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Pressure-tuned magnetic and magnetoelectric phases in erythrosiderite

The large family of erythrosiderite-type compounds $A_2[\text{FeCl}_5(\text{H}_2\text{O})]$ (A = alkali metal or ammonium ion) presents a large variety of compounds with closely related crystal structures and well documented magnetic orderings, ranging from type-II magnetic multiferroics ($A = \text{NH}_4$) to commensurate antiferromagnetic order with linear magnetoelectric coupling ($A = \text{Rb}, \text{Cs}, \text{and K}$) [1]. Previous high-pressure studies of the ammonium compound revealed complex pressure-induced behavior, including a reentrant ferroelectric phase below 4K and pressures below 0.5GPa [2] highlighting the strong sensitivity of this family to external pressure. We will perform a neutron diffraction experiment at PSI in extreme conditions ($T > 6 \text{ K}, H < 11 \text{ T}, P < 8 \text{ GPa}$) in order to unveil the missing part of the (P-T-H) phase diagram of this type-II multiferroic.

We also investigate the pressure dependence of the magnetic properties of the $A = \text{Rb}$ compound. Magnetization measurements were performed using vibrating sample magnetometry (VSM) along the magnetic easy axis at ambient pressure, 0.6 GPa, and 0.9 GPa.

Three main features are observed as the pressure increases. The field-induced transition gets broader and its associated boundary shifts to lower magnetic fields. The phase boundary of the temperature-driven transition is modified in the high-field region. These preliminary results suggest an evolution of the magnetic phase diagram under pressure. We will perform Neutron diffraction and pyrocurrent measurements under pressure to help link the magnetoelectric and structural behaviour in the Rb compound and extend our understanding of the complex magnetic ordering in erythrosiderite.

[1] Ackermann, M. et al., Magnetoelectric properties of $A_2[\text{FeCl}_5(\text{H}_2\text{O})]$ with $A = \text{K}, \text{Rb}, \text{Cs}$, Journal of Physics: Condensed Matter 26, 506002 (2014).

[2] Wu, Y. et al., Reentrance of spin-driven ferroelectricity through rotational tunneling of ammonium, arXiv:2101.02795 (2021).

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