High Field Magnetisation of the Frustrated Quantum Magnet HoB_4

W. Guo, S. D. Das, S. E.Sebastian (Cambridge), O. Petrenko, G. Balakrishnan (Warwick), N. Harrison (LANL)

Introduction

Frustrated magnets always attract much attention because of their complex magnetic phenomena under low temperature. Rare-earth compound HoB4 is one of them with Shastry-Sutherland lattice structure in ab-plane showing two antiferromagnetic transitions at temperature T1=7.1K and T2=5.7K whose ordered spin direction is aligned along c-axis[1]. Although many experiments (neutron scattering[2], X-ray diffraction[2], transport measurement[3]) and theoretical methods have been used to investigate the details of this frustrated structure, the nature of these magnetic transition remains unknown.

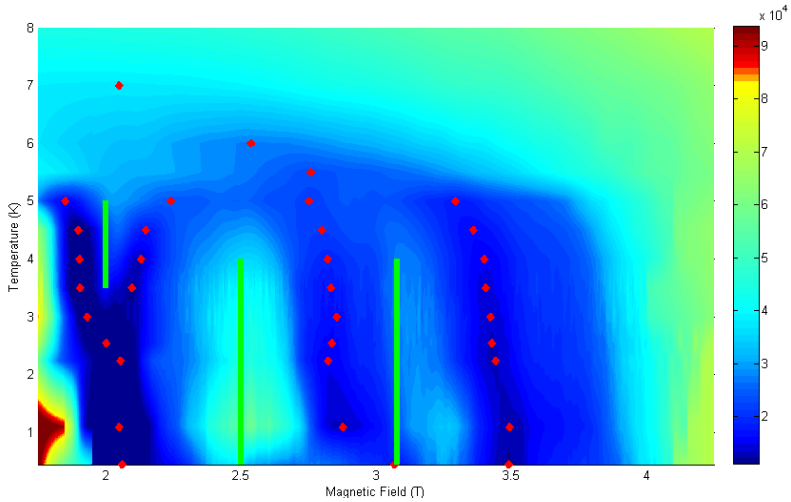
This experiment is designed to study the rich magnetic properties of single crystal HoB4 in low temperature and high magnetic field.

Experimental

High field was measured using an extraction magnetometer on a single crystal HoB4 magnetisation with applied magnetic field $\mu_0 H \parallel c$. Measurements were made at multiple temperatures ranging from 8K to 0.45K. At each temperature, a magnetic field pulse up to 30T was applied in order to reach magnetic fields at which the magnetization saturates.

Results and Discussion

A magnetic phase diagram has been constructed from the magnetic susceptibility extracted from the measured magnetization as a function of applied magnetic field. The figure shows a colour scale that indicates the inverse magnetic susceptibility (dH/dM). Plateaux in the magnetization are revealed by light regions of the contour plot (indicated by green lines). Phase transitions between the magnetic plateau are denoted by red dots, extracted from peaks in the magnetic susceptibility (dM/dH). Three plateaus (at fractional values 0.15, 0.3, and 0.45 of the saturated magnetisation) were found between the four phase transitions in the temperature range of 5K to 2K.



The sequence of magnetization plateaux observed is similar to that expected for the Shastry-Sutherland model, for example realized in the magnetically frustrated magnet $SrCu_2(BO_3)_2$. An interesting question pertains to whether the broad regions of magnetization between the plateaux may be characterized by spin liquid behavior [4]. A further question relates to the difference in the hierarchy of phases between magnetization measurements performed with increasing magnetic field decreasing magnetic field.

Conclusions

The magnetisation of single crystal HoB_4 was measured between 8K and 0.45K and a phase diagram constructed as a function of magnetic field and temperature (shown in the figure). Theoretical investigations are underway to discern the magnetic structure corresponding to the magnetisation plateaux, and the nature of the intervening regions of magnetisation.

References

[1] Z.Fisk., *et al.*, Solid.State.Commu., **39**, 1189 (1981).
[2] D.Okuyama., *et al.*, J.Phys.Soc.Jpn., **77**, 044709 (2008).
[3] J.Y.Kim., *et al.*, J.Appl.Phys., **105**, 07E116 (2009).
[4] M.S.Kim., *et al.,* Phys.Rev.Lett., **110**, 017201 (2013).