Experimental report

20/02/2019

Proposal: 5-32-859 **Council:** 4/2018

Title: Spin correlations on an Ising-likechain compound Sr4Mn2CoO9

Research area: Physics

This proposal is a new proposal

Main proposer: Vincent CAIGNAERT

Experimental team: Lucile MANGIN-THRO
Charles SIMON
Vincent CAIGNAERT
Nahed SAKLY

Local contacts: Lucile MANGIN-THRO

Samples: Sr2Ca2Mn2CoO9
Sr4Mn2Co09

Instrument	Requested days	Allocated days	From	To
D7	7	4	13/09/2018	17/09/2018

Abstract:

The aim of this proposal is the caracterization of the spin correlations by polarized-neutron diffraction in Ising-like chain compound Sr(4-x)Ca(x)Mn2CoO9 for x=0 and x=2. The magnetic measurements and powder neutron diffraction performed on these compounds show a slow spin dynamics for both compounds and a long range ordering for the x=2 sample. The goal of this study is to track the evolution of the magnetic response as a function of the separation between the magnetic chains due to the substitution of Sr by Ca.

Experimental Report

Proposal: 5-32-859

Title: Spin correlations on an Ising-like chain compound $Sr_4Mn_2CoO_9$.

Main proposer: CAIGNAERT Vincent

Local Contact: MANGIN-THRO Lucile

Instrument: D7 Req. Days: 4 All. Days: From 13/09/2018 to 17/09/2018

Experimental Team:

SIMON Charles
DAMAY Françoise
RAVEAU Bernard
PEREZ Olivier
HARDY Vincent
SAKLY Nahed

Abstract:

The aim of this proposal was the characterization of the spin correlations by polarized-neutron diffraction in Ising-like chain compound $Sr_{4-x}Ca_xMn_2CoO_9$ for x=0 and x=2. The magnetic measurements and powder neutron diffraction performed on these compounds show a slow spin dynamics for both compounds and a long range ordering for the x=2 sample. The goal of this study is to track the evolution of the magnetic response as a function of the separation between the magnetic chains due to the substitution of Sr by Ca.

Report:

Oxides of general formula $A_3MM'O_6$ (M and M' are transition metal ions) have attracted considerable interest in the last two decades, because their peculiar crystal structure leads to unconventional magnetic properties. This crystal structure of this family of compounds, such as $Ca_3Co_2O_6$, Ca_3CoMO_6 (M=Mn, Rh, Ir) and Sr_3NiIrO_6 consists of chains of alternating face-sharing octahedra (MO_6) and trigonal prisms ($M'O_6$) linked by their faces and arranged in a hexagonal motif. The magnetic structure of these compounds was initially described with a partially disordered antiferromagnetic (PDA) configuration with only two thirds of the chains

that order with an antiferromagnetic interchain coupling [1]. However, several recent studies report that the magnetic structure of $Ca_3Co_2O_6$ takes the form of a long-wavelength spin density wave (SDW) propagating along the chains which undergoes an ultraslow magnetic relaxation in a commensurate antiferromagnetic phase [2]. This transition occurs over a time scale of several hours and is never complete. This behavior is probably linked to the slow spin dynamic revealed previously by magnetic measurements [3]. Recently the spin correlations in $Ca_3Co_2O_6$ have been characterized by polarized-neutron diffraction and Monte-Carlo study on the D7 diffractometer [4]. This study shows that intrachain and interchain correlations can be studied by the analysis of the magnetic diffuse scattering data.

The compounds $A_4M_2M'O_9$ with one prismatic polyhedral alternating with two octahedra have received little attention for their magnetic properties. We have investigated in detail by DC magnetization, AC susceptibility and specific heat measurement for the spin chain oxides of formulation $Sr_{4-x}Ca_xMn_2CoO_9$ [5-7]. Our study of the slow spin relaxation in these compounds let us to suggest a new description of the magnetic response involving behaviors like Single-Ion Magnet (SIM) and Single-Chain Magnet (SCM) that are usually restricted to molecular compounds. For $x<1$ there are the coexistence of SIM and SCM behavior. For $x>1.5$ a long range ordering (LRO) with a SIM behavior, at lower temperature, is observed. Our recent neutron powder diffraction on G4.1 (LLB, Saclay) study confirms that long-range order is present for $x=2$ while no magnetic order is detected for $x=0$.

We have measured the temperature dependent magnetic scattering intensities of powder sample of $Sr_4Mn_2CoO_9$ ($x=0$) on the D7 diffractometer at ILL. The data were collected at four temperatures (1.6K, 12K, 40K and 80K) with a neutron wavelength set to 3.14 Å. The magnetic, nuclear and incoherent signals were extracted by tri-axial polarization analysis.

The total magnetic contribution obtained is weak for the four temperatures (1.6K, 12K, 40K and 80K) but the difference between data at 1.6K and 80K seems significant (Fig.1).

