Experimental Report

05/03/2014

Proposal: **4-01-1114** **Council:** 10/2011

Title: Investigation of the dispersive character of the Fincher-Burke modes in antiferromagnetic Chromium

This proposal is a new proposal

Researh Area: Physics

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Samples: Cr

Instrument	Req. Days	All. Days	From	To
IN12	8	7	29/11/2012	06/12/2012

Abstract:

The nature of the low-energy excitation spectrum of antiferromagnetic chromium is still not understood. In particular, the dispersive character of the so-called Fincher-Burke modes, which only occur in the transversely polarized spin wave state is unclear, with recent investigations finding asymmetries in the magnetic scattering cross section that would indicate a collection of local modes, rather than a dispersive excitation. We propose a high-resolution inelastic neutron scattering study of the low-energy excitations in order to prove or disprove the dispersive character of the FB modes.

EXPERIMENTAL REPORT

Experiment Title

Investigation of the dispersive character of the Fincher-Burke modes in antiferromagnetic Chromium

Proposal number	4-01-1114
Instrument	IN12
Date of Experiment	Nov 29-Dec 6, 2012
Local Contact	Wolfgang Schmidt

Experimental Team

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Incommensurate magnetic or charge order is the direct cause of many interesting effects in condensed matter physics. In order to better understand the rich variety of such effects occurring in complex materials, like high-T_c superconductors, the model systems should be completely understood. For spin density wave systems the most prominent model system is chromium, but although it is a single-element material with a simple bcc structure it exhibits very complicated magnetism. In particular, the low-energy excitation spectrum is not understood.

Cr as the prototypical spin density wave (SDW) system has been the focus of many experimental and theoretical investigations over the years. At the Néel temperature, $T_N = 311$ K, paramagnetic Cr undergoes a transition to a transversely polarized spin density wave (TSDW) phase characterized by the incommensurate wave vectors $\mathbf{Q}^{\pm} = (0, 0, 1 \pm \delta)$ with $\delta \cong 0.046$. At the spin-flip temperature, $T_{SF} = 121$ K, a second transition to a longitudinally polarized spin wave (LSDW) phase occurs.

The excitation spectrum shows a surprisingly rich behavior. High-velocity excitations, commonly identified as spin waves, emerge from the incommensurate positions $\mathbf{Q}^{\pm}$ in both the TSDW and LSDW phase. In addition, only in the TSDW phase another excitation, the so-called Fincher-Burke mode, is found at low energies ($E < 8$ meV). It was found first by Fincher et al. and Burke et al. and investigated more closely by Sternlieb et al. The nature of these modes is still not understood, especially since Hiraka et al. found that only one branch of the “lower” FB mode is dispersive, by performing constant-**Q** scans instead of constant-energy scans.

The aim of this experiment was to explore further the dispersive character of the Fincher-Burke modes, by reproducing scans from previous experiments and doing new types of scans along the assumed dispersion, with an instrument with high flux and also very good energy resolution.

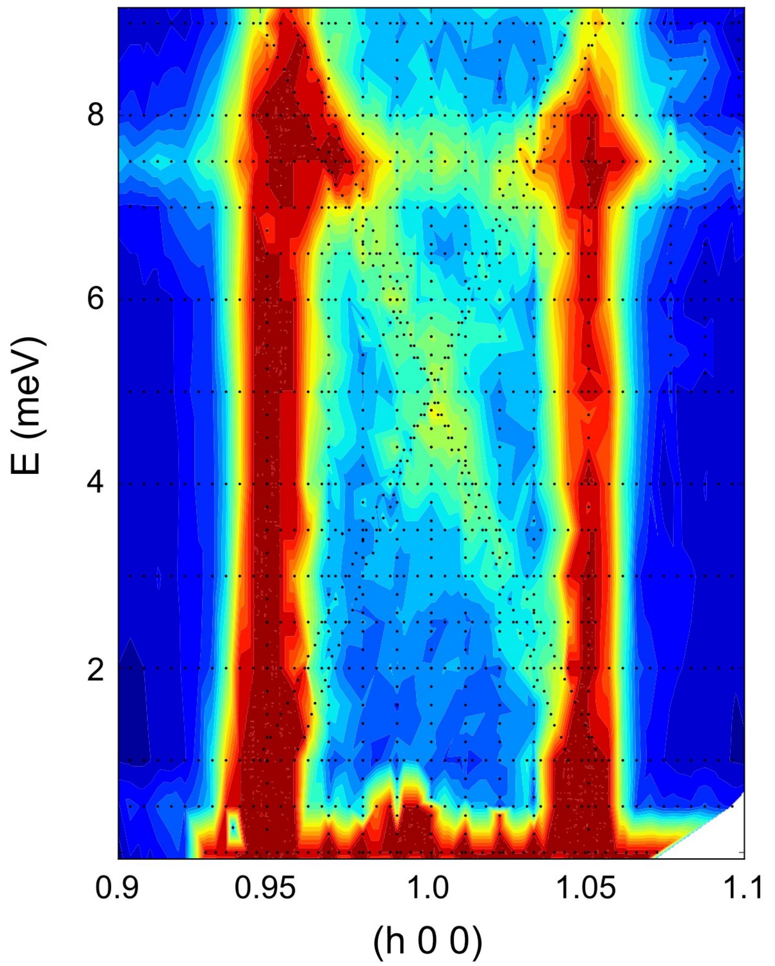

Fig. 1:
Excitations in Cr measured at IN12 longitudinally around the (100) point, at $T = 140$ K. Total exposure time for this mapping was about 3 days. Note the spurious intensity at low energies around the (1 0 0) point, which indicates second-order neutrons scattering at (2 0 0). The band of intensity at 7.5 meV is probably also spurious, but not explained yet.

Our sample was a very good and large single crystal of Chromium, brought into a single-**Q** state by cooling through T_N in a field of 20 T, applied in a (100) direction parallel to the desired magnetic **Q** domain direction at the Laboratoire National des Champs Magnétiques Intenses on the CNRS campus in Grenoble.

We performed mostly constant-E scans and some “diagonal” scans at a final wavevector of $k_f = 1.35$ Å^{-1} and a temperature of 140 K, the results of which can be seen in Figure 1. Similar mappings (but with less scans) were performed at 110 K (below the spin-flop transition, where the FB-modes are not visible) and 220 K, and around the (010) point.

The instrument performed admirably in this experiment with very few outages.