Magnetization of 2D (Square and Rectangular) Quantum Heisenberg Antiferromagnets

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Introduction

Low dimensional quantum antiferromagnets have been studied since the earliest days of quantum mechanics. Much of the theoretical attention has been devoted to purely one-dimensional (1D) or two-dimensional (2D) lattices with only one exchange strength. However, the physics becomes richer when an additional interaction strength is introduced; for a 1D system with alternating exchange interactions ($J$ and $\alpha J$), an energy gap appears for any alternation parameter $\alpha < 1$. Many examples of alternating chain compounds are known and have been studied [1].

The simplest 2D model with two exchange strengths is the rectangular system in which the exchange interactions along the two axes are $J$ and $\alpha J$, respectively, with $\alpha$ defined to be less than one. While there are no theoretical studies of such magnets, more than a dozen physical realizations are known. We have begun a systematic study of this system, both through experimental studies of the known compounds, as well as quantum Monte Carlo simulations of thermodynamic properties. Our first publication [2] dealt with Cu(pz)Br$_2$ ($pz =$ pyrazine) in which only the susceptibility was studied, since the anticipated saturation field (80 T) has exceeded available fields, until recently.

We report here the magnetization of another rectangular magnet, copper pyrazine diazide, Cu(pz)(N$_3$)$_2$ [3]. This is the first magnetization study of a rectangular magnet.

Experimental

The high field magnetization data were collected on polycrystalline samples using a 33 T Bitter magnet, the Vibrating Sample Magnetometer, and a 4He cryostat with a 3He insert.

Results and Discussion

Figure 1. Molar magnetization of Cu(pz)(N$_3$)$_2$ at 1.3 K in fields up to 33 T.

The susceptibility is described by exchange strengths $J = 15.5$ K and $\alpha = 0.5$. These interactions predict a saturation field of 33 T for an average $g$-factor of 2.1, slightly less than the experimental critical field observed. QMC simulations of the magnetization are in progress to provide a quantitative comparison to the experimental data.

Conclusions

The first magnetization study of a rectangular antiferromagnet has been performed. Studies in higher fields and comparisons to simulated magnetization data are in progress.

References