Modulation Calorimetry in Pulsed Magnetic Fields

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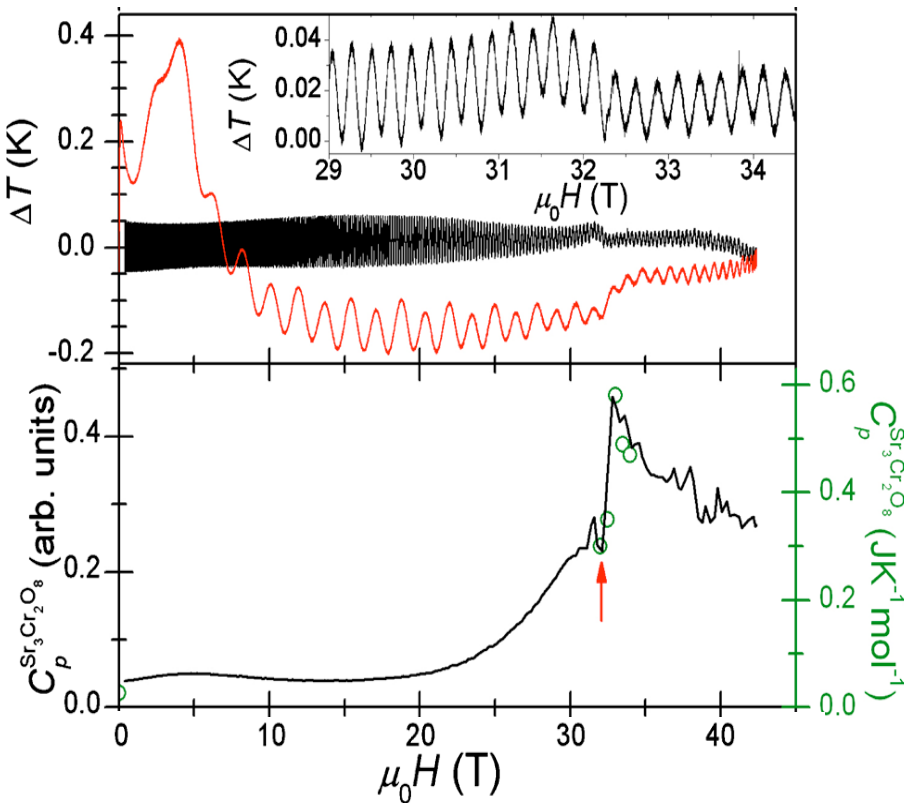
DMR-Award 0654118

Pulsed Field Facility User Program, LANL

Measuring specific heat in a rapidly pulsed magnetic field was thought to be virtually impossible; however Magnet Lab scientists recently demonstrated a rapid temperature modulation technique for heat capacity and magnetocaloric measurements of small samples in pulsed magnetic fields. Ruthenium oxide thermometry enabled precision as good as 4 mK at T = 2 K. NHMFL scientists tested the method up to $\mu_0 H$ = 50 T, but it can be extended to even higher magnetic fields.

The power of this new technique is demonstrated on the spin-dimer compound $Sr_3Cr_2O_8$ whose phase diagram was able to be completely mapped to record high magnetic fields.

Modulation calorimetry was recently made available to NHMFL users to obtain the phase diagram of heavy fermion compounds in the Ce-115 family.



(Top) Temperature oscillations in the sample recorded as a function of magnetic field to 45 T in a 250 msec long magnetic field pulse. (Bottom) Specific heat calculated from the inverse amplitude of the temperature oscillations above.

Y. Kohama, C. Marcenat., T. Klein, M. Jaime,
***Rev. Sci. Instrum.* (2010) in the press.**

A.A. Aczel, Y. Kohama, C. Marcenat, F. Weickert, M. Jaime, O.E. Ayala-Valenzuela, R.D. McDonald, S.D. Selesnic, H.A. Dabkowska, G.M. Luke, G.M., *Phys. Rev. Lett.,* 103, 207203 (2009).

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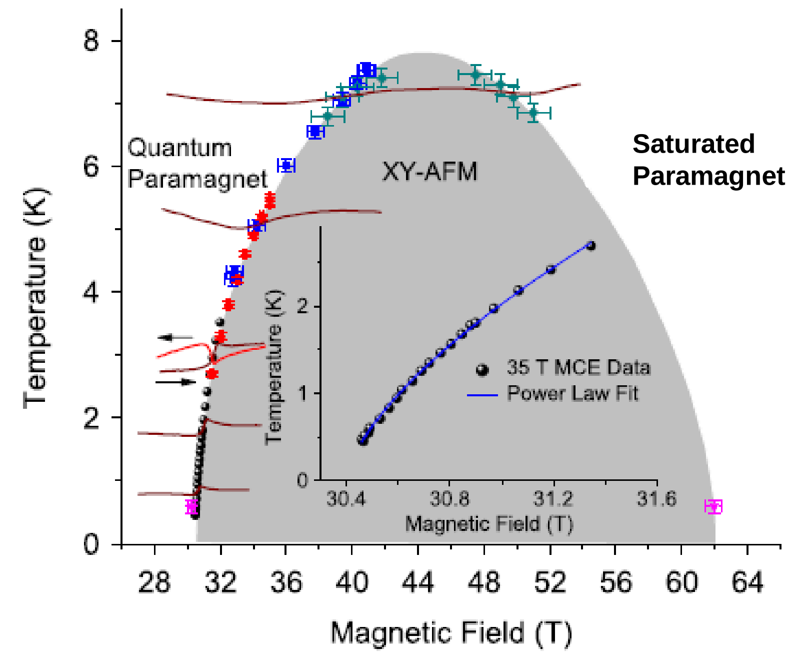
The new modulation calorimetry developed by NHMFL scientists was used to measure the first available single crystals of the spin dimer system $Sr_3Cr_2O_8$. Magnetization, heat capacity, and magnetocaloric data up to 65 T reveal magnetic order between applied fields of $\mu_0 H_{c1}$ = 30.4 T and $\mu_0 H_{c2}$ = 62 T.

The experiments strongly suggest that $Sr_3Cr_2O_8$ is a new realization of a Bose-Einstein condensation of magnetic triplons. This field-induced BEC order (shaded region in figure) persists up to T_{max} = 8K at the optimal field of $\mu_0 H_{max}$ = 44T, the highest temperature for any quantum magnet where the upper critical field H_{c2} is experimentally accessible.

These techniques are now available to NHMFL users for modulation calorimetry experiments in DC magnets to 45T and pulsed magnets to 60T.



$Sr_3Cr_2O_8$ phase diagram with the magnetically ordered phase shaded as a guide to the eye. The new data are the blue and green points near the apex of the ordered phase, an important region beyond the reach of DC magnet techniques. The inset shows the fit to data near Hc1 to a power law $T_c = [H_c(0)-H_c(T)]^{3/2}$, a signature of Bose-Einstein condensation of magnons.

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