Experimental Report

Proposal: **4-01-1273** **Council:** 10/2012

Title: Electric field control of spinon polarisation in a quantum multiferroic

This proposal is continuation of: 4-01-1109

Researh Area: Physics

Main proposer: **ENDERLE Mechthild**

Experimental Team: HIRTENLECHNER Eva
CEMAL Eron
FAK Bjorn

Local Contact: ENDERLE Mechthild

Samples: LiCuVO4

Instrument	Req. Days	All. Days	From	To
IN20	10	11	29/04/2013	06/05/2013

Abstract:

In contrast to other multiferroics which display several branches of discrete spin-wave-like excitation spectra, the excitations of the spin 1/2 multiferroic LiCuVO4 form a continuum with multi-spinon character. The chirality of the spinon excitations is predicted to survive only very close to the magnetic Bragg peak, unlike classical multiferroics or spiral magnets. Our preliminary data indicate that LiCuVO4 does not behave like a classical multiferroic nor according to the theoretical predictions - we find non-chiral continuum states close to the magnetic Bragg peak and chiral states even far away from the magnetic Bragg peak. Our preliminary study was hampered by technical problems to do the full polarisation analysis (y- and z-channels), we can therefore not extract the total magnetic intensity. We ask for 10d to complete our polarized inelastic study with the missing polarisation channels.

Electric field control of spinon polarisation in a quantum multiferroic

$LiCuVO_4$, which crystallizes in the space group *Imma* with edge-shared CuO_2 chains running along the b axis, is an exchange-frustrated low-dimensional quantum (S=1/2) antiferromagnet which develops cycloid magnetic order and simultaneously a ferroelectric polarization below T_N=2.4 K [1–3]. $LiCuVO_4$ is dominated by next-nearest neighbour antiferromagnetic exchange along the b-axis, while nearest-neighbour exchange along b is smaller and ferromagnetic [3,4]. The largest interchain interaction is again ferromagnetic and acts between next-nearest neighbours in the ab-plane. Below 2.4 K, incommensurate magnetic order with propagation vector k_{AF}=(0,0.532,0) sets in, a perfectly circular ab-cycloid that flops into the bc-plane above a spin-flop field $H^a_{SF} \approx 2.5$ T applied parallel to the a-axis [5]. At zero magnetic field and in the spin-flop phase, the rotation sense of the cycloid can be fully controlled by an applied electric field [5] with 99% single-domain population. In contrast to other multiferroics which display several branches of discrete spin-wave-like excitation spectra, the excitations of $LiCuVO_4$ form a continuum with multi-spinon character, cf. Fig. 1a [4]. In magnetic fields above 9 T, $LiCuVO_4$ enters a bond-nematic phase with quantum spin-quadrupolar order [6], intimitely linked to the multi-spinon spectra at zero field.

Aim of the present experiment was to explore the influence of an applied electric field on the multi-spinon continuum. The majority of the data were taken in the following configuration of IN20: Heusler(111) monochromator hor. focused – open-guide field – F1 – guide-field – M1 – guide field – D1 – Sample – D2 – PGfilter with guide field – open – F2 – Heusler(111)analyser, hor. focused – detector. $k_f = 2.662\text{Å}^{-1}$ was kept fixed, and the scattering sense was SM/SS/SA=-1/+1/-1. Around the sample we had the standard Helmholtz coil. A 50mm^3 single crystal of $LiCuVO_4$, oriented in the $(0k\ell)$ scattering plane, was cooled to $T = 0.4$ K by a ^{3}He-insert inside the IN20-CO. The high voltage was applied along the vertical a-axis, above the phase transition, and the sample cooled through the transition with the high voltage applied (between 2 and 3 kV). This way we achieved a perfect chiral one-domain state, as evident from the polarisation of the magnetic Bragg peak. The magnetic chirality could be completely switched by the electric field.

We measured the cross sections $\sigma^{x\bar{x}}$, $\sigma^{\bar{x}x}$, $\sigma^{xx}, \sigma^{y\bar{y}}, \sigma^{z\bar{z}}$ for a constant energy and two constant k-scans across the continuum which allows to determine the ratio of chiral scattering with respect to total magnetic scattering.

References

1. B.J. Gibson *et al.*, Physica B **350**, e253 (2004).
2. F. Schrettle *et al.*, Phys. Rev. B. **77**, 144101 (2008).
3. M. Enderle *et al.*, Europhys. Lett. **70**, 237 (2005).
4. M. Enderle *et al.*, Phys. Rev. Lett. **104**, 237207 (2010).
5. M. Mourigal, M. Enderle *et al.*, Phys. Rev. B **83**, 100409(R) (2011).
6. M. Mourigal, M. Enderle *et al.*, Phys. Rev. Lett. **109**, 027203 (2012).