Magnetostriction and Magnetic Texture to 100.75 Tesla in Frustrated $SrCu_2(BO_3)_2$

M. Jaime (LANL, NHMFL), R. Daou (MPI, CPfS), S. Crooker (LANL, NHMFL), F. Weickert (LANL, CMMS), A. Uchida (LANL, NHMFL), Adrian E. Feiguin (Univ. of Wyoming, Physics), Cristian D. Batista (LANL, T4), H. A. Dabkowska (McMaster, Physics), B.D. Gaulin (McMaster, Physics)

Introduction

Strong geometrical frustration in magnets leads to exotic states such as spin liquids, spin supersolids, and complex magnetic textures. $SrCu_2(BO_3)_2$, a spin-1⁄2 Heisenberg antiferromagnet in the archetypical Shastry–Sutherland lattice, exhibits a rich spectrum of magnetization plateaus and stripe-like magnetic textures in applied fields. The structure of these plateaus is still highly controversial due to the intrinsic complexity associated with frustration and competing length scales. We discover magnetic textures in $SrCu_2(BO_3)_2$ via magnetostriction and magnetocaloric measurements in fields up to 100.75 T. In addition to observing low-field fine structure with unprecedented microstrain resolution, the data also reveal lattice responses at 73.6 T and at 82 T that we attribute, using a controlled density matrix renormalization group approach, to a unanticipated 2⁄5 plateau and to the long-predicted 1⁄2 plateau.[1]

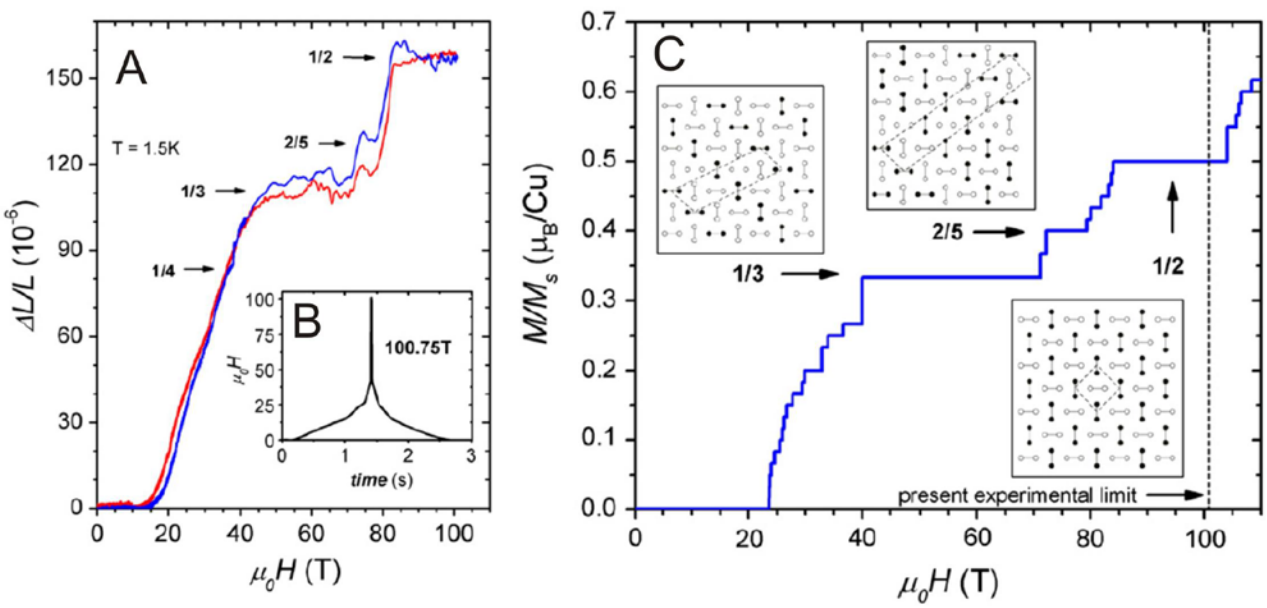

Figure 1. A, Magnetostriction vs. magnetic field for ΔL||H|| c-axis measured in a 100 T (red and blue) pulsed magnet. Data taken during field upsweep (red) and downsweep (blue) are included. Two new features at 73.4 T and 82.4 T in the high field data are attributed to the onset of the 2⁄5 and 1⁄2 magnetization plateaus. This sample was measured while held in place solely by the optical fiber used for magnetostriction. **B**, Field profile of the 100 T repetitively pulsed magnet at the National High Magnetic Field Laboratory. **C,** Normalized magnetization vs. field calculated using a Density matrix Renormalization Group technique in a 4 × 30 site lattice for J_0 = 78 K and J_1/J_0 = 0.62 showing that the most stable magnetization plateaus occur at 1⁄3, 2⁄5, and 1⁄2 of magnetization saturation. Inset: Solid circles represent Cu^{2+} dimers occupied by spin triplet states, open symbols are spin singlet states, organized in the 1/3, 2/5 and 1/2 states.

Acknowledgements

AF acknowledges NSF funding under grant DMRG-0955707. Experiments at the High Magnetic Field Laboratory Dresden (HLD) (not shown) were sponsored by Euro-MagNET II under the EU contract 228043. Work at the NHMFL was supported by the National Science Foundation, the US Department of Energy, and the State of Florida. This research was also supported by the NHMFL Users Collaboration Grants Program (MJ).

References

[1] M. Jaime *et al.*, *Proc. Natl. Acad. Sci* **109**, 12404 (2012).