Multiple Magnetic Phases in the Frustrated S=1 Spin-Dimer Compound $Ba_3Mn_2O_8$

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Introduction

$Ba_3Mn_2O_8$ is a spin-dimer compound based on vertical pairs of S=1 $3d^2$ Mn^{5+} ions arranged on a triangular lattice. Antiferromagnetic intradimer exchange leads to a singlet ground state in zero-field, with a gap to excited triplet and quintuplet states. Previous measurements revealed multiple ordered states where the triplet state crosses the singlet state. Our experiments at the NHMFL probe thermodynamic behavior of this system, revealing an additional ordered state as the gap to the quintuplet band is closed.

Experiment and Results

Magnetization measurements were performed at temperatures down to 0.5K in the 50T midpulse magnet at the NHMFL in Los Alamos. These measurements revealed two different regimes of linearly increasing magnetization as the triplet and quintuplet bands are filled (fig. 1(a)). Heat capacity and magnetocaloric effect experiments were also undertaken in the hybrid magnet at the NHMFL in Tallahassee. Those experiments revealed a third distinct ordered state in the phase diagram for $Ba_3Mn_2O_8$ above 33T where the quintuplet band crosses the triplet band (fig. 1(b)).

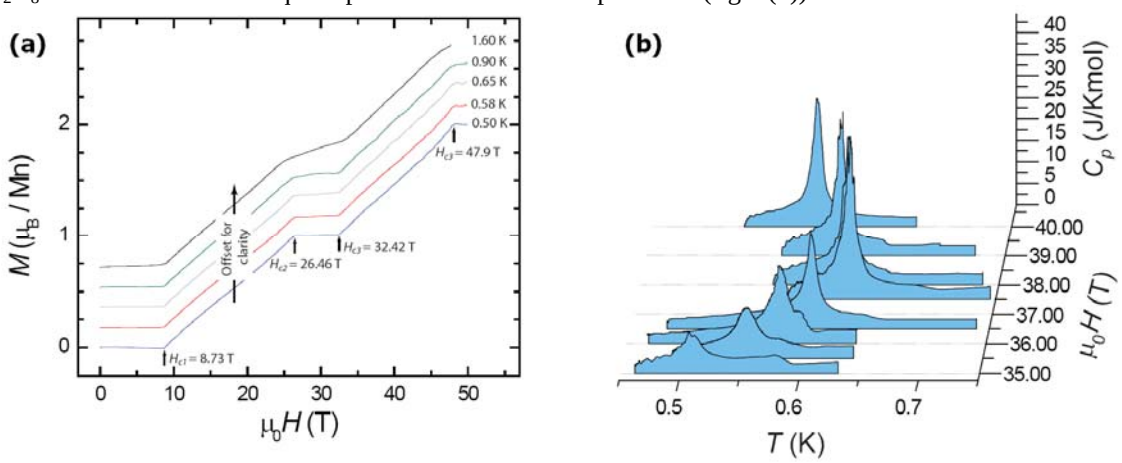

Fig 1. (a) Magnetization curves taken at successive temperatures. Positions of critical fields determined from second derivative with respect to field. (b) Heat capacity curves, taken on cooling for H ⊥[001], as a function of temperature and field showing transitions into the triplet-quintuplet ordered state.

Discussion

The remarkable phase diagram of $Ba_3Mn_2O_8$ contains at least three ordered states across the triplet and quintuplet regimes. Each of the phases are novel modulated spiral structures characterized by multiple order parameters, arising as a consequence of the competition between the effects of interdimer coupling on a triangular lattice and single ion anisotropy. The differences between the ordered states in the triplet regime and in the quintuplet regime, evident in the maximum T_c and the asymmetry in the ordered states, can all be understood from the minimal spin Hamiltonian [1].

Acknowledgements

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References

[1] Samulon, E. C., *et al.*, Physical Review B, **77**, 214441 (2008).