Magnetic Order in an Exotic Breathing Kagome Lattice Compound $Pb(OF)Cu_3(SeO_3)_2(NO_3)$

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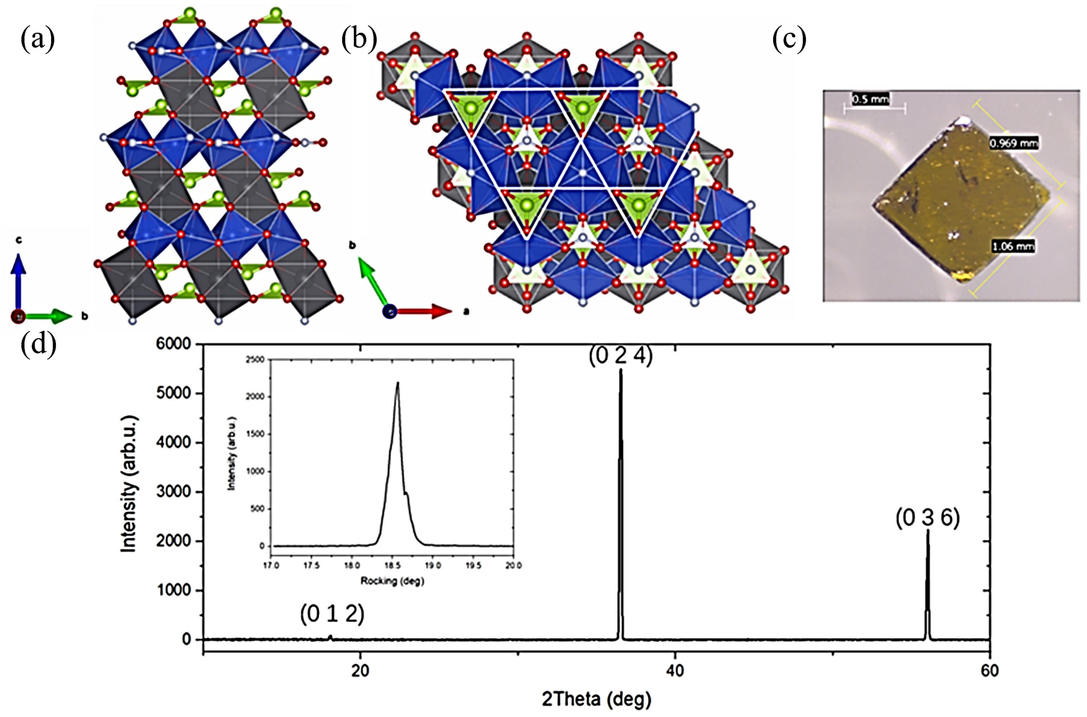
Abstract

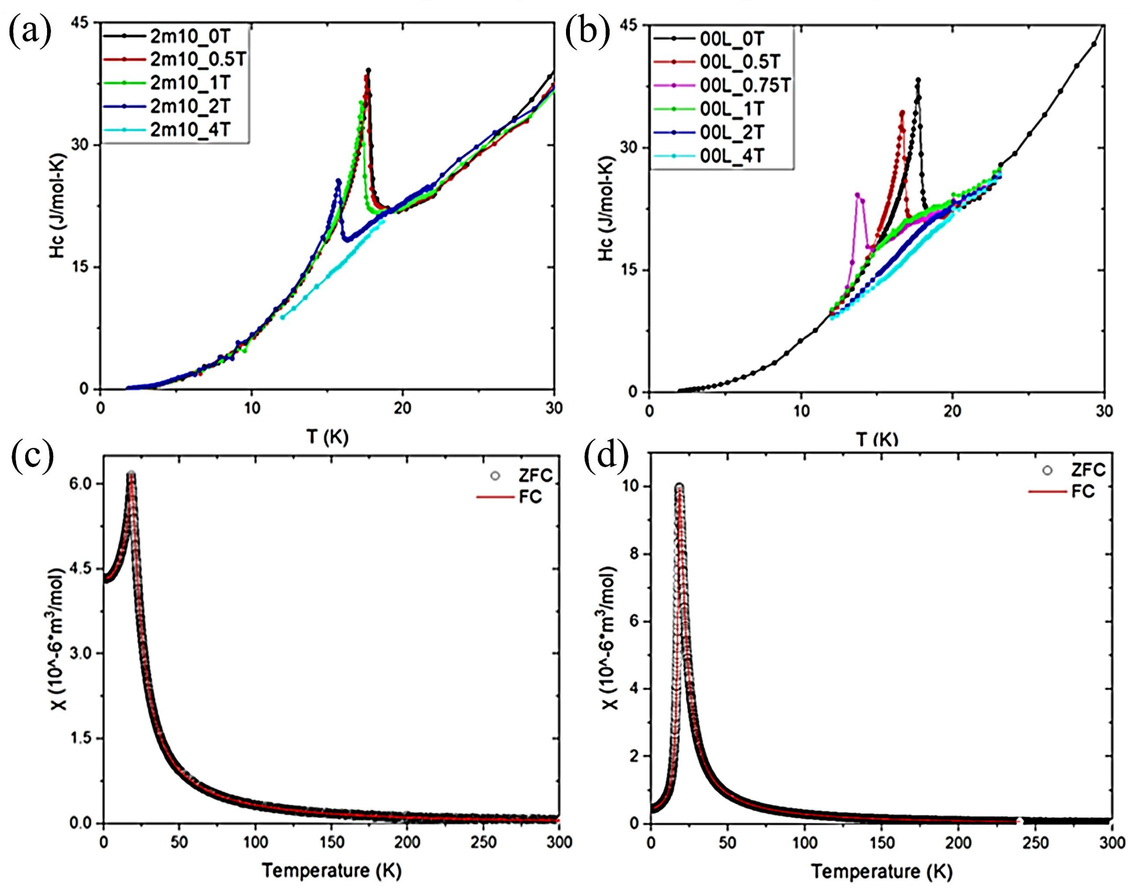
Recently, kagome lattice materials have attracted considerable interest in various fields of condensed matter physics. In terms of magnetism, the kagome lattice consisting with corner sharing triangles is considered as one of the most geometrically frustrated lattices, and is a great platform to search for quantum spin liquid states and topological magnetism. In this work, we studied a new breathing kagome lattice magnet $Pb(OF)Cu_3(SeO_3)_2(NO_3)$ where the bond length of the corner sharing triangles in the kagome lattice changes alternatively. Our experiments reveal that $Pb(OF)Cu_3(SeO3)_2(NO_3)$ exhibits an A-type magnetic order below 18 K with a magnetic propagating vector of k = (0 0 0.5). The ordered moment of ~ 0.97 μ_B/Cu^{2+} points mostly along the c-axis with a small canting along the (H -H) direction in the kagome plane. When applying a magnetic along the c direction, clear magnetization plateaus are observed and the moments are fully polarized above 1.81 T. Our results indicate dominant in-plane ferromagnetic interactions together with weak interlayer antiferromagnetic interactions in this system.

