Experimental report

20/02/2019

Proposal: 5-42-460 **Council:** 4/2017

Title: Wide Temperature Range Biskyrmion Magnetic Nanodomains in MnNiGa Study by Small Angle Neutron Scattering

Research area: Materials

This proposal is a new proposal

Main proposer: Xiyang LI

Experimental team: Robert CUBITT
Jonathan WHITE
Xiyang LI

Local contacts: Robert CUBITT

Samples: MnNiGa polycrystalline sample
MnNiGa single-crystalline

Instrument	Requested days	Allocated days	From	To
D11	0	2	13/03/2018	15/03/2018
D33	7	0		

Abstract:

Magnetic skyrmions are topological vortex-like spin objects that were recently discovered in bulk chiral magnetic materials. Last year we discovered super stable magnetic biskyrmions which is a new type of skyrmion formed by two bound skyrmions with oppositely magnetic helicities, in an extremely wide temperature range of 100 - 340 K in MnNiGa sample by in-situ real-space Lorentz transmission electron microscopy. Considering that the biskyrmion size is around 100 nm and its lattice ~ 400 nm, SANS is the ideal tool for studying its properties. Aiming for map the biskyrmions in reciprocal space and study the biskyrmion lattice kinetics as a function of magnetic field at different temperatures, we propose to perform SANS experiment in MnNiGa polycrystalline sample and also the new synthesized cylindrical-shaped single-crystalline MnNiGa sample at temperature range of 10 - 320 K. Study the magnetic biskyrmions lattice kinetics as a function of magnetic field at different temperatures is essential to understand the topological properties of biskyrmion.

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1 PRINCIPAL INVESTIGATOR *Name and institution of the Principal Investigator*
X. Y. Li Institute of Physics Chinese Academy of Sciences China

2 EXPERIMENT DETAILS	
Reference Number: 5-42-460 Title: Wide Temperature Range Biskyrmion Magnetic Nanodomains in MnNiGa Study by Small Angle Neutron Scattering Equipment/Facility Used: D11 Dates Scheduled: 13 Mar 2018 to 15 Mar 2018 Days: 2	
Date of Experimental Report:	20 Feb 2019

3 LIKELY OUTCOMES FROM EXPERIMENT *Please indicate what the experiment is likely to lead to by putting an 'x' next to one or more of the possible outcomes below.*	
Journal publication	Accepted by Advanced Materials
Data for thesis	PhD thesis expected by Jun 2019
Follow-up experiment at another facility	Zoom@ISIS
Other	
No outcome anticipated	
If you have indicated 'Other' or 'No outcome anticipated', please provide further details – e.g. what the outcome might be if you ticked 'other', or what the reasons are if no outcome is anticipated.	

4 EXPERIMENT REPORT

A biskyrmion consists of two bound, topologically stable skyrmion spin textures. These coffee-bean-shaped objects have been observed in real-space in thin plates using Lorentz transmission electron microscopy (LTEM). From LTEM imaging alone, it is not clear whether biskyrmions are surface-confined objects, or, analogously to skyrmions in non-centrosymmetric helimagnets, three-dimensional tube-like structures in bulk sample. Here, we investigate the biskyrmion form factor in single- and polycrystalline MnNiGa samples using small angle neutron scattering (SANS).

We first used SANS2d@ISIS measured MnNiGa polycrystalline sample, and showing two peaks steaming from biskyrmions lattice scattering in the 2D pattern. In the 1D reduced data also showing peaks from the biskyrmions self-scattering. The position of the structure factor peaks at $Q_x \sim 0.0015 – 0.0018$ Å^{-1} (a ≈ 350 - 420 nm) agrees well with the biskyrmions lattice parameter which we have measured by real-space Lorentz transmission electron microscopy (LTEM). SANS2d cannot provide a parallel magnetic field which need to be used for mapping the expected biskyrmion sixfold lattice in our new-synthesized MnNiGa single-crystalline sample. Then we used D11@ILL to measure it due to the accessible q-range and large experimental area provide a 3-dimentional magnet with the rocking scan mode.

We find that biskyrmions are not long-range ordered, not even in single-crystals. Surprisingly all of the disordered biskyrmions have their in-plane symmetry axis aligned along certain directions, governed by the magnetocrystalline anisotropy. This anisotropic nature of biskyrmions may be further exploited to encode information.

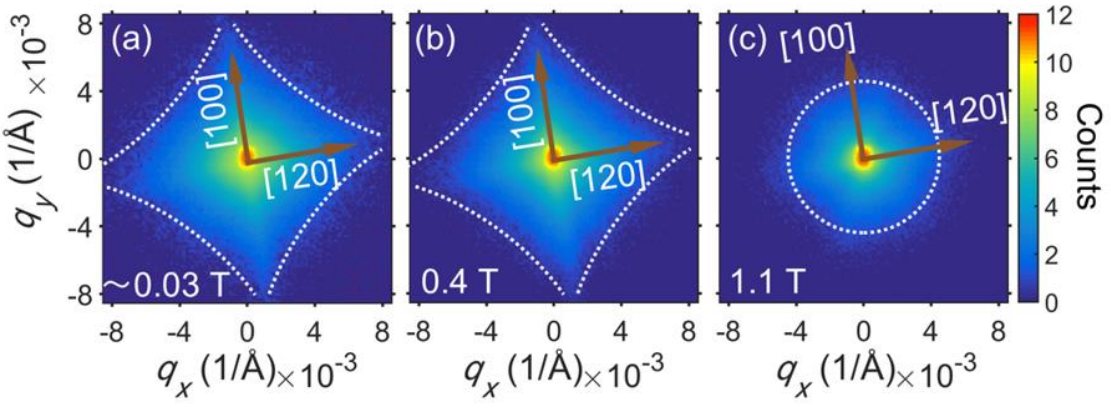

Fig.1 Oriented three-dimensional magnetic biskyrmion in MnNiGa measured by small angle neutron scattering.

5 SUGGESTIONS FOR IMPROVEMENTS TO YOUR EXPERIMENT, EQUIPMENT OR THE FACILITY

I suggest you can improve the motor the of 3-dimentional magnet. It took a lot of time for me to rocking the angle. It wasted a lot of beam time.

Thank you very much.