Magnetocaloric Effect of Spin Dimer Compound $\text{Sr}_3\text{Cr}_2\text{O}_8$ in Pulsed Magnetic Fields

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Introduction
Magnetocaloric effect (MCE) is the change in temperature observed in a magnetic material through the application or removal of an external magnetic field. While this effect is better known in the context of magnetic refrigeration, MCE is highly valuable in experimental solid state physics since it helps to map magnetic field-temperature phase diagrams. The spin dimer compound $\text{Sr}_3\text{Cr}_2\text{O}_8$ shows a XY-AFM phase above 30T, and a full determination of its magnetic phase diagram was never carried out before.

Experimental
A tiny single crystal sample of $\text{Sr}_3\text{Cr}_2\text{O}_8$ was polished and glued on a bare-chip calibrated RuO$_2$ thermometer using GE vanish for the MCE measurement in a 50 T capacitance bank driven magnet, and 60 T motor generator driven magnet. The RuO$_2$ thermometer was thermally connected to a Si thermal bath using a 20 micro meter Kapton film. The thermometer, sample, and thermal bath ensemble was inserted in the core of the pulsed magnet using a standard 4He/3He cryostat, where the temperature was measured as a function of magnetic field at 1 to 10 kHz frequency with a digital lock-in technique. For the MCE measurement under 35 T DC field, we used a home-built calorimeter that includes a Cernox1010 thermometer, a Si platform, and a Ag-alloy thermal bath. [1] The MCE data in a DC magnet were measured with a slow field sweep rate of 3T/min.

Results and Discussion
The figure in the right displays MCE measurements took in the pulsed and DC magnets. The temperature traces clearly show a kink at magnetic phase boundaries. The resultant phase diagram reveals magnetic order between of $H_{c1} = 30.4$ and $H_{c2} = 62$ T with a maximum ordering temperature of ~ 8K. The temperature dependence of phase boundary was successfully fitted with the expression $T_c = A(H-H_c)^{2/3}$ near $H_{c1}$, which indicates that the universality class of the ordered state is that of XY-AFM, same as BEC of triplons.

Conclusions
We determined the full $(H, T)$ phase diagram for $\text{Sr}_3\text{Cr}_2\text{O}_8$. The maximum ordering temperature is the highest measured for a field-induced XY-AFM where $H_{c2}$ is experimentally accessible. The phase boundary near $H_{c1}$ can be fit to a power law supporting the XY-AFM universality class.

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References