Experimental report

25/05/2023

Proposal:	**CRG-2846**		**Council:**	4/2021
Title:	Study of the inelastic scattering inDyFeO3 at low energy range			
Research area:	Physics			

This proposal is a new proposal

Main proposer: **Vladimir HUTANU**

Experimental team:

Local contacts: Wolfgang F SCHMIDT

Samples: DyFeO3

Instrument	Requested days	Allocated days	From	To
IN12	5	5	24/09/2021	29/09/2021
ORIENTEXPRESS	1	1	23/09/2021	24/09/2021

Abstract:

ErFeO3 belongs to the interesting rare-earth orthoferrites family RFeO3 that crystal structure is described by the space group Pbnm. Below TSR ¿ 113 K the magnetic coupling between the net moment of Fe site and induced moment at the Er site along the easy-axis is always antiferromagnetic. At Tcom ¿ 48 K, the net moment of the Fe site is canceled by the induced moment at the Er and the total magnetization becomes dominated by the moment of the Er site at temperatures below Tcom. Er3+ alignment takes place at TRN = 4.3 K.

The application of the external magnetic field to the single crystal of ErFeO3 induced two completely discontinuous steps in the continuous transition, which effect was attributed to the variation in the magnetic anisotropy. Up to our knowledge, no studies with inelastic neutron scattering on ErFeO3 were performed. The inelastic neutron investigations of ErFeO3 single crystals will give opportunity to obtain for the first time the parameters of the magnetic interactions, anisotropy variation in different magnetic phases.

At the first stage of the experiment, crystal was oriented by reflections [0 2 0], [0 0 4] and [0 0 2] and the parameters of the unit cell were refined at the temperature 40 K. The obtained structure corresponds to space group Pbnm with cell parameters a = 5.302 Å, b = 5.598 Å, c = 7.623 Å.

Then the measurements of the inelastic scattering were performed at the temperature T=2K. They include series of scans along *k* direction in the reciprocal space. Scans were made near node *q* = [0 1 1] along *k* direction in the range from *q* = [0 0 1] to *q* = [0 1.6 1]. During the experiment we used the scans in “constant-q” mode, where the measurements were made in the energy range 0 – 3 meV with the energy step $\Delta E = 0.05$ meV along the scan.

Scans at *q* = [0 *k* 1] where *k*=0.1 and 0.2 show a strong peaks around 0.8 meV (see fig. 1a). However, these peaks changed energy when changed *kf* from 1.55 to 1.2 and were completely suppressed when the filter was installed. Thus, most likely, these peaks correspond to some kind of instrumental artifacts.

Scan at *q* = [0 1 1] and in the E range from 0.2 meV to 6 meV did not show any sharp increase in intensity (fig. 1b). Therefore, we can say that the energy gap is bigger than 6meV or smaller than 0.4meV. This means that orthoferrite $DyFeO_3$ has strong single-ion anisotropy in Fe-sublattice or the anisotropy magnitude is very small. Additional measurements on thermal three-axis spectrometer are needed to find the exact answer to this question.

The peaks that most likely correspond to excitation by magnons lie in the 2-3meV range (fig 1c). This differs from other orthoferrites [1-3], where the dispersion curve lies below 1 mev and does not agree with our previous models. This may be associated with the influence of Fe-sublattice on Dy-sublattice and indicates about the strong exchange $J^{Fe\text{-}Dy}$. To fully understand the full picture of exchange interactions and to explain the positions of the measured peaks, additional measurements on a thermal spectrometer are needed.

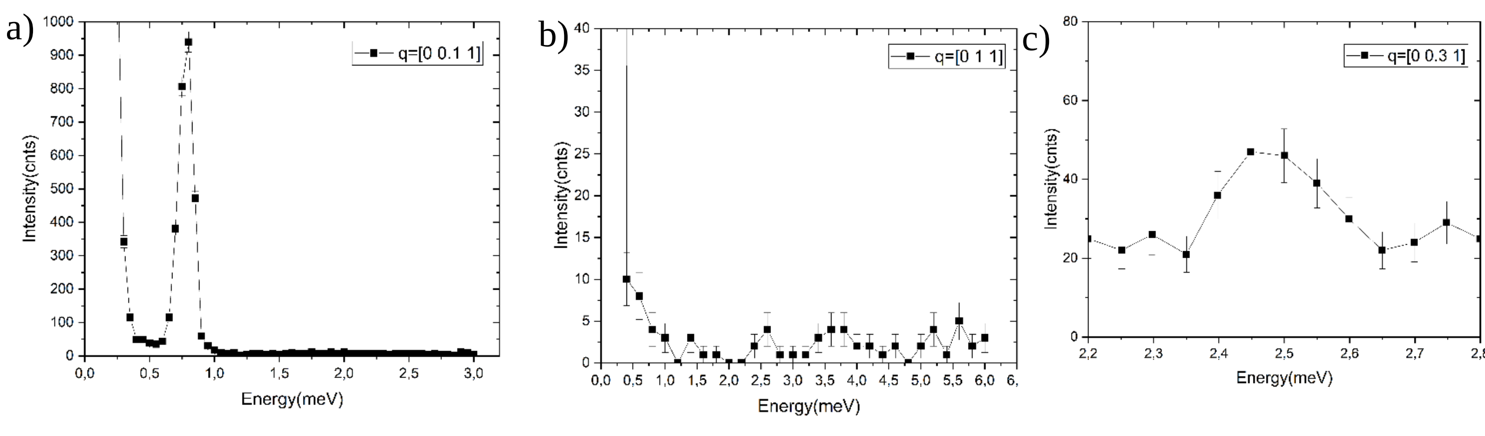

Figure 1. (a) Constant-q scan at q=[0 0.1 1] with a measurement artifact. Black dots – measured intensity. (b) Constant-q scan at q=[0 1 1]. Indicates the absence of an energy gap. (c) Constant-q scan at q=[0 0.3 1]. The peak most likely corresponds to the excitation from the magnon.

References

[1] A.K. Ovsianikov, O.V. Usmanov, I.A. Zobkalo, V. Hutanu, S.N. Barilo, N.A. Liubachko, K.A. Shaykhutdinov, K. Yu Terentjev, S.V. Semenov, T. Chatterji, M. Meven, P.J. Brown, G. Roth, L. Peters, H. Deng, A. Wu, «Magnetic phase diagram of HoFeO3 by neutron diffraction», Journal of Magnetism and Magnetic Materials, Volume 557, 1 September 2022

[2] A. K. Ovsianikov, O.V. Usmanov, I. A. Zobkalo, W. Schmidt, A. Maity, V. Hutanu, E. Ressouche, K.A. Shaykhutdinov, K. Yu Terentjev, S.V. Semenov, M. Meven, G. Roth, L. Peters, «Inelastic neutron studies and diffraction in magnetic fields of $TbFeO_3$ and $YbFeO_3$», Journal of Magnetism and Magnetic Materials, Volume 563, 1 December 2022

[3] S.E. Nikitin, L.S. Wu, A.S. Sefat, K.A. Shaykhutdinov, Z. Lu, et al., Phys. Rev. B 98 (2018), 064424.