Field-induced Bose-Einstein Condensation in a Heisenberg Quantum S=1/2 Gapped Antiferromagnet

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Introduction

Quantum phase transition has been a long studied fundamental issue to understand the universality of quantum critical behavior in many-body systems [1]. The ground state of spin-1/2 Heisenberg gapped antiferromangets is a non-magnetic singlet state and there is a spin gap Δ to the first excited triplet state. Such a system has the potential to exhibit quantum critical phenomena as a function of applied magnetic field. For instance, in our previous study on such a material -- $(C_7H_{10}N)_2CuBr_4$ (DIMPY for short), a long range magnetic order (LRO) state due to the weak inter-ladder couplings, also known as a Bose-Einstein condensation (BEC) of magnons [2], is revealed at temperatures up to 340 mK and fields above a critical field $H_c \approx 3.0$ [3].

Another S=1/2 organic-metallic compound $C_9H_{18}N_2CuBr_4$ (DMA for short) has been discussed recently [4]. Based on the crystal structure, it is suggested to be a two-leg spin ladder with the ladder direction along the crystallographic **b** axis [4]. The susceptibility data are also well described as an antiferromagnetic Heisenberg two-leg ladder model with the exchange constants J_{rail}=-7.95 K and J_{rung}=-4.07 K [4].

Experimental

We performed the specific heat and magnetocaloric effect measurements on a deuterated single crystalline DMA sample at SCM1 with the temperature down to 0.1 K and the field up to 18 T.

Results and Discussion

Figure 1 shows the measured phase diagram as a function of field H and ordering temperature T_N. We estimate that the lower critical field H_{c1}, where the gap is closed, is about 2.2 T and the upper critical field H_{c2}, where the spin is fully polarized, is about 16.5 T. The data near H_{c1} and H_{c2} will be fitted to a power law and the obtained critical exponents will be compared to the universal value 2/3 for BEC.

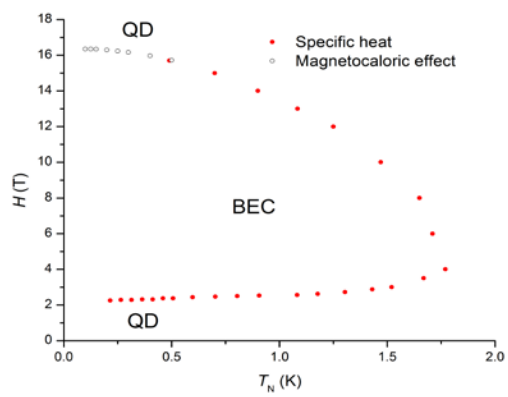

Figure 1: Measured *H-T* phase diagram as determined from calorimetric measurements.

Conclusions

We observed the intriguing field-induced LRO of DMA and have successfully mapped out the complete *H-T* phase diagram. The analysis is undergoing and we will write a paper about that.

Acknowledgements

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