



Quantum fluctuations and strong mass renormalization in $\text{NiCl}_2\text{-4SC(NH}_2)_2$



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Quantum magnetism underlies many important problems in condensed matter including high- T_c superconductivity. Understanding the simpler problem of insulating quantum magnets is a pre-requisite to conductors and superconductors. Here we explore the dramatic role of quantum fluctuations at a quantum phase transition.

$\text{NiCl}_2\text{-4SC(NH}_2)_2$ has been studied for Bose-Einstein Condensation (BEC) of the spin system for several years. The magnetic field-induced phase transitions into an ordered phase between 2 and 12 T can be mapped onto BEC where the transverse antiferromagnetic order parameter corresponds to the number of condensed bosons.

At first sight the two phase transitions at 2 and 12 T should be symmetrical. However, asymmetry is widespread in the physical properties of this and other BEC materials. We show via a theory and experiment collaboration that quantum fluctuations suppress the boson mass near 2 T, where the spins and magnetic field are perpendicular. Near 12 T, the spins align with the magnetic field, creating a semi-classical problem with minimal quantum fluctuations. We also answer the puzzling question of why the thermal conductivity is the only physical property to be nearly symmetric.

Facilities: National High Magnetic Field Lab, Pulsed Field Facility.

Acknowledgements G.S. Boebinger (NSF DMR-0654118)

Citation: Y. Kohama, A. Sologubenko, N. Dilley, V. S. Zapf, M. Jaime, J. Mydosh, A. Paduan-Filho, K. Al-Hassanieh, P. Sengupta, S. Gangadharaiah, A. L. Chernyshev, and C. D. Batista, *Phys. Rev. Letters* **106**, 037203 (2011).

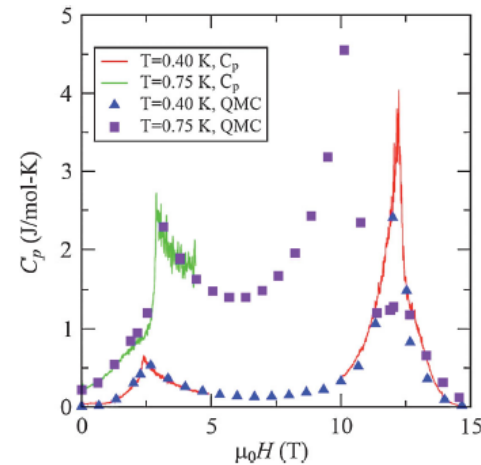


Fig 1: Specific heat C vs magnetic field H showing experiment (data points) and theory (lines). Asymmetry between the low field (2 T) and high field (12 T) specific heat jumps is caused by quantum fluctuations.

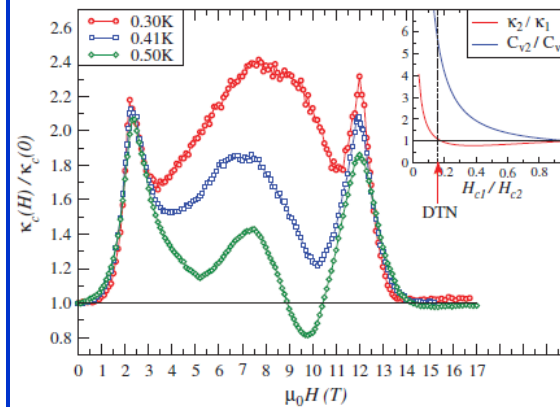


Fig 2: Normalized thermal conductivity K_c along c -axis vs magnetic field H showing phase transitions at 2 and 12 T. K_c shows symmetry between 2 and 12 T since the boson mass renormalization by quantum fluctuations is partially cancelled by renormalization of the boson-impurity scattering.