Heat Capacity at ^{3}He temperatures in BEC magnet $BaCuSi_2O_6$

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Spin gap compounds can exhibit many interesting quantum effects that are only be realized at low temperatures and high magnetic fields. One of the most exciting possibilities is that these spin gap compounds may be magnetic analogs of the Bose Einstein Condensate (BEC). The spin dimer compound $BaCuSi_2O_6$ has been proposed as a possible physical manifestation of this proposal [1]. In addition, it appears that this system also exhibits a dimensional reduction amongst the spin-triplet magnetic degrees of freedom at high magnetic fields and low temperatures [1]. Such dimensional reduction is of particular interest since it appears to occur near a quantum critical point, a phenomenon of much speculation, but with very little experimental evidence until now.

In this experiment, we report our attempt at additional evidence for this dimensional reduction utilizing heat capacity measurements. While previous work has uncovered an unusual phase boundary that is consistent with dimensional reduction, the heat capacity should provide a clear-cut distinction between 2D and 3D behavior in the putative dimensionally reduced regime of this compound. Unfortunately, we were unsuccessful in our attempt due to a variety of technical difficulties associated with measuring heat capacity in the brand new ^{3}He system available at NHMFL-FSU. However, we appeared to have solved all the major technical obstacles so that our next experimental run should allow us to address the very interesting question of "how does the heat capacity behave near a dimensional reduction at a QCP?".

This attempt to measure heat capacity was the *first* user experiment run on the new Janus ^{3}He refrigerator. A standard relaxation method was used to measure heat capacity. While the heat capacity measurement method and the refrigerator were sound and well tested separately, problems with the construction of the heat capacity stage caused a "touch" between the stage and the vacuum can of the He-3 system. This caused the base temperature to reach no lower than about 1.1 K. This temperature was too high in order to properly study what we wanted. We adjusted our design and rebuilt the probe onsite and corrected this main problem.

We present our successful measurement of heat capacity of $BaCuSi_2O_6$ at zero field in Fig. 1. When this setup was tested at high fields, unfortunately, we encountered very long time constants in the probe, rendering a complete measurement impossible within the remaining magnet time. In addition, we were only able to reach a base temperature of 0.5 K, which may have been due to the difficulty of heat sinking the sample platform adequately. A number of design tests are underway at the NHMFL, Los Alamos, in order to overcome the remaining technical difficulties.

Acknowledgements

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References

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[2] S. E. Sebastian *et al.* Nature **441**, 617 (2006).

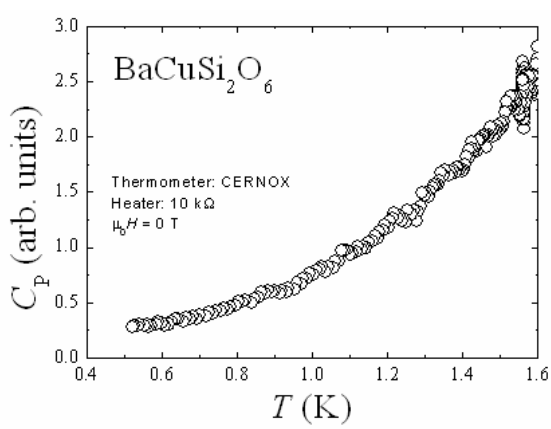

Fig. 1, *Heat Capacity of $BaCuSi_2O_6$ down to 0.5 K.*