Single crystal structure



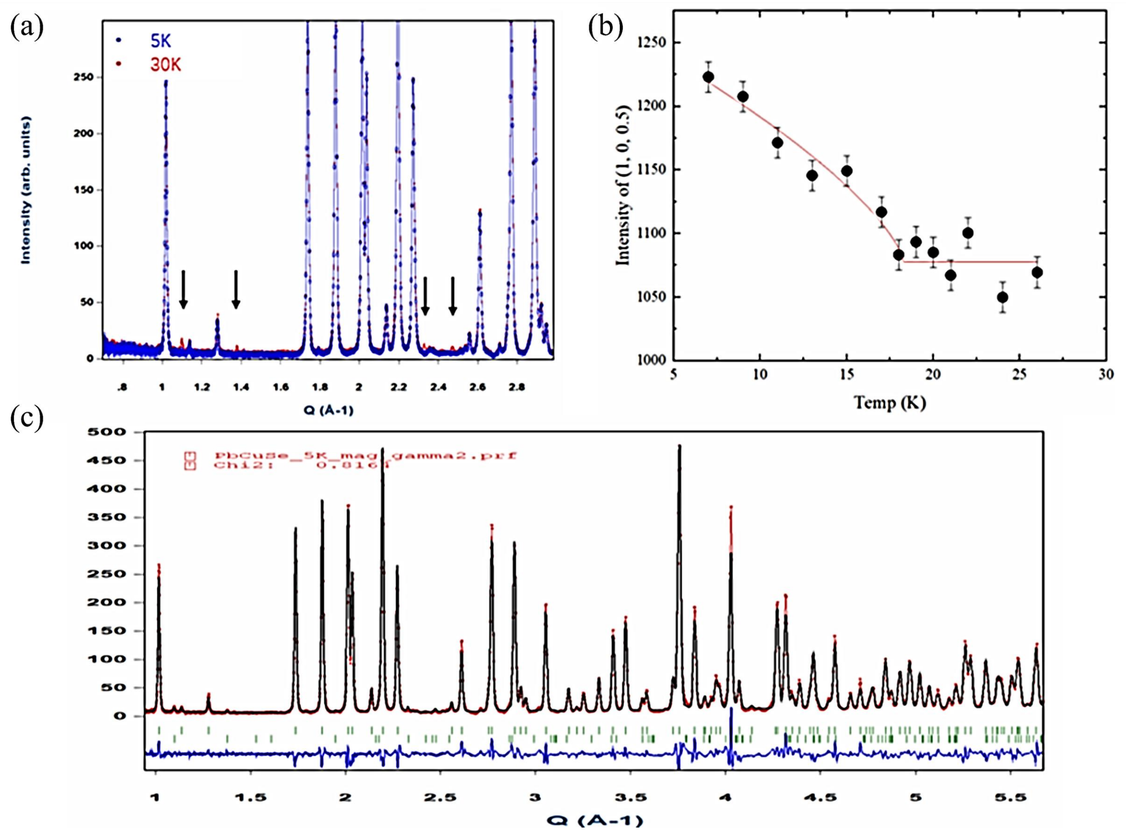
(a-b) Crystal structure has been shown in two different directions. When viewing along a-axis, clear quasi two dimensional structure could be observed. The breathing kagome lattice could be seen while viewing along c-axis. The motif has been marked out in by white lines. **(c)** A photograph of a typical $Pb(OF)Cu_3(SeO_3)_2(NO_3)$ single crystal sample. **(d)** The 2θ scan of the joint plane (0 K 2K) of single crystal $Pb(OF)Cu_3(SeO_3)_2(NO_3)$ sample. The inset shows the Rocking curve of the (0 2 4) peak.

