Pulsed Field Magnetization of $NiCr_2O_4$

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Introduction

The magnetoelectric effect is of interest in condensed matter physics for both fundamental science and its potential application in devices.[1] One avenue for discovering new magnetoelectrics is to explore compounds with complex electronic states such as frustrated systems or those near phase boundaries and quantum critical points.[2] Spinel $NiCr_2O_4$ is such a system that exhibits magnetodielectric behavior, as previously shown by Mufti and co-workers.[3] We recently explored $NiCr_2O_4$ and found concurrent magnetic and structural transitions that indicate a strong coupling between the crystal structure and spin ordering.[4] Here we report a detailed study of the magnetodielectric coupling in $NiCr_2O_4$ using magnetometry, heat capacity, neutron, capacitance, and pulsed field measurements, which is in press at PRB.[5]

Results and Discussion

Powder samples of $NiCr_2O_4$ were prepared by solid-state reaction. The hysteresis of the dielectric response mimics that of the magnetization. Additionally, consistent with the Ginzberg-Laundau theory for second-order phase transitions, the dielectric constant increases linearly with respect to the magnetization squared up to H = 4 T, at which point it flattens off. Magnetization isotherms, $M(H)$, were measured in short-pulsed fields up to 65 T and down to 2 K. These are consistent with the laboratory magnetometry data and show that the magnetization increases linearly all the way out to H = 65 T.

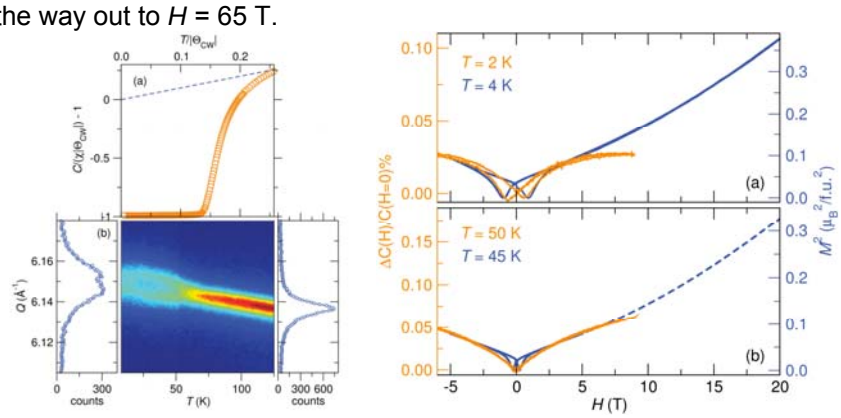

Fig. (left) Magnetostructural transition in $NiCr_2O_4$ as observed by synchrotron X-ray diffraction and magnetometry.[4] (right) Change in capacitance relative to zero field and $M^2(H)$ of powder $NiCr_2O_4$ at different temperatures.[5]

Conclusions

$NiCr_2O_4$ is an interesting magnetodielectric material that exhibits hysteresis and a maximum response of $\Delta\varepsilon(H)/\varepsilon(0)$ = 0.06%. We illustrate the general sensitivity of magnetocapacitance measurements to magnetostructural changes by revealing a previously unknown anomaly at 20K that corresponds to the completion of magnetic and structural ordering. The high-field experiments show that the Heisenberg spins continue to respond all the way out to H = 65 T. This work is in press at PRB.[5]

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