

Experimental report

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Proposal: 4-01-1772

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Title: High energy magnetic lattice dynamics in DyFeO₃

Research area: Physics

This proposal is a new proposal

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Samples: DyFeO₃

Instrument	Requested days	Allocated days	From	To
ORIENTEXPRESS	1	1	04/06/2023	05/06/2023
IN20	6	6	06/06/2023	12/06/2023

Abstract:

The aim of the proposed work is to study the magnon dispersion at high-energy transfer in DyFeO₃ orthoferrite by the inelastic neutron scattering. This measurements will give the experimental material for the calculation of the parameters for Fe-Fe exchange, DM interaction and anisotropy.

interactions. These investigations are an essential part in determining of the microscopic mechanisms responsible for the emergence of ferroelectricity in DyFeO₃ in particularly and in other members of RFeO₃ orthoferrites family in generally.

We expect to shed the new light in the understanding of the effect of R on the magnetoelectric properties in the RFeO₃ family of orthoferrites

High energy magnetic lattice dynamics in DyFeO₃

(proposal no 4-01-1772, IN20 and OrientExpress)

Experimental Report

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DyFeO₃ crystallizes in the orthorhombic Pbnm crystal structure with $a = 5.30 \text{ \AA}$, $b = 5.59 \text{ \AA}$, and $c = 7.59 \text{ \AA}$. Below $T_{N,Fe} = 650 \text{ K}$ the magnetic moments of iron are oriented according to the $Pb'n'm$ magnetic space group, i.e. the Γ_4 irrep of the Pbnm space group corresponding to the $G_x A_y F_z$ mode in Bertaut notation. At $T_{SR,Fe} \approx 40 \text{ K}$ a reorientation of the iron spins occurs and Fe³⁺ magnetic moments become oriented according to the Pbnm.1 magnetic space group, i.e. the Γ_1 irrep corresponding to $A_x G_y C_z$ mode without a ferromagnetic component. Below $T_{N,Fe} = 4 \text{ K}$ the dysprosium sublattice establishes a long-range magnetic order with an incommensurate, modulated structure [1, 2].

The crystal orientation (see Fig. 1a) and its lattice parameters were refined at $T = 1.6 \text{ K}$. For inelastic neutron scattering sample was mounted with bc scattering plane. Preliminary measurements were performed at 1.6 K (both Dy³⁺ and Fe³⁺ magnetically ordered). The main measurements were performed at 10 K (only Fe³⁺ magnetically ordered). Scans with energy transfers below 40 meV were performed using the velocity selector in the incoming neutron beam, scans above this energy transfer were done without the velocity selector.

Figures 1c) and 1d) show magnetic excitations maps measured at 10 K with $(0 \text{ k } -1)$ and $(0 \text{ k } 5)$ momentum transfers, respectively. Scans contributing to Fig. 1c) were measured in constant energy transfer modes, scans contributing to Fig. 1d) were measured in constant Q vector mode. The map in Figure 1c) was measured in transition with the full cylinder sample. In order to avoid the large Dy neutron absorption for the benefit of stronger signals, we continued with the sample cut into a half cylinder with large (001) surface, that was used then for the measurements in reflection geometry shown in Fig. 1d).

We observed a non-dispersive band of excitations at 18 meV which we ascribe to the crystal field. In Fig. 1c) there is a gapped excitation around $(0 \text{ 3 } -1)$ with a gap of about 4 meV . The FWHM (full width at half maximum, along the K direction) of this excitation is increasing linearly with energy transfers as shown in Fig. 1b), consistent with a steep dispersion. The top part of this dispersion is visible on Fig. 1d) with a maximum at $(0 \text{ 2.25 } 5)$ and energy transfer of 63 meV . Our measurements, as well as those reported for related compounds [3-8], show that magnons in the 5 to 65 meV energy band correspond to Fe sublattice spin waves. Future inelastic neutron diffraction studies are needed to trace the full dispersion without Dy³⁺ ordering and to investigate excitations in the Dy³⁺ magnetically ordered phase.