Heat capacity and susceptibility



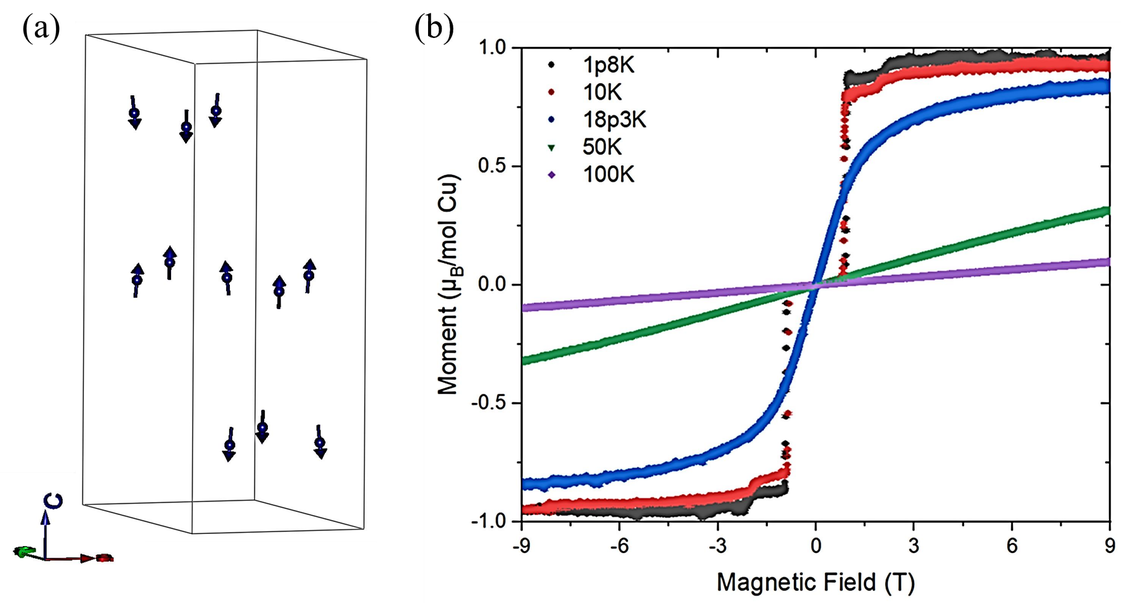
Heat capacity measured on single crystal with external field lies within ab-plane **(a)** and along c-axis **(b)**. Sharp λ-like peaks could be seen in the data of both field directions but field along c-axis seems to suppress the phase transition faster than field applied within the plane. Besides, field along c-axis would leave a hump after the sharp peak is suppressed while the hump is not seen for measurements with external field applied within ab-plane. Susceptibility measured with external field within ab-plane **(c)** and along c-axis**(d)**. Both data sets obey Curie-Weiss behavior at high temperature. The peak intensity for the susceptibility measurement with field along c-axis is higher while the residual part is much smaller compared to the measurements taken with an in-plane magnetic field.

Neutron diffraction taken on polycrystalline $Pb(OF)Cu_3(SeO_3)_2(NO_3)$ at POWGEN, SNS.



(a) Extra peaks could be seen whet the sample is cooled below phase transition temperature, as marked in the plot with black arrows. **(b)** Order parameter of the antiferromagnetic phase transition of $Pb(OF)Cu_3(SeO_3)_2(NO_3)$ with T_n = 18.26K. **(c)** The full pattern of the neutron diffraction of Pb(OF)Cu3(SeO3)2(NO3) measured at 5K. Red dots stands for data points while black lines are from Rietveld refinements.

Magnetic structure we determined and magnetization measurement



(a) Magnetic structure of $Pb(OF)Cu_3(SeO_3)_2(NO_3)$ get from Rietveld refinement. The magnetic moments mostly align along c-axis along with a small canting along (H -H) within ab-plane. The total ordered moment is 0.97 μ_B, which means the Cu^{2+} are almost fully ordered. **(b)** Magnetization measured on single crystal. The main figure stands for data measured with external along c-axis and the inset is for field within ab-plane. Clear stairs could be seen when the field is along c-axis, which indicates that magnetic fields outside the breathing kagome planes tends to flip the whole layer of copper ion moments simultaneously while if we apply an in-plane field, the moments would be polarized gradually with increasing magnetic field. The fully polarized moment for $Pb(OF)Cu_3(SeO_3)_2(NO_3)$ is about 1 μ_B for both directions, which is consistent with the moment get from neutron diffraction..