Magnetic spin dynamics in Mn-hureaulite

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A hureaulite-type synthetic compound, $Mn^{2+}_5(PO_4)_2(PO_3(OH))_2(HOH)_4$ undergoes complex magnetic phase transitions. At 6.17 K, the paramagnetic (PM) phase (space group: ***C***2/c) transforms to inherit a ferrimagnetic (FM) order (magnetic space group: ***C***2'/c'), followed at 1.86 K by an incommensurately modulated antiferromagnetic (AFM) order (magnetic superspace group: $\boldsymbol{P}2_1/c.1'(\alpha 0 \gamma)\boldsymbol{00s}$ with the propagation vector $\boldsymbol{k}(0.523(2), 0, 0.055(1))$ [1]. In the FM state, AFM interactions are dominant for both intra and inter pentamers of $Mn^{2+}(O, HOH)_6$ octahedra. Differently aligned spin-canting sublattices at three unique Mn sites in the FM phase explains a weak ferromagnetism in the title compound. More interestingly, magnetic spin-canting reorientations continuously proceed below the Curie temperature (T_c = 6.17 K), e.g. at 6.1 K, all three Mn sites exhibit large values for magnetic moments in ***a*** direction, but at 3.4 K in ***c*** direction (Fig. 1).

This vivid spin dynamic system could be confirmed by alternating current magnetic susceptibility (χ_{ac}) at H_{ac} = 5 Oe within a frequency (f) window of 10-10000 Hz. In Fig. 2, the acquired χ_{ac} spectra demonstrate high and complex dynamics in the whole temperatures (T) covering all PM/FM/AFM regions. The presence of the out-of-phase part $\chi''_{ac} > 0$ below T_c agrees with a strong (T, f)-dependent reorientations of magnetic spins. Around T_c, as frequency increases, χ'_{ac} decreases, but χ''_{ac} increases and shifts to higher temperatures. A minimum of in the real part (χ'_{ac}) at 5.28 K shifts to lower temperatures at elevated frequencies. Both χ'_{ac} and χ''_{ac} below 2.6 K show two extremely different tendencies below and above 2500 Hz. More details of these vital magnetic spin dynamics are reported at the meeting DGK 2022.

[1] Park, S.-H. Hartl, A., Sheptyakov, D, Hoezel, M., Arauzo, A. Structural Investigation into Magnetic Spin Orders of a Manganese Phosphatic Oxyhydroxide, $Mn_5[(PO_4)_2(PO_3(OH))_2](HOH)_4$. *Symmetry* **2021**, *13*(9), 1688 (pp18).

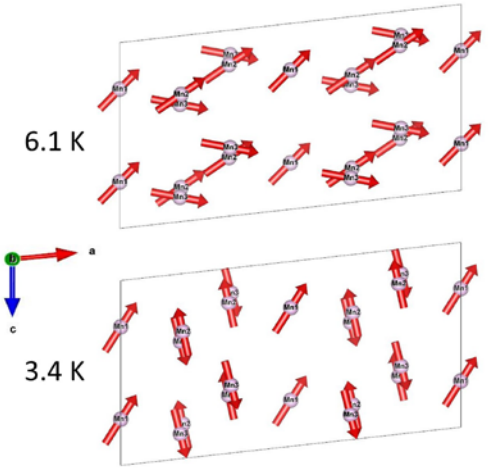

Fig. 1 Magnetic spin-canting sublattices of Mn-hureaulite in the FM state at 6.1 and 3.4 K.

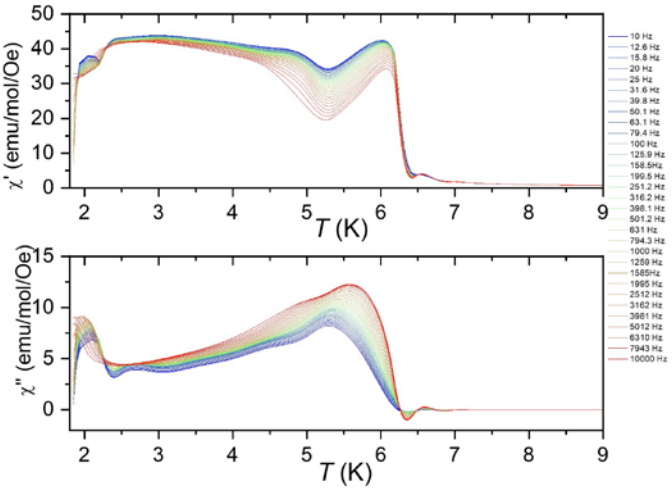

Fig. 2 $\chi_{ac}(T,f)$ spectra of Mn-hureaulite in oscillating magnetic field.