Experimental report

16/09/2016

Proposal: TEST-2547 **Council:** 4/2015

Title: Interplay between Dzyaloshinskii-Moriya interaction and single-ion anisotropy in multiferroic BiFeO3

Research area:

This proposal is a new proposal

Main proposer: Je-Geun PARK

Experimental team: Milan KLICPERA
Jaehong JEONG

Local contacts: Martin BOEHM

Samples: BiFeO3

Instrument	Requested days	Allocated days	From	To
THALES	3	3	30/11/2015	03/12/2015

Abstract:

Experimental report

Experimental title: **Interplay between Dzyaloshinskii-Moriya interaction and single-ion anisotropy in multiferroic $BiFeO_3$**

Proposal number: **TEST-2547**

Instrument: **ThALES**

Date of experiment: 30.11 – 3.12. 2015

Local contact: Martin Boehm

Experimental team: Milan Klicpera[1,2], Martin Boehm[2], Jaehong Jeong[3], Je-Geun Park[3]

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Abstract: In collaboration with the instrument team of recently constructed cold neutron triple-axis spectrometer ThALES at ILL, we would like to propose to measure the low energy excitations in $BiFeO_3$ as a test of the instrument that may also yield scientifically interesting results. We have measured a low-energy spin waves in this unique multiferroic material on 4F2 at LLB, thus it would be informative to repeat the scans we measured before in order to gauge the count rate and resolution of the new instrument. Moreover, we may resolve complex coupled modes from the Dzyaloshinskii-Moriya interaction and single-ion anisotropy, which could not be resolved in the previous measurement, by a better resolution in momentum transfer with tighter collimations. For this proposal, 3-4 days' measurement time is proposed.

Scientific background:

$BiFeO_3$ is the only known room-temperature multiferroic material [1]. It has a ferroelectric transition around 1100 K and adopts a long wavelength spiral antiferromagnetic structure below 640 K. The spin waves in this multiferroic phase have a large dispersion with a maximum around 70 meV energy transfer [2]. However, anisotropy gaps appear at low energy around the Γ-point, which have been explained by an interplay of both Dzyaloshinskii-Moriya and single-ion anisotropy. Theoretical spin wave dispersion shows a complex mixing between the "phason" mode and two "spin-flip" modes by the Dzyaloshinskii-Moriya interaction, which is not resolved in previous inelastic neutron scattering measurements [3,4].

Aim of the experiment:

We would like to propose to measure the low energy excitations in $BiFeO_3$ at 5 K as a test of the instrument that is supposed to also yield scientifically interesting results.

We measured a co-aligned crystal array with total mass of 1.6 g on the cold triple-axis spectrometer 4F2 at the Orphee reactor in Sacley, France. This time we have a single crystal with a mass of 0.57 g, but the reactor power of ILL is approximately 4 times higher than that of Orphee. Thus, it would be informative to repeat the scans we performed before in order to compare the count rate of the new instrument with that of a similar instrument in Sacley.

Results:

The $BiFeO_3$ single crystal was measured on ThALES triple-axis spectrometer using 40' collimation of neutron beam. The sample alignment was done using hexagonal nuclear reflections (003), (102) and (00-3). We employed the results of our previous test measurements on OrientExpress (TEST-2534) and IN3 instruments to properly choose the scattering plane for ThALES experiments. The measurement was done at temperatures from 16 K to 270 K with $\boldsymbol{k}_f$ = 1.55 Å and 1.3 Å.

ThALES experiment showed certain mosaicity of the single crystal leading to relatively broad peaks; and quite high background.

The low-lying magnetic excitations were mapped. The island in *Q-E* maps at around 1 meV observed previously on 4F2 at LLB was reproduced to some extent as on ThALES data a peak is found at such energy (see Fig.1). Three-peak structure (two shoulders) corresponding to spin-wave like excitations was observed (see Fig.2). Nevertheless, another peak expected at around 4 meV was not reproduced. The precise analysis of all measured data is still underway.

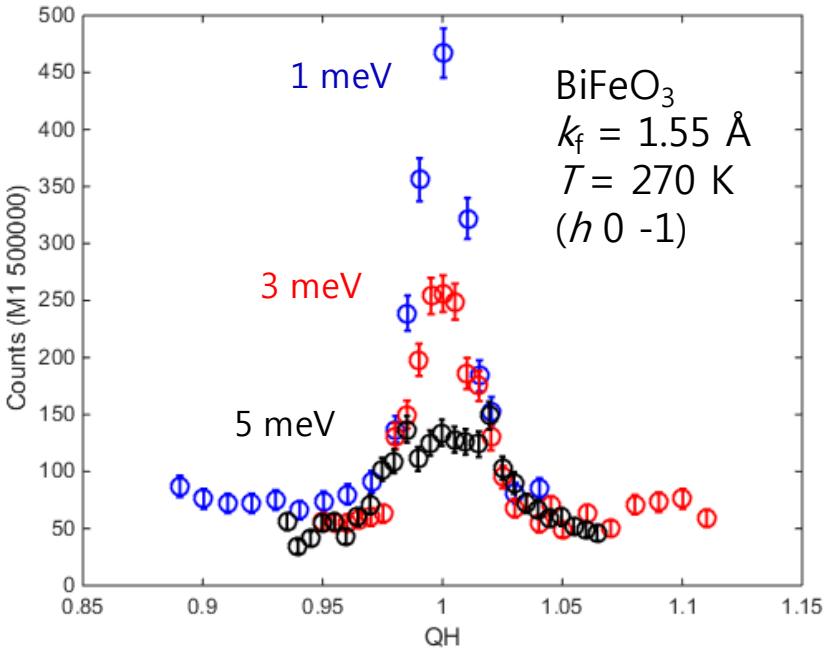

Fig.1 – The *h*-scans around (1 0 -1) reflection at several energies mapping an island in E-Q space previously observed in $BiFeO_3$ [3,4].

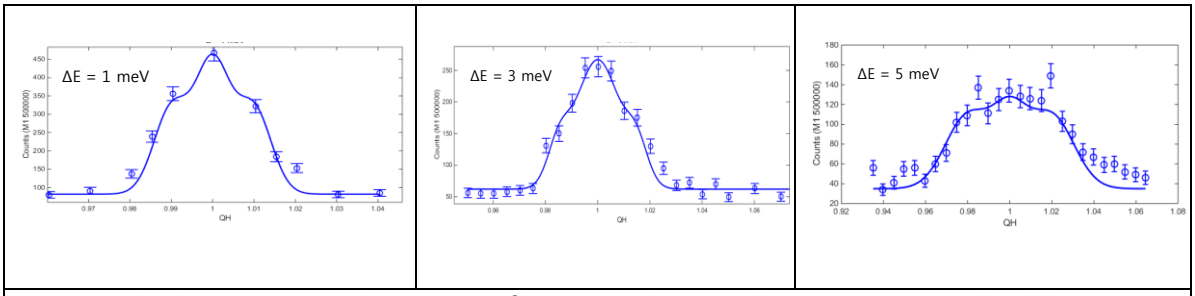

Fig.1 – The *h*-scans around (1 0 -1) reflection. Three-peak structure (two shoulders) corresponding to spin-wave like excitations is observed.

[1] Catalan and Scott, *Adv. Mater.* **21**, 2463 (2009)
[2] Jaehong Jeong et al., *Phys. Rev. Lett.* **108**, 077202 (2012)
[3] M. Matsuda et al., *Phys. Rev. Lett.* **109**, 067205 (2012)
[4] Jaehong Jeong et al., *Phys. Rev. Lett.* **113**, 107202 (2014)