Specific Heat, Magnetocaloric Effect, and Thermal Conductivity of $Cu(pz)_2(ClO_4)_2$ in the 60T Long-pulsed Magnet

C. P. Landee, F. Xiao (Clark U., Physics); Y. Kohama, M. Jaime (NHMFL, LANL)

Introduction

Low-dimensional quantum (S = ½) antiferromagnets display unique behavior due to the strong influence of quantum fluctuations. The ideal 2D Quantum Heisenberg Antiferromagnet (2D QHAF) of exchange strength J only orders at T = 0 but 3D interactions (J´), exchange anisotropy (Δ), or external fields lead to states of long-range order. There is no quantitative theory connecting an observed T_N to this set of parameters.

$Cu(pz)_2(ClO_4)_2$ is a quasi-2D QHAF [1–3] well established to have an exchange strength J = 17.5 K, a saturation field of $\mu_0 H_{SAT}$ = 50 T, a zero-field ordering temperature T_N = 4.24 K, and an easy plane anisotropy Δ of 0.5%. The excellent 2D isolation in this compound is revealed by the critical ratio T_N/J = 0.24. In the absence of the exchange anisotropy, this ratio corresponds to a J´/J ratio of 7 x 10^{-4} [1], but given the presence of Δ, only an upper bound for J´/J is known.

The critical temperature increases with field to a maximum value of 6.0 K in 17 T, decreasing with still higher fields. Preliminary measurements in fields up to 35 T at NHMFL-Tallahassee showed T_N(35 T) = 4.2 K, but with an increasingly negative slope. The current experiment was conducted to determine the complete phase diagram and hence to compare it to quantitative models to extract the correct J´/J ratio.

Experimental

The phase boundary of $Cu(pz)_2(ClO_4)_2$ was determined at constant temperatures T ≥ 2 K by monitoring the specific heat and the magnetocaloric effect in static and pulsed fields up to 55 T, using the 60 T long pulse magnet at NHMFL – LANL. Two different crystals were studied in the pulsed-field measurements.

Results and Discussion

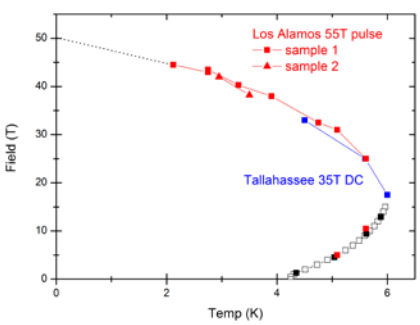

Figure 1: Phase diagram of $Cu(pz)_2(ClO_4)_2$.

The phase diagram of $Cu(pz)_2(ClO_4)_2$ is displayed in **Figure 1**. Data from the current experiment appear in red: circles for low-field dc data and squares and triangles for the pulsed-field data. Selected data from previous experiments [2,3] are also shown. Agreement between the data sets is within experimental uncertainties.

Conclusions

The magnetic phase diagram of $Cu(pz)_2(ClO_4)_2$ has now been determined up to 45 T, 90% of the saturation field. The completed diagram is now being compared to the results of QMC simulations to determine the J´/J ratio, the one remaining parameter in the compound's Hamiltonian. Manuscripts will be submitted for publication in 2013.

References

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[2] Tsyrulin, N. *et al.*, *Phys. Rev. Lett.* **102**, 197201: 1-4 (2009).
[3] Tsyrulin, N. *et al.*, *Phys. Rev. B* **81**, 134409: 1–9 (2010).