Experimental report

26/02/2021

Proposal:	**4-05-774**	**Council:**	10/2019
Title:	Spin excitation spectra in the kagome candidate material Y3Cu9(OH)18OCl8		
Research area:	Physics		

This proposal is a new proposal

Main proposer: **Jannis WILLWATER**

Experimental team: Jannis WILLWATER
Edwin KERMARREC

Local contacts: Jacques OLLIVIER

Samples: Y3Cu9(OH)18OCl8

Instrument	Requested days	Allocated days	From	To
IN5	6	5	23/09/2020	28/09/2020

Abstract:

Recently, unusual low-temperature properties have been found in the frustrated magnet Y3Cu9(OH)18OCl8. It is argued, that the copper ions in this system build a kagome lattice with an antiferromagnetic in-plane coupling. The magnetic properties have been investigated with bulk thermodynamics, muon spin relaxation and neutron diffraction experiments. Based on these studies, there is no sign of any long-range magnetic ordering down to 20 mK. Therefore, the material might be in a quantum spin liquid state at low temperatures similar to Herbertsmithite, which we would like to further explore by inelastic neutron scattering.

Experimental report: Spin excitation spectra in the kagome candidate material $Y_3Cu_9(OH)_{18}OCl_8$

Summary

In quantum magnetism, the search for the quantum spin liquid state has generated significant efforts, largely triggered by the discovery of the emblematic Heisenberg kagome antiferromagnet candidate Herbertsmithite [1]. In this context, en route towards the "perfect" quantum kagome antiferromagnet, only a few candidates have emerged throughout recent years. Our approach is to investigate a new kagome candidate, whose structure forbids any interlayer defects. Recently, unusual low-temperature properties have been found in the frustrated kagome antiferromagnet $Y_3Cu_9(OH)_{18}OCl_8$ [2,3]. Its magnetic properties have been investigated with bulk thermodynamics, muon spin relaxation and neutron diffraction experiments. Based on these previous studies, it was concluded that there is no long-range magnetic ordering down to 20 mK. Therefore, it was argued the material might be in a quantum spin liquid state at low temperatures similar to Herbertsmithite. Correspodingly, we have carried out inelastic neutron scattering experiments to further explore the predicted spin liquid state. However, instead and to our surprise we have found signatures of long range magnetic order in our experiments.

Experimental procedure and results

A single-crystal array of deuterated $Y_3Cu_9(OD)_{18}OCl_8$ with a total mass of approximately 0.3 g has been assembled on an aluminium plate and was used for the experiment. After the thermalization and alignment of the sample, we measured the excitation spectra at 1.5 K with a wavelength of 2.6 Å and at temperatures of 1.55, 5 and 60 K with a wavelength of 4.8 Å.

Surprisingly, in the measurement at 1.55 K clear magnetic intensity at (2/3, 2/3, L) [and also at (4/3, 4/3, L)] was detected, which does indicate long-range magnetic order. This observation is supported by additional muon spin relaxation measurements on single crystalline $Y_3Cu_9(OH)_{19}Cl_8$, which exhibit a fast decay of the muon spin polarization below 2.2 K [4]. The difference to the measurements on polycrystalline/powder samples, where no long-range order was found [3], is due to slight differences in the structure between the powder and the single crystals, triggered by different procedures for sample preparation [5]. Since the intensity in our neutron scattering spectra is flat along the (0, 0, L) direction, it appears to be predominantly 2D magnetism within the kagome plane. The (1/3, 1/3, 0) symmetry suggest that $Y_3Cu_9(OH)_{19}Cl_8$ has a $\sqrt{3} \times \sqrt{3}$ magnetic structure at low temperatures. This is supported by recent theoretical work [6].To fully establish the magnetic structure it requires a magnetic Bragg peak mapping at low temperatures for single crystalline $Y_3Cu_9(OH)_{19}Cl_8$.

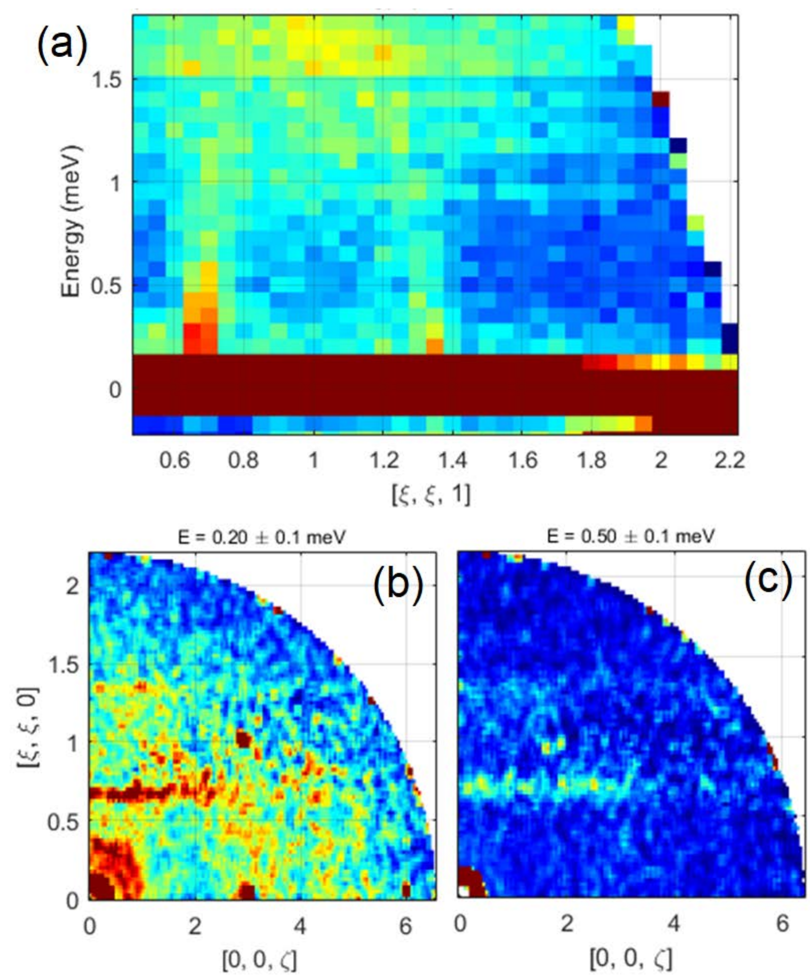

Fig. 1: Inelastic neutron data of $Y_3Cu_9(OD)_{19}Cl_8$ at T = 1.55 K (IN5, 4-05-774): $S(Q,E)$ maps showing: (a) Energy versus (*ξ*, *ξ*, 1) and (*ξ*, *ξ*, 0) vs (0, 0, L) for (b) E = 0.2±0.1 meV and (c) E = 0.5±0.1 meV.

Literature

[1] T.-H. Han et al., Nature 492, 406 (2012).

[2] P. Puphal et al., J. Mater. Chem. C 5, 2629 (2017).

[3] Q. Barthélemy et al., Phys. Rev. Mat. 3, 074401 (2019).

[4] F. Bert et al., private communication.

[5] P. Puphal et al., private communication.

[6] R. Valentí et al., private communication.