that was never observed before. The blue trace obtained during the field down sweep seems to indicate that sample/fiber detached from each other due to magnetic shockwave.

Conclusions

This proof of principle effort needs to be complemented with additional measurements to confirm that the observed behavior to 150T is indeed produced by a second spin transition in the 110-125T region.

Acknowledgements

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References

[1] Altarawneh M., et al Phys. Rev. Lett. 109, xxx, 2012
[2] Jaime et al., Proc. Natl. Acad. Sci. 109, xxxx, 2012.