# Experimental report

01/10/2019

**Proposal:** **5-53-274** **Council:** 4/2017

**Title:** Quantum fluctuations on a hyperkagome lattice

**Research area:** Physics

**This proposal is a new proposal**


**Main proposer:** **Pascale Petronella DEEN**

**Experimental team:** Ingrid Marie Bergh BAKKE
Pascale Petronella DEEN
Richard EDBERG
Kim LEFMANN
Lise SANDBERG

**Local contacts:** Lucile MANGIN-THRO


**Samples:** Yb3Ga5O12

| Instrument | Requested days | Allocated days | From | To |
|---|---|---|---|---|
| D7 | 5 | 7 | 27/06/2018 | 04/07/2018 |


**Abstract:**

In this proposal we intend to study the rare earth garnet Yb3Ga5O12 (YbGG) which is isostructural to the canonical frustrated compound Gd3Ga5O12 (GGG). In YbGG the Yb3+ ions are positioned on two interpenetrating hyperkagome sublattices and provide an effective quantum spin S = 1/2. Magnetisation measurements determine antiferromagnetic exchange interactions with a Curie-Weiss temperature θCW = -118K and no indication of long rang order down to TN = 54 mK [3]. This makes YbGG one of the most frustrated compounds known to date with a frustration index of θCW / TN = 2000. In contrast, GGG has a frustration index of ~14. The aim of the study is to determine the magnetic correlations in the short ranged ordered phase of YbGG.

# Experimental Report: Quantum fluctuations on a hyperkagome lattice, proposal number 5-53-274

1. oktober 2019

Proposal number: 5-53-274
Title: Quantum fluctuations on a hyperkagome lattice
Instrument: D7
Experimental team: Lise Ørduk Sandberg, Richard Edberg, Ingrid Marie Berg Bakke, Kim Lefmann, Pascale P. Deen.
Local Contact: Lucile Mangin-Thro and Andrew Wildes
Dates: 27/6/2018-04/07/2018
Sample: 60 $mm^3$ $Yb_3Ga_5O_{12}$ (YbGG) single crystal with an estimated mass of 0.47 g.

## 1 Measurements

YbGG was aligned with the (-H H 0) and (L L 2L) axes in the scattering plane. Measurements were performed with neutrons of wavelength 3.1795 Å with a dilution fridge and XYZ PA was used with a 1:4 flipping ratio. Measurements were performed at temperatures of 50 mK, 200 mK and 800 mK.

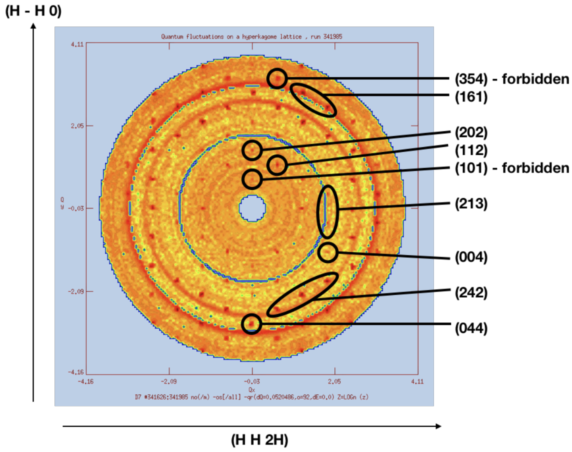
## 2 Results

Nuclear Bragg peaks are presented and indexed in figure 1. All predicted Bragg peaks are present, but two additional sets of Bragg peaks are observed ((354) and (101)). These additional peaks are caused by the freezing of oxygen atoms which vibrate between multiple positions at room temperature, but the atoms are forced into one position as thermal fluctuations are reduced.

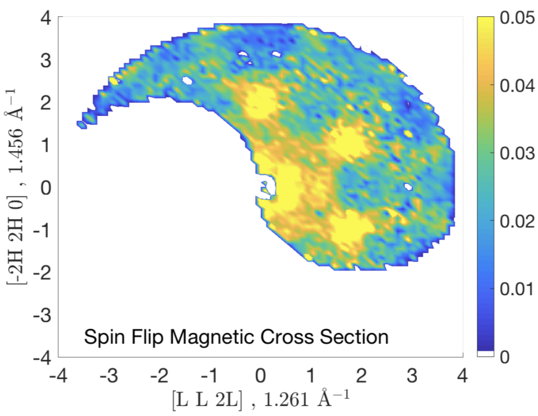
The spin flip channel (figure 2 left) shows distinct diffuse scattering whose symmetry follows the crystallographic symmetry. This shows the occurrence of a strongly correlated, non-ordered magnetic state.

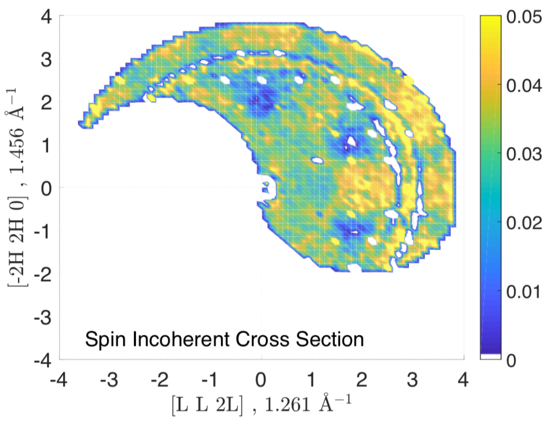
The spin incoherent channel should be flat, since quartz measurements show no great polarisation difference, see figure 3. However, the spin incoherent channel (figure 2 right) also shows hexagonal features which indicates a depolarisation of the neutron beam, possibly due to a net FM contribution from the sample which shows that the PA does not fully work.

Further data analysis indicates that the strongly correlated state observed in the spin flip channel is associated with the 10-spin loops of the system in a similar way to what was observed in the isostructural $Gd_3Ga_5O_12$ (GGG) despite significant differences in the magnetic nature of $Gd^{3+}$ which has spin 7/2 as opposed to the pseuodo spin S=1/2 of $Yb^{3+}$ and while $Gd^{3+}$ has no spin orbit coupling and a local planar anisotropy of the spins, $Yb^{3+}$ has strong spin orbit coupling and a local Ising anisotropy.

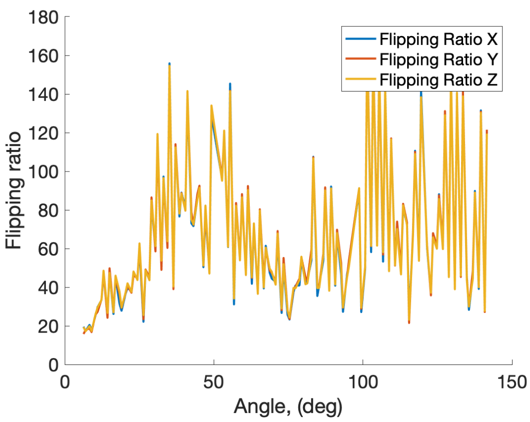



FIGUR 1: Indexed Bragg peaks of YbGG. All allowed Bragg peaks are present, and two additional sets of forbidden Bragg peaks are observed.




FIGUR 2: Spin flip scattering at 50 mK (left) shows distinct diffuse scattering in a hexagonal symmetry which follows the crystal symmetry. Spin incoherent scattering at 50 mK (right) shows similar features to the spin flip channel which is opposite in intensity (high intensity in the spin flip channel matches low intensity in the spin incoherent channel).




FIGUR 3: The quartz calibration shows no great polarisation effect.