Experimental report

18/11/2016

Proposal: **TEST-2621** **Council:** 4/2016

Title: Tests of D4's new cryofurnace on aweakly-scattering and highly absorbing magnetic sample (Sm-containing)

Research area:

This proposal is a new proposal

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Experimental team: Tapan CHATTERJI

Local contacts: Henry FISCHER

Samples: $SmCrO_3$
$SmSrCrO_3$

Instrument	Requested days	Allocated days	From	To
D4	2	2	26/08/2016	28/08/2016

Abstract:

Evolution of magnetic structure in highly neutron absorbing $SmCrO_3$ polycrystallites

Introduction

Being a member of the functional material family of rare earth orthochromites, $SmCrO_3$ is a newly emerging compound due to novel magnetic and dielectric anomalies, an abrupt spin reorientation phase transition (SRPT), and multiferroic properties [1], making it a potential candidate for ultrafast spin switching to modify recording media, thermomagnetic power generation and magnetic refrigeration [2,4]. $SmCrO_3$ is reported to be ordered in the Γ_4 (G_x, A_y, $F_{z,}$; F_z^R) configuration below T_N at 191K and exhibits the abrupt spin reorientation transition at 34K [1]. Based on acoustic velocity measurements, Gorodetsky *et al.*,[5] reported that below SRPT the magnetic structure of $SmCrO_3$ changes from Γ_4 to Γ_2 continuously, marking a second order transition. In our earlier studies [6] using dc magnetization measurement as a probe, we observed that in the vicinity of SRPT the warming and cooling M(T) curves do not coincide and this thermal hysteresis extends up to T_N with a very broad temperature width ($\Delta T \sim 163K$ at H=0.01T) as shown in Fig. 1. In addition, we have also confirmed the phase coexistence and magnetic glass like freezing across SRPT which further suggests that in differing to the earlier report, spin reorientation in $SmCrO_3$ should be a first order Morin type reorientation transition in which moments flip from high temperature Γ_4 to low temperature Γ_1 state discontinuously. Unfortunately the inconsistency between various earlier reports and our observed results cannot be resolved as there is no available report in literature describing the magnetic structure of $SmCrO_3$. Due to high absorption of natural Sm atom, the neutron diffraction of $SmCrO_3$ was not measured till now. Stimulated by some recent reports in which the neutron diffraction measurements of some samarium

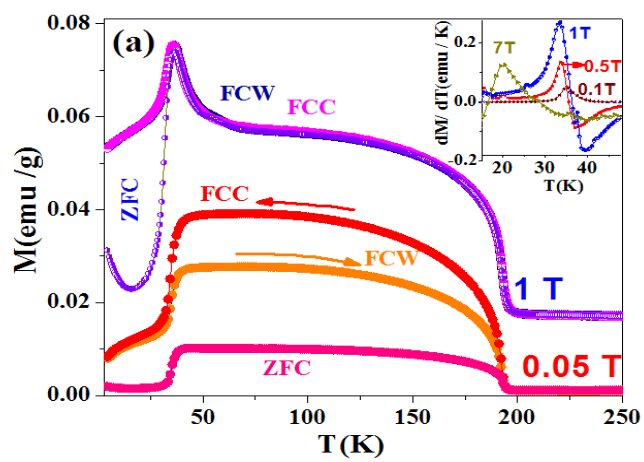

Fig. 1 The M(T) curves following Zero field cooled (ZFC), Field cooled warming (FCW) and Field cooled cooling (FCC) protocol at 0.05T and 1T applied magnetic field.

containing compounds are performed using short wavelength neutron beams, we planned to perform an experiment at the disordered materials diffractometer D4 in ILL using short wavelength λ= 0.5Å.

Experiment

We used hot neutrons with λ= 0.5Å reflecting from Cu (220) monochromator at D4. After calibration of the neutron wavelength using a nickel powder sample, the neutron diffraction intensity was normalized using a standard vanadium sample and corrected for background attenuation, multiple-scattering, and inelasticity (Placzek) effects. We measured the spectra at various temperatures ranging from 2-300K in warming mode without applying magnetic field.

