Experimental report

24/02/2025

Proposal: **INTER-599** **Council:** 4/2024

Title: Dysprosium orthoferrite, DyFeO3

Research area:

This proposal is a new proposal

Main proposer: **Karin SCHMALZL**

Experimental team: Michal STEKIEL
Dnyaneshwar Raghunath BHOSALE
Karin SCHMALZL

Local contacts: Karin SCHMALZL

Samples: Dysprosium orthoferrite
DyFE3

Instrument	Requested days	Allocated days	From	To
IN12	3	3	11/03/2024	14/03/2024

Abstract:

Experimental report INTER-599

Background and motivation

Rare-earth orthoferrites have recently attracted attention owing to their application in magnonics, where spin transport of an antiferromagnet with weak ferromagnetic moment provide promising properties in magnonic devices. Thus, the effect of the rare-earth on the overall magnetic properties of orthoferrites was studied, by investigating the ordering of the rare-earth sublattice.

In particular, $DyFeO_3$ was reported as a particularly interesting platform, given a large spin-orbit coupling, projecting to highly desired effects in optical manipulation of magnetization and magnons [1].

Previous reports on the long-range magnetic order of Dy sublattice in $DyFeO_3$ are inconsistent. Study by Ritter *et al.* [2] on polycrystalline sample shows incommensurate, long-wavelength modulation of Dy magnetic moments, while reports on the single-crystal by Biswas *et al*. [3] do not show satellite reflections. Apart from magnonic applications, such type of modulated order drew attention in $TbFeO_3$, where it was found that under applied field the arising magnetic order can be described with virtual-magnon-mediated Yukawa forces.

As such scenario could be present in $DyFeO_3$ without applied field and driven by application in magnonics, we set to investigate the long-range magnetic order of Dy sublattice in $DyFeO_3$.

Reported experiment

We have performed our measurements at IN12 in a high-momentum-resolution mode. The monochromator and analyzer were set to elastic mode with k=1.1 $Å^{-1}$ and we placed the 20'-20' slits in the beam path before and after the sample. We have cooled the sample to the base temperature in orange cryostat, and measured a series of diffractograms as a function of temperature, across the ordering temperature T=4 K.

An exemplary scan is shown in Fig 1, where the data was collected in the ordered state at T=1.5 K. We observed satellites of the nuclear-forbidden (001) reflection up to the 7^{th} order. We have characterized the intensity and modulation length as a function of temperature.

These measurements proved that our single-crystal establishes a modulated long-range order according to the report of Ritter *et al*. It provided a base for further beamtimes, where a characterization with polarized neutrons allowed to get insight into the type of magnetic order of Dy sublattice.

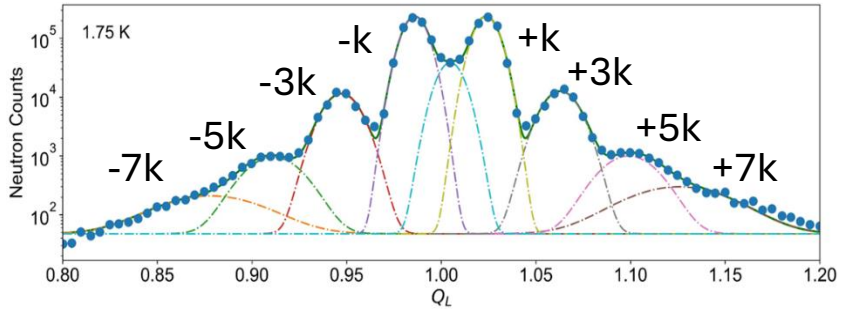


Fig 1. Q-scan across the (001) reflection of $DyFeO_3$ measured at 1.75 K. It reveals magnetic satellites of odd order, related to the long-range magnetic order of the Dy sublattice.

[1] Kimel *et al.*, *Nature*, **435** 655-657, (2005). DOI: 10.1038/nature03564

[2] Ritter *et al.*, *J.Phys. Cond. Matt.*, 34 265801, (2022) DOI: 10.1088/1361-648X/ac6787

[3] Biswas *et al.*, *Phys Rev. Mater.*, 6 074401, (2022). DOI: 10.1103/PhysRevMaterials.6.074401