Magnetic Phase Diagram of the Spin-1/2 Triangular-Lattice Antiferromagnet Cs_2CuCl_4

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Introduction

The interplay between geometric frustration and quantum fluctuations makes spin-1/2 antiferromagnets on a triangular lattice extremely sensitive to small perturbations [1]. This is particularly evident in Cs_2CuCl_4, where the Heisenberg exchange interaction *J* between nearest-neighbor spins along the crystallographic *b* axis is 0.374(5) meV and *J'* between other nearest-neighbor spins is 0.128(5) meV [2]. In this material, the small Dzyaloshinskii-Moriya (DM) interaction--only about 5.3% of *J* [2]--leads to a rich, strongly anisotropic magnetic phase diagram [3,4]. Most of the ordered phases that appear when the magnetic field *H* is parallel to the *c* axis have been identified with neutron scattering [3] and NMR [5]. In order to study the role of the DM interaction in the stability of those and other phases, we have studied the evolution of the magnetic phase diagram as the direction of the magnetic field is changed from parallel to *c* to parallel to either *a* or *b*.

Experimental

In this work, we have measured the magnetocaloric effect on two Cs_2CuCl_4 single crystals at about 100 mK at magnetic fields up to 9.3 T at the NHMFL DC-Field Facility in Tallahassee. For one crystal, the direction of the magnetic field was changed from parallel to *c* to parallel to *b* in steps of at most 5°. For the other crystal, the field direction was changed stepwise in a similar manner from parallel to *c* to parallel to *a*. For each direction, the field was swept at a rate of 0.2 T/min or 0.1 T/min, while we looked for anomalies indicative of transitions between different ordered phases.

Results and Discussion

When the field direction is changed from parallel to *c* to parallel to *b*, the phase diagram evolves gradually and smoothly as expected, allowing us to identify some of the previously unidentified ordered phases for $H||b$. By contrast, when the field direction is changed from $H||c$ toward $H||a$, a large number of new phases appear over a narrow range of field directions, before these phases are taken over by the spiral phase, which for $H||c$ occupies only the field region up to 1.4 T. These results confirm and augment our earlier results using a cantilever magnetometer at 20 mK.

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References

[1] Starykh, O.A., *et al*., *Phys. Rev. B* **82**, 014421 (2010).
[2] Coldea, R., *et al*., *Phys. Rev. Lett.* **88**, 137203 (2002).
[3] Coldea, R., *et al*., *Phys. Rev. Lett*. **86**, 1335 (2001).
[4] Tokiwa, Y., *et al*., *Phys. Rev. B* **73**, 134414 (2006).
[5] Yoshida, M., *et al*., unpublished.