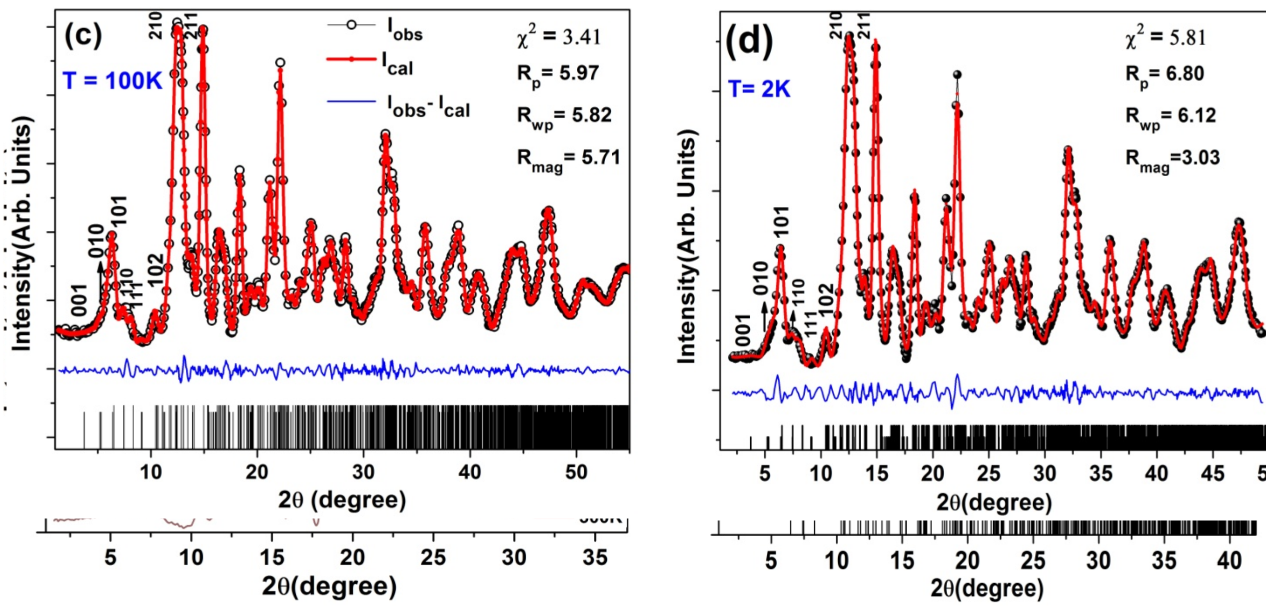

Fig. 2(a): Thermal evolution of neutron diffraction pattern **(b)**,**(c)** and (**d**) shows the structural and magnetic refinements of neutron diffraction patterns at 2K, 100K and 300K.

Fig. 2(a) shows the thermal evolution of neutron diffraction pattern of $SmCrO_3$ at temperatures ranging from 2-300K. A clear magnetic peak is observed at lower angles below T_N = 190K. The lower angle part of neutron diffraction data along with the Rietveld refined patterns is shown in Fig. 2(b)-2(d). Below T_N, a peak of magnetic origin appears at (010) and (101) Bragg positions. We observe an enhancement in (210) peak due to additional magnetic contribution below T_{SRPT} at 34K. The calculated pattern is generated with distorted orthorhombic structure (Pbnm space group) and **k** = (0,0,0) propagation vector. The representation analysis using program *BasIrpes* leads to four allowed spin configurations for Cr atoms at 4b Wyckoff positions and 8 possible spin configurations for Sm at 4c Wyckoff positions. For the simultaneous ordering of both Cr and Sm atoms only four irreducible representations Γ_2, Γ_4, Γ_6 and Γ_8 are possible. Using the Fullproof for Rietveld refinement of the crystal and magnetic structure we found that Γ_8 representation provides unambiguously agreeable matching with experimental and calculated patterns for 40K $<T<T_N$. The total moment value obtained is also comparable with the magnetic moment measured from bulk dc magnetization. Across the T_{SRPT} (10K<T<40K) the ambiguity for two IR's Γ_4 and Γ_8 is noticed which may arise due to the coexistence of two phases and magnetic glass like freezing. The neutron diffraction pattern at 2K is observed to match with Γ_6 representation which indicates a clear change in magnetic structure in between 2-5K due to ordering of Sm atoms.

References:

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