Dielectric Constant and Dilatometry in the Organic Quantum Magnet CDC

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Introduction

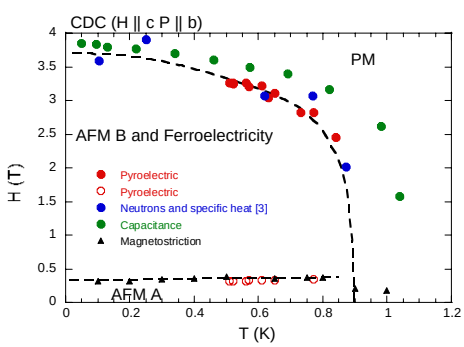
This year we reported ferroelectricity induced by magnetic fields in the organic quantum magnet CDC ($CuCl_2 \cdot 2(CH_3)_2SO$) [1], which we observed via the pyroelectric effect in pulsed magnetic fields. This is the first example of multiferroic behavior in an organic quantum magnet. This compound contains chains of Cu S=1/2 spins [2] that exhibit antiferromagnetic (AFM) order below T_N = 0.93 K, observed in specific heat and neutron diffraction measurements [3]. For H applied along the crystallographic c-axis, two phases (AFM A and B) are observed separated by a spin-flop transition at 0.35 T, where the B phase breaks inversion symmetry. Here we complement the previous pyroelectric measurements via dielectric effect and magnetostriction measurements on the same sample.

Experimental

The dielectric constant was measured capacitatively down to 20 mK in the liquid mixing chamber of the dilution refrigerator of the 20 T magnet at NHMFL-LANL. In order to rule out magnetostriction effects affecting the capacitance measurements, we also measured this compound in a dilatometer in vacuum for H || c and L || b down to 50 mK in the same dilution refrigerator. In the dilatometer, the capacitance is measured across two plates not spanning the sample, so dilatometry and dielectric effects of the sample can be separated.

Results and Conclusion

The capacitance of the sample is shown in Fig 2. Second order-like transitions are observed at the AFM B to PM phase transition near 4 T, confirming the existence of an electric ordering in the sample at the same fields and temperatures as antiferromagnetism. The magnetostriction on the other hand does not show the 4 T transition, and shows only a very weak signal at the spin-flop transition at 0.35 T. This difference between the two measurements confirms that the capacitance measurements are not significantly affected by magnetostriction effects and are therefore indicative only of the dielectric constant. The phase diagram in Fig 1 indicates that the peaks in the capacitance occur at slightly higher temperatures than those measured via specific heat, neutrons, and the pyroelectric effect.



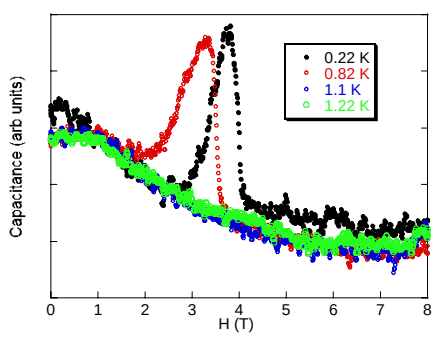


Fig 1: Phase diagram of CDC showing regions of AFM with inversion symmetry (AFM A), AFM without inversion symmetry (AFM B) ferroelectric polarization, and paramagnetism (PM). Capacitance and magnetostriction data points are from this work, pyroelectric effect data points from [1] and neutron and specific heat data from [3].
Fig 2: Capacitance measurement of CDC along b vs magnetic field along c. Data shifted by a constant for clarity.

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References

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