# Experimental report

01/10/2019

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| **Proposal:** | **5-53-275** |
| **Council:** | 4/2017 |
| **Title:** | Investigating the nature of short range spin correlations in the phase separated quasi-one-dimensional magnet gamma-CoV2O6 |
| **Research area:** | Physics |

**This proposal is a new proposal**


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**Samples:** CoV2O6

| Instrument | Requested days | Allocated days | From | To |
|---|---|---|---|---|
| D7 | 4 | 5 | 30/05/2018 | 04/06/2018 |


## Abstract:

We propose to use polarised neutrons to study the nature of short range correlations in the phase separated quasi-one-dimensional magnet gamma-CoV2O6. From this investigation, we aim to (1) quantitatively understand the complex spin exchange network, and (2) find out the origin of the unconventional magnetic phase separation in this system.

**Experimental report 5-53-275**

### Investigating the nature of short range spin correlations in the phase separated quasi 1-D magnet γ-$CoV_2O_6$

The aim of this D7 experiment was to perform diffuse scattering measurements on a powder sample of the quasi 1-D magnet γ-$CoV_2O_6$ and explore links between the short range correlations and the proposed magnetic phase separation at low temperatures [1].

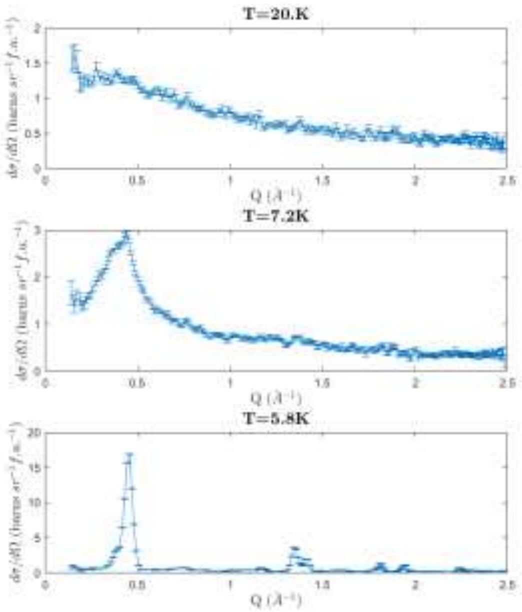


**Figure 1:** Neutron diffraction patterns collected on D7.

During the experiment we measured at six different temperatures, shown in Figure 1, over a momentum transfer range from 0.14 and 2.48 $Å^{-1}$, where we expected to see the strongest diffuse scattering profile [1]. This was backed up by the data above at temperatures above 7 K, where we can see the evolution of the broad bump of diffuse scattering more clearly here than in the powder diffraction work reported in Ref. [1].

To analyse these data, we have used the inverse Monte Carlo refinement program Spinvert [2]. With this, we have calculated the spin correlation function for the three highest temperatures that we measured 7.2 K, 10 K and 20 K (**Fig. 2**). We also tried Spinvert on the 1.6 K, 5.8 K and 6.8 K, but we have not yet been able to mask out the Bragg peaks sufficiently well to avoid perturbing the operation of Spinvert.

Once we fitted the data at the highest temperatures, we obtained spin-correlation data. This can be used to look at the spin-correlation length, which provides information on the domain sizes, by fitting $\exp(-r/\xi)$ [3]. We have also explored other models for the *r* dependence of the spin-correlation length, but the results shown here are for the simple exponential. The temperature dependence of the spin-correlation length (**Fig. 3**) shows how the correlation length decreases with increasing temperature.

We can also identify particular exchange paths, from the spacing between the relevant Co ions, and see at what temperatures these exchange paths become active, and if they are ferromagnetic or antiferromagnetic in character. The correlations along the *b* axis are ferromagnetic at all temperatures shown in Figure 2. In contrast, a particular skew exchange path linking the two types of Co ion along the *a* axis has antiferromagnetic character at 7.2 K; this path is not correlated at 20 K, and only weakly correlated at 10 K.

It is known (Ref. [1] and references therein) that γ-$CoV_2O_6$ develops two magnetic phases, with the modulation vectors $k_1$ = (1/2, 0, 0) and $k_2$ = (1/4, 0, -1/4). The Néel temperature for the $k_1$ modulation is accepted to be $T_{N1}$ = 6.6 K. We have recent (unpublished) µSR data that indicates that the modulation actually orders at $T_{N2}$ = 7.5 K.

