Thermodynamics of S = 1/2 Quantum Antiferromagnets

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Introduction

Frustration happens when competing interactions cannot be simultaneously satisfied. Strong frustration together with enhanced quantum effects at low temperatures produce exotic phenomena, such as valence bond solid state, valence bond glass state and quantum spin liquid state. In these states, the spins are correlated without freezing or ordering down to T = 0 K. Experimental realization of such states have been challenging since spin orderings/local moments are almost always stabilized as T → 0 K due to disorder, symmetry breaking interactions, etc.

Lattices involving triangular motifs have been an active playground. Several compounds have shown promising properties, such as kagome [1,2] and triangular antiferromagnets [3]. Thermodynamic studies often provide crucial hints for precise theoretical modelings [4]. We would like to understand the exotic magnetism—start with the specific heat—on a collection of triangular frustrated antiferromagnets[3].

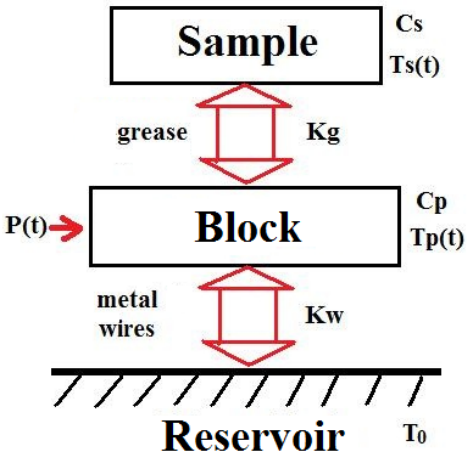

Fig.1 A relaxation calorimeter.

Experimental

The heat capacity has been measured using the SCM1 superconducting magnet with a dilution refrigerator at NHMFL Tallahassee. Using the relaxation method (Fig.1), the measurements have been performed at several fields down to ~0.1 K. For each temperature-field, the relaxation has been repeated to reduce random errors. For each relaxation measurement, the temperature-time profile has been recorded for roughly ten times as long as the time constant—necessary for a reliable estimation of the fridge temperature background. The amount of grease has been minimized to reduce the background-to-signal ratio.

Results and Discussion

The grease counts for approximately one quarter of the total measured heat capacity. At temperatures of Kelvins and above, a T^3 contribution from phonons has been observed. In contrast, the behaviors at lower temperatures are complicated. To have reliable results, the raw relaxation curves are currently being analyzed using a better calibration for the field dependences of the thermometers. At dilution fridge temperatures, a tau-two correction may be necessary to account for the poor thermal link between the sample and the block.

Conclusions

Based on the quality of the data, we may be able to determine the specific heat of the sample to a high precision and separate the magnetic and lattice entropies. The data analysis is currently in progress which will shed light on a possible magnetocaloric effect.

Acknowledgements

We thank Tim Murphy, Glover Jones and Ju-Hyun Park for their help with the SCM1 dilution refrigerator. Work at the NHMFL was done under NSF Cooperative Agreement No. DMR-1157490, the State of Florida, and the U.S. Department of Energy.

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