Contribution ID: **1** Type: **not specified**

Probing the multiferroic properties of the geometric frustrated CuCrO2 compound using neutron large scale facilities at Paul Scherrer Institut, Oak Ridge and Los Alamos

Wednesday 21 May 2014 20:45 (1 hour)

low-temperature properties in general, and the tunability of the magnetic structure through an electric field and the electric polarization through a magnetic field in particular. The most promising candidates for such controllable multiferroics have been found among the materials with inherent geometric magnetic frustration.

Among these, the delafossite CuCrO2, which crystallizes in the rhombohedral R-3m space group, is a multiferroic compound with an apparent strong coupling of spin and charge. In contrast to other multiferroic compounds CuCrO2 shows a spontaneous electric polarization upon antiferromagnetic ordering without an accompanying structural phase transition, thus the spiral magnetic ordering alone breaks the inversion symmetry. The peculiar magnetic structure of CuCrO2 allows the direct quantitative analysis of the domain population.

In our contribution, we present a detailed study on CuCrO2 single crystals using neutron diffraction in applied electric and magnetic fields. With the fields we were able to tune the multiferroic states
in CuCrO2 and could directly relate them to the underlying domain physics. Surprisingly, the domain population is changed only slightly by the electric field and the observed multiferroic properties arise therefore from a multi-domain state. Further, the sign reversal of the electric polarization through a reversed electric field is not accompanied through domain re-distribution. This evidences the proposed coupling of the electric polarization to the chirality of the magnetic spiral. We will also show that the three domain state is driven by strain induced across domain walls and that therefore one- or two-domain state is a non-equilibrium state. The underlying mechanism is key to understand the multiferroic properties of CuCrO2.

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Session Classification: Evening Sessions