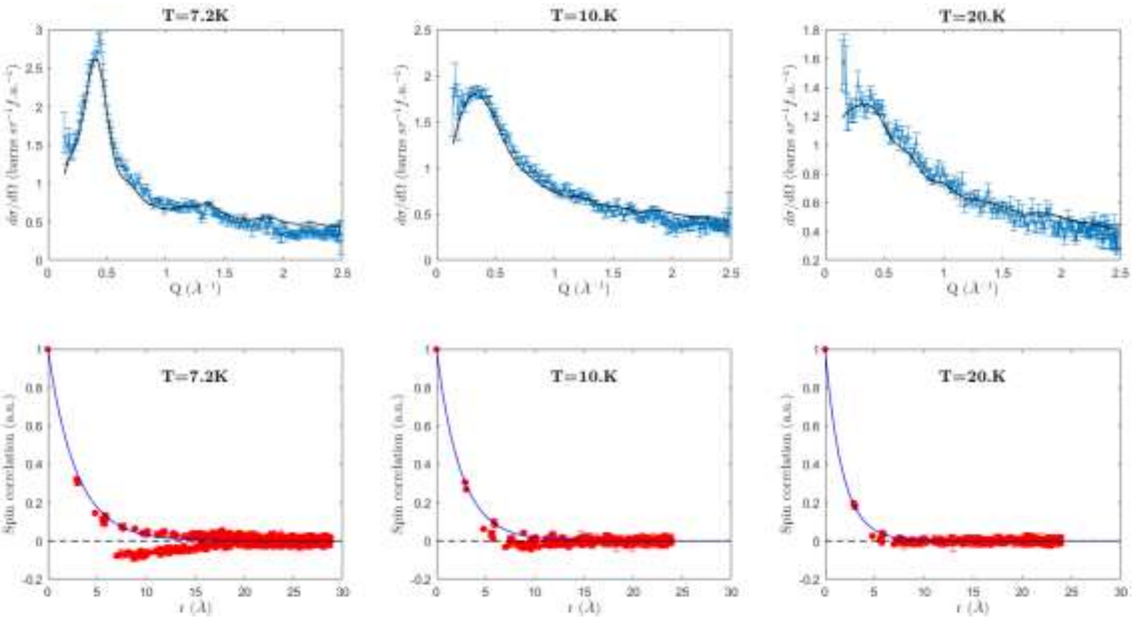


**Figure 2:** (upper panels) Neutron diffraction patterns collected at on D7. The diffuse scattering profiles were fitted using Spinvert [2]. (lower panels) Spin correlation functions calculated by Spinvert (positive values indicating FM correlations and negative AFM correlations). The fit lines are for an exponential model of the spin correlation length as used in Ref. [3]. The points on the line at 10 K correspond to correlations along the *b*-axis.

Given this information, and the results we have obtained so far, these data appear to support the µSR results. However, we do not have enough temperatures to be able to make a clear link. We are also still working on extracting exchange parameters from Spinvert.

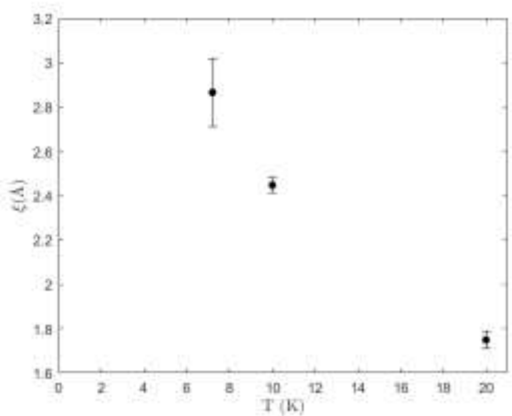


**Figure 3:** Spin correlation length obtained from the fittings in **Fig. 2.**

**References:**

[1] L. Shen *et al. Phys. Rev. B* 96, 054420 (2017).
[2] J. A. M Paddison *et al. J. Phys.: Condens Matter* 25, 454220 (2013).
[3] J. A. M Paddison *et al. Phys. Rev. B* 97, 014429 (2018).