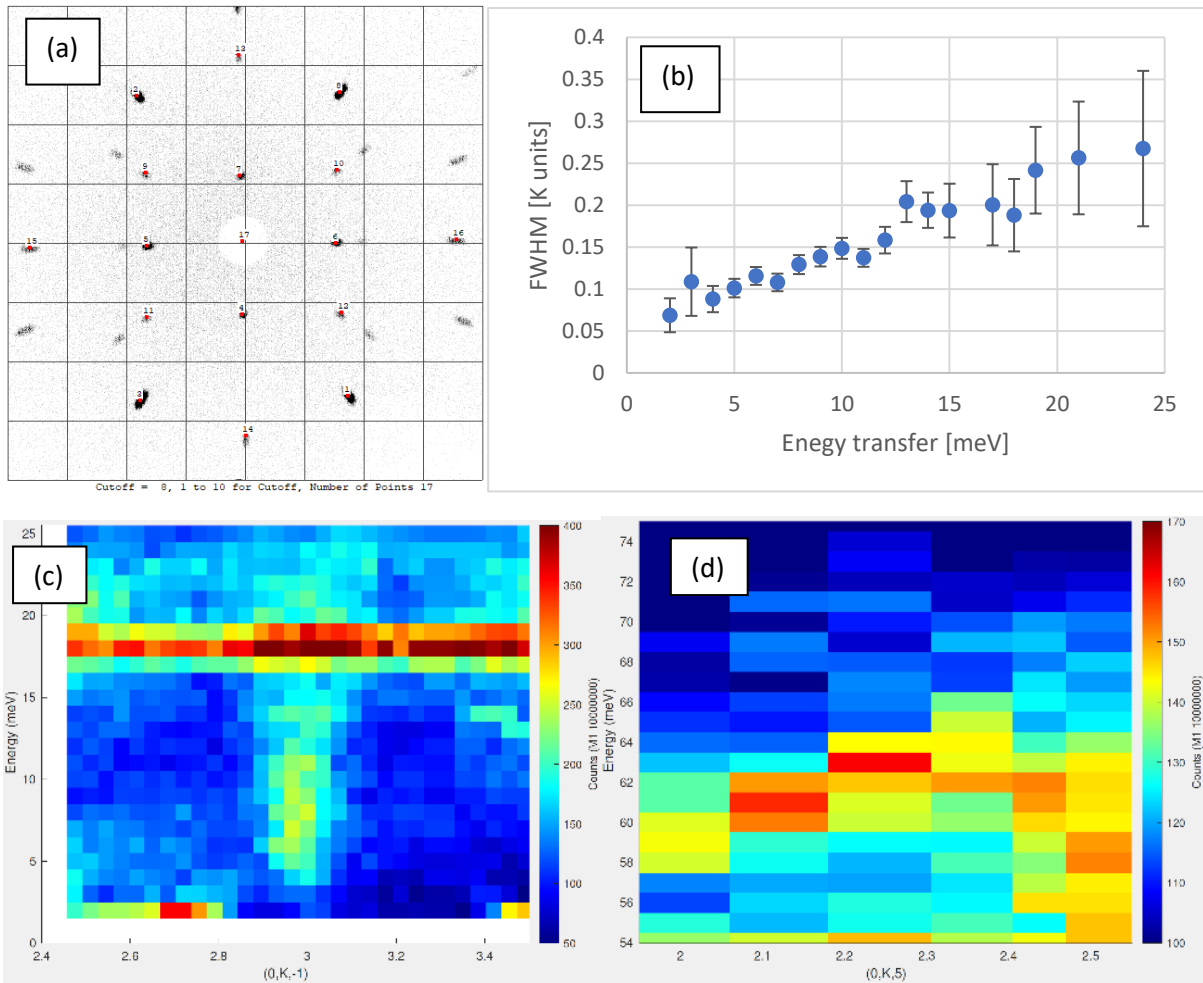


Figure 1. (a) Neutron Laue camera image obtained on OrientExpress on DyFeO₃ along the a axis. (b) FWHM as function of energy transfer of the excitations at (0 3 -1) shown in fig. c. (c) Lower part of spin wave dispersion with momentum transfer (0 k -1) measured at 10 K. (d) Upper part of the spin wave dispersion with momentum transfer (0 k 5) measured at 10 K.

References

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