Experimental report

04/04/2016

Proposal: 5-51-512 **Council:** 4/2015

Title: Spin structure in the Ferroelectric Phase of Magnetoelectric Y-type hexaferrite $Ba_{0.6}Sr_{1.4}Zn_2Fe_{12}O_{22}$

Research area: Physics

This proposal is a new proposal

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Samples: $Ba_{0.6}Sr_{1.4}Zn_2Fe_{12}O_{22}$

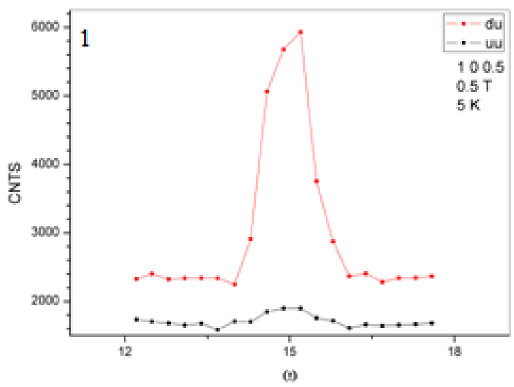
Instrument	Requested days	Allocated days	From	To
IN12	7	7	16/09/2015	23/09/2015

Abstract:

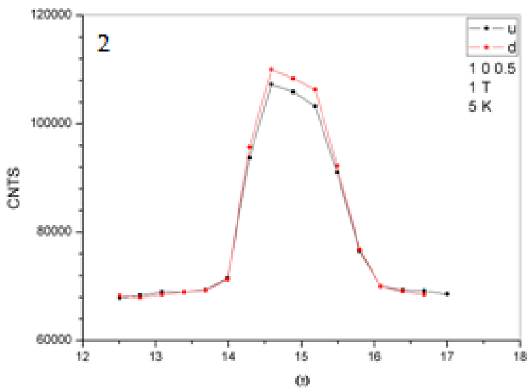
In the Y-type hexaferrite $Ba_{0.6}Sr_{1.4}Zn_2Fe_{12}O_{22}$, the observed magnetic field driven ferroelectricity cannot be explained by the proposed fanlike structure. We observed large circular dichroism in soft X-ray diffraction at (0,0,1.5) in horizontal H||ab in the ferroelectric, which implies that the magnetic structure is chiral. In an additional experiment with a vertical field H||ab we observed the same domain pattern with linear dichroism. The chiral domains are not consistent with the proposed fanlike structure but consistent with transverse conical spin structure, which would be consistent with a Dzyaloshinskii-Moriya-type ferroelectric mechanism. However, soft X-ray diffraction does not provide enough experimental constraints to test that model and fix the parameters. Using polarized neutron diffraction we will provide more constrains allowing testing our model and refining the parameters. We can also observe chirality with neutrons, in a half-polarized setup, which will provide additional tests of the model and parameters.

Spin structure in the ferroelectric phase of Magnetoelectric Y-type hexaferrite $Ba_{0.6}Sr_{1.4}Zn_2Fe_{12}O_{22}$

In the Y-type hexaferrite $Ba_{0.6}Sr_{1.4}Zn_2Fe_{12}O_{22}$, the observed magnetic field driven ferroelectricity cannot be explained by the proposed fanlike structure. We observed large circular dichroism in soft X-ray diffraction at (0, 0, 1.5) in horizontal H||ab in the proposed ferroelectric phase, which implies that the magnetic structure is chiral. The chirality is not consistent with the proposed fanlike structure, but e.g. is consistent with a transverse-conical spin structure, which would be consistent with a ”Dzyaloshinskii-Moriya” ferroelectricity of mechanism. However, soft X-ray diffraction does not provide enough experimental constraints to test that model and fix the parameters. Therefore, we used polarized neutron diffraction to provide more constraints, allowing testing our model and refining parameters. We had to use a horizontal magnet, because in a vertical magnet the modulated moments for our model are restricted to the scattering plane, which implies no chiral scattering. Scattering cross section of the neutrons is given by using this formula $6_Q=6^N_{Q,coh}+6^N_{isotope\ \ inc}+6^N_{spin\ \ inc}+|M^{\perp}_{-Q}|^2+P(N_{-Q}M^{\perp}_{Q}+M^{\perp}_{-Q}N_Q)+iP(M^{\perp}_{-Q}xM^{\perp}_{-Q})$. The last two terms are the only ones depending on the polarization at the incoming neutrons describe nuclear-magnetic interference scattering and chiraity, respectively. In our case, according to X-ray diffraction we have no nuclear scattering present e.g. at (1 0 0.5), which means that we need only the last term for the intensity dependence on the polarization of the incoming neutrons.

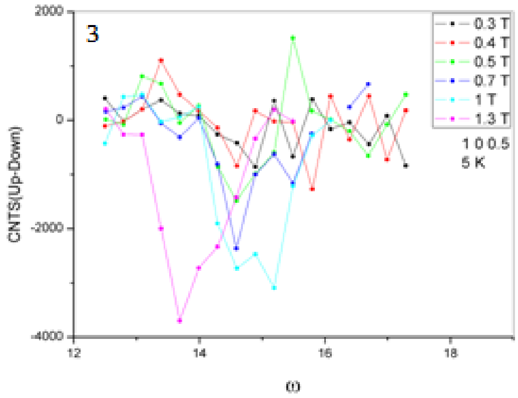


Pic. 1: full polarization analysis (”du” means spin-flip and ”uu” non-spinflip).

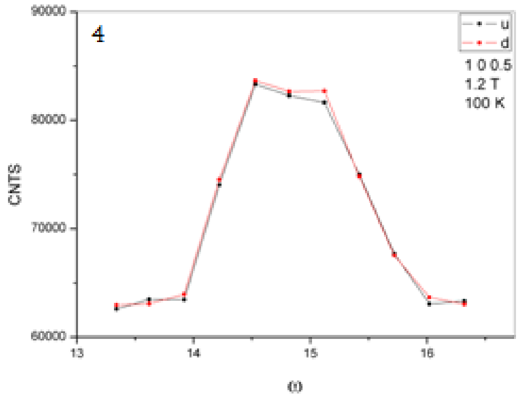


Pic.2: half polarization analysis (”u” and ”d” means positive/negative incoming polarization)

At first we carried out full polarization analysis to give further constraints for the spin directions. Check possibly position of magnetic and structural peaks and took peak which has visible difference (pic.1) between intensities of negative/positive neutron, then carried out half polarized and full polarized neutron analysis at different fields and temperatures and saw difference between intensities of negative and positive polarized neutron, which means that the magnetic structure is chiral.



Pic. 3: difference between scattered intensity with negative/positive incoming neutrons.



Pic.4: half polarization analysis (''u'' and ''d'' means positive/negative incoming polarization)

Half polarized neutron analysis shows (pic.2,4) that at 1 and 1.2 T field exist visible difference between scattered intensity with negative/positive incoming neutrons, which is confirmation of chiral domain structure. On the picture (3) are shown difference between of intensities of negative and positive polarized neutron at different fields, which will be used to map the phase boundaries for the chiral phase.

Full and half polarization analysis experimental data will be compared to simulations from models developed based on the soft X-ray data.