Experimental report

20/01/2021

Proposal: CRG-2697 **Council:** 10/2019

Title: Magnetic lattice dynamics in $HoFeO_3$; continuation at low-energy range

Research area: Physics

This proposal is a new proposal

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Samples: $HoFeO_3$

Instrument	Requested days	Allocated days	From	To
IN12	5	5	05/02/2020	10/02/2020

Abstract:

In order to better resolve Ho^{3+} dispersion in the vicinity of CF line,observed during the previous experiment we plan to make the measurements of the spectrum in two Brillouin zones; with different parity of L Miller indexes, e.g. along [H 0 1] and [H 0 2] centred at Q = (1 0 1) and (1 0 2). As it follows from our simulations, the distribution of the dispersion branches intensities will be different for zones with different L-parity. This will provide more-comprehensive data for fitting procedure and exchange parameter determining. The temperature of measurements: 2.5 K, in the transfer energy range of 0-5 meV. For this purpose we ask for 3 days of beam time on IN12.
In order to unambiguously conclude on the magnetic origin of the observed low energy scattering and suppress the incoherent background we propose to use in addition the polarized neutron option of IN12. Thus, we request totally for 5 days (3 unpolarised + 2 polarised) of beam time.
This experiment is a part of the PhD thesis of Mr. A. Ovsyanikov in frame of DFG supported project at Institute for Crystallography RWTH Aachen University.

Polarized neutron inelastic scattering experiment shown strange result in $HoFeO_3$. The scattering intensity was higher with the polarizer on (see fig. 1). Due to the fact that the experiment time is limited. The sample of $HoFeO_3$ was replaced by $YbFeO_3$. The experiment was performed in a standard setting without polarized neutrons.
Crystal structure of $YbFeO_3$ is described by space group Pnma (#62, Pbnm in another setting), Below T_N=600K Fe sublattice has antiferromagnetic order with the strongest component along c-axis, and weak ferromagnetic component along b axis. Compound have spin-orientation transition at Tsr=7.5K from the magnetic phase Γ4 to the phase Γ2 where moments of Fe^{3+} rotate in directed along b axis. Yb order happens at temperature T_{NR}=7.5K[1].
At the beginning of the experiment, the crystal was oriented with cell parameters a = 5.591 Å, b = 7.604 Å, c=5.280 Å. Experiments on inelastic neutron scattering were performed around node [1 0 1] along h and l directions at temperature T=2K. During the experiment we used the scans in "constant-q" mode, where the measurements of scan were made in the energy range 0 - 2 meV with the energy step ΔE = 0.1 meV along the scan. For a more accurate determination of the energy gaps, some of the measurements were made with better energy resolution ΔE = 0.05 meV. The absence of Yb energy levels [1] and parasitic effects made it possible to measure the peaks of magnons very well. A typical scan is shown in fig. 2a.
Energy map was obtained by summarizing all the scans (see fig.2b). The dispersion is linear in the direction q=[h 0 1] and it show some dependence on q in the direction q=[1 0 l]. The exchange values inside the Yb sublattice are J=0.20(2). The appearance of exchange interaction inside Yb sublattice leads to a redistribution of the balance of exchange interactions. And the system passes from the magnetic phase Γ4 to the phase Γ2.
The temperature dependence of the energy gap of Fe subsystems was measured in temperature range 2-13K (see fig. 2c). We may see the sharp increase in the energy of the gap after $T_N^{Yb} = 7.5K$. It shows the competition between energy of exchange interactions inside Yb sublattice and easy axis anisotropy of Fe ions. In addition, The temperature dependence of the energy gap shows the presence of a mixed phase in the temperature range T=6.5-7.5K.

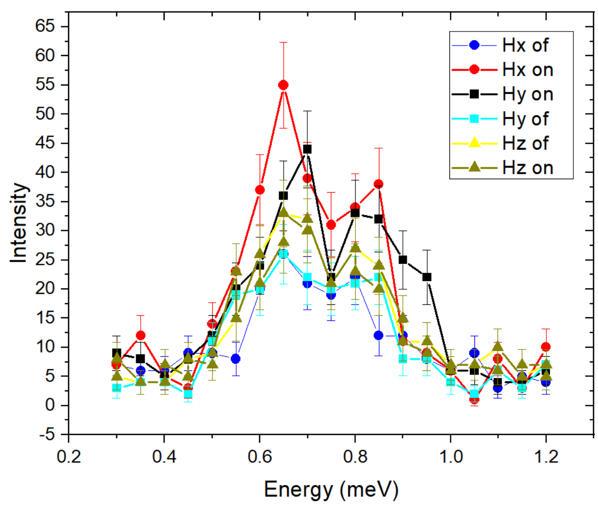

Figure 1. Intensity of inelastic peak with different polarizer parameters.

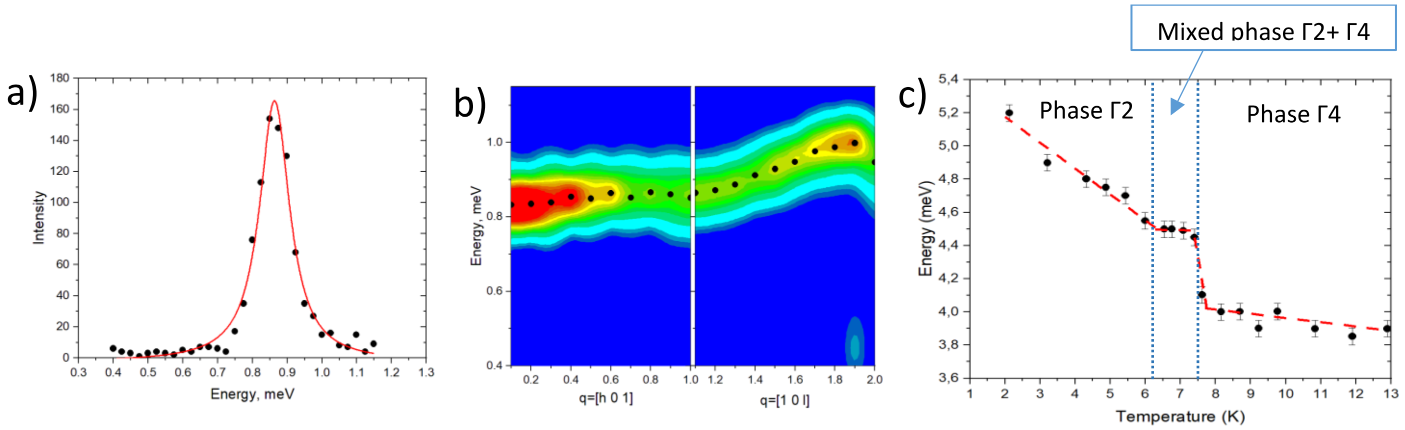

Figure 2a) Typical scans of inelastic neutron scattering, obtained at T = 2 K. Solid lines – fitting results. b) Energy maps, obtained at temperature T=2 K in directions q= [h 0 1] and q = [1 0 l]. The colors show the intensity, the black dots – positions of the inelastic peaks. c) The temperature dependence of the energy gap of Fe subsystems. Red line – guide for the eyes.

References

1. S. E. Nikitin, L. S. Wu, A. I. Kolesnikov, A. Podlesnyak, Phys. Rev. B 98, 064424 – Published 27 August 2018.

2. John C. Walling and Robert L. White Phys. Rev. B 10, 4737 (1974)