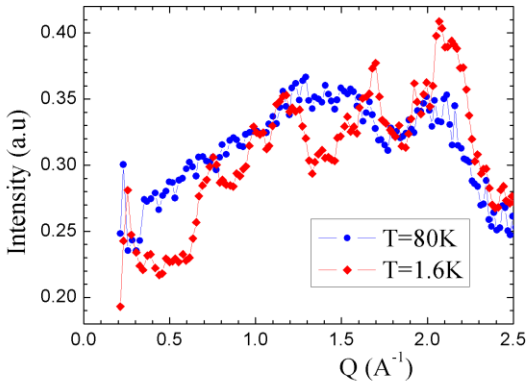

Fig.1: Magnetic scattering data for $Sr_4Mn_2CoO_6$ at 1.6 K (red diamond) and 80 K (blue circle).

The data were then treated by reverse Monte Carlo refinement (RMC) using the SPINVERT code [8] to fit a large configuration of spins to experimental powder magnetic neutron diffraction data at 1.6K, 12K, 40K and 80K. We show the results of these refinements on figure 2.

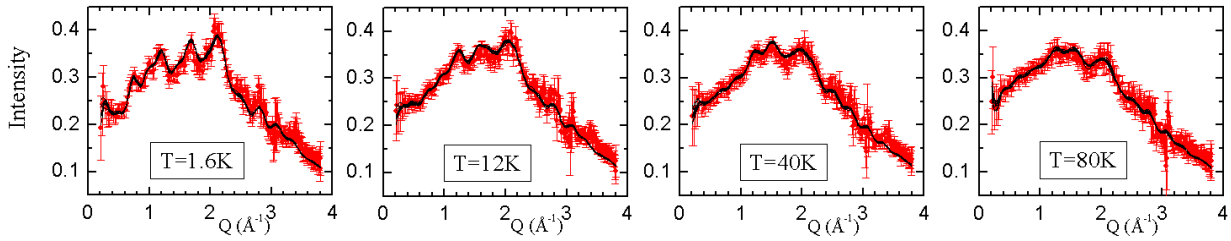

Fig.2: RMC refinement of magnetic scattering data at 4 temperatures for $Sr_4Mn_2CoO_9$.

At this stage of the analysis of the spin correlations in the $Sr_4Mn_2CoO_9$ compound:

- We are able to confirm that this compound is an ISING spin chain compound.
- The spin correlations are mainly AF and along the $\vec{c}$ axis from 1.6K to 80K (Fig.3).
- At 1.6 K and 12K we observed small inter-chain correlations (AF or F depending of the cationic distances, Fig.3).
- At 80 K, the inter-chain correlations disappear (Fig.3) while spin correlations along $\vec{c}$ persist.

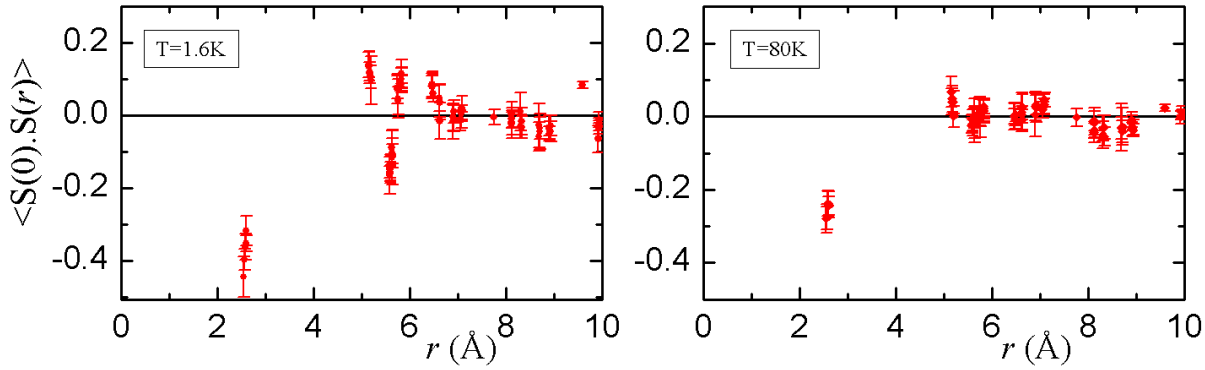

Fig.3: Radial spin correlation on $Sr_4Mn_2CoO_9$ at 1.6K and 80K.

References:

[1] Kageyama & al, J. Phys. Soc. Jpn. 67, 357 (1998).

[2] Agrestini S. & al, Phys. Rev. Lett. 106, 197204 (2011).

[3] Hardy V. & al, Phys. Rev. B 70, 064424 (2004).

[4] Paddison J. & al, Phys. Rev. B 90, 014411 (2014).

[5] Seikh M. & al, Phys. Rev. B 95, 174417 (2017).

[6] Seikh M. & al, J. Mater. Chem. C 6, 3363 (2018).

[7] Hardy V. & al, Phys. Rev. B 98, 144414 (2018).

[8] Paddison J. & al, J. Phys. Condens. Matter. 25, 454220 (2013).

Work fully performed at ILL
Proposal-number: 5-32-859
Instrument: D7