Controlled introduction of disorder in coordination polymer quantum magnets, Experiment E001-PF Investigating bond disorder in a Haldane gapped molecular spin chain

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Introduction

The coordination polymer $NiI_2(3,5\text{-lut})_4$ has been shown to be an ideal Haldane chain material [1], with minimal single-ion anisotropy placing it at the heart of the Haldane phase [2]. This compound is uniquely well suited to exploring the effects of both site and bond disorder in the Haldane phase, via substitution of the magnetic sites and the halide ions which mediate the intrachain magnetic interactions. Controlled introduction of disorder is a proven pathway to exciting new physics [3], and bond disorder has not been experimentally studied in Haldane chains, to date. Pulsed-field (PF) measurements enable the study of the closure of the Haldane gap, and also magnetic saturation in these systems.

Experimental

Powder samples were synthesized of Haldane chain compounds with various dopant concentrations of Zn (site disorder), Br and F (bond disorder). Compensated-coil magnetometry, using short pulsed magnets in magnetic fields up to 65 T, at helium-3 temperatures were performed at the PF facility at LANL. Complementary SQUID magnetometer measurements were performed in Warwick, in order to scale the PF data to absolute units and measure temperature-dependent susceptibility. The dopant concentrations in the samples have been quantified using wavelength dispersive x-ray fluorescence (XRF) measurements, also at Warwick.

Results and Discussion

Magnetization data for samples across the Br/I series are shown in Fig. 1(a), and are seen to lie between the two parent compounds in the (*M,H*) plane. The Br parent compound $NiBr_2(3,5\text{-lut})_4$ is believed to possess easy-plane single ion anisotropy (unlike the I Haldane chain), and an AFM intra-chain interaction which is weaker than that of the I Haldane chain. The magnetization data show a reduction in the saturation field as more Br is introduced, where the behavior monotonically scales with the Br dopant concentration determined using XRF. Complementary susceptibility data are shown in Fig. 1(b). While the F dopant series was not successful, the introduction of non-magnetic Zn ions was seen to increase the proportion of spin-half end-chain degrees of freedom, as has been studied in similar Haldane systems [4].

Conclusions

We have successfully demonstrated a novel route to achieving bond disorder in a Haldane chain, using the series $Ni(I/Br)_2(3,5\text{-lut})_4$. Together with complementary techniques, PF magnetization forms a seminal part of this experimental study. We shall now determine whether further experiments are required in order to fully characterize this series.

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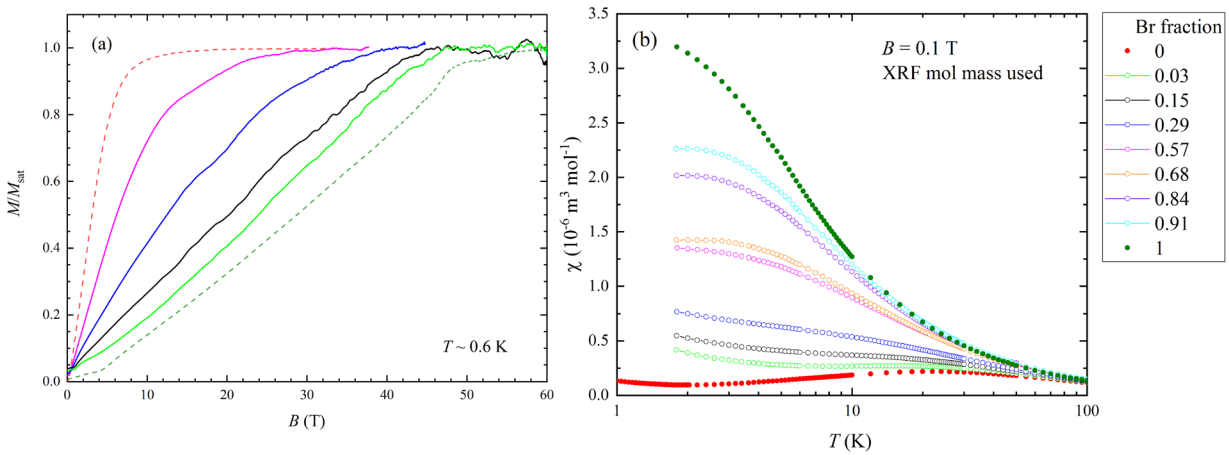

Fig.1 (a) Representative low-temperature pulsed-field magnetization, and (b) susceptibility data for a selection of Br doped compounds, with the data of the two parent compounds included for comparison. The Br fractions quoted in the legend are determined using XRF measurements.