Pulsed Field AC-heat Capacity in 2D-AFM System RbFe(MnO₄)₂

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Introduction
We have developed a new AC-calorimeter for pulsed magnetic fields. So far, as proof of principle, measurements of AC-$C_p$ have been carried out on the spin-dimmer compound Sr₃Cr₂O₈, the AFM RbFe(MnO₄)₂, and Si single crystals. The resultant temperature-magnetic field phase diagram of Sr₃Cr₂O₈ agrees with previous magnetocaloric effect measurement. However, since Sr₃Cr₂O₈ does not show magnetic order in zero magnetic field, a detailed comparison of AC-$C_p$ with $C_p$ obtained with a traditional calorimeter has not been carried out. In this report, we present the AC-$C_p$ data in a the two dimensional Heisenberg AFM RbFe(MnO₄)₂, which displays magnetic order at about 4 K in zero magnetic field [1,2]. Since this material shows an interesting (H,T) phase diagram, we also measured the AC-$C_p$ in pulsed fields up to 20 T.

Experimental
Single-crystal samples of RbFe(MnO₄)₂ were grown by a flux method [3]. The tiny single crystal (~ 10 μg) was carefully polished, and a NiCr heater was deposited on one of the surfaces. The heater resistance was 1.5 kΩ at 4 K, which does not show a detectable magnetoresistance up to 50 K. By applying AC current at a frequency of 200 Hz to the heater, we detected second harmonic oscillations (400 Hz) with an in-house digital lock-in system.

Results and Discussion
Figure 1 shows the temperature dependence of AC-$C_p$. As shown in the inset of the figure, the data were taken within 30 sec with decreasing temperature. Even for this fast sweep rate, the $C_p$ data shows a clear peak, and the shape of the anomaly is consistent with previous $C_p$(T) results.[2] Although the determination of the absolute value of $C_p$ is still difficult due to the small mass of the sample, our data indicate that our devise can measure $C_p$ using a fast temperature sweep. Figure 2 shows the AC-$C_p$ data as a function of magnetic fields. We can clearly see two phase transition at about 3 T and 10T. The shift of the magnetic field with changing temperature also agrees with the reported phase diagram.[1,2]

Conclusions
We measured AC-$C_p$(H,T) in the Heisenberg antiferromagnet RbFe(MnO₄)₂. The resultant temperature-magnetic field phase diagram agrees with previous reports.[1,2] This indicates that our devise can measure $C_p$ in a variety of different samples roughly independent of the heat capacity and thermal conductivity magnitudes.

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References