Magnetostriction and Thermal Expansion Measurements in Azurite in Vacuum at Dilution Fridge Temperatures in Magnetic Fields up to 18 T

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Introduction

Azurite is a dark blue mineral $Cu_3(OH_2)(CO_3)_2$ with the monoclinic structure. The discovery of an antiferromagnetic (AF) transition at 1.8 K involving only one third of the Cu magnetic ions suggests a picture for this compound in which two groups of spins can be defined **[1]** and the model structure is the frustrated distorted diamond chain having J1, J2 and J3 AF exchange coupling constants **[2]**. The dominant J2 interaction between the spin ½ half on the Cu(2) sites yields the formation of singlet dimers. Below 1.8 K, an additional AF coupling between the remaining monomers on the Cu(1) sites is switched on leading to the AF transition. The proposed model structure for azurite is however disputed **[3][4]**, recent neutron scattering measurements indicating a non frustrated structure with J3 < 0 and J1 ~ 0 below 1.8 K **[4]**. In the present work, we investigate the effects of the inter-monomers ordering on the lattice carrying out dilatometry measurements in vacuum between 50 mK and 2.3 K in fields up to 18 T at NHMFL-LANL. The purpose is two-fold: to demonstrate the feasibility of such a measurement and to gain insight into the spin correlations in this particular compound.

Experimental

The lattice length changes have been measured along the *a*, *b* and *c* high symmetry axis of azurite single-crystals oriented by X-ray diffraction and polished down to a parallel-plate flat-face shape of ~ 8 mm^3 size. The dilatometer is a Ti capacitive cell **[5]** of 0.75 in. diameter that can be placed into the vacuum space of the 20 T dilution refrigerator at NHMFL-LANL. A proper thermal linking to the mixing chamber yields a cooling down to 50 mK where the absence of thermal gradient was checked by recording the temperature on the mixing chamber in the zero magnetic field region and on the sample platform screw. The design of a Ti cell holder allowed us to apply the magnetic field both along the direction of expansion and orthogonal to it so as to probe the volume expansion. Measurements consisted of sweeping the magnetic field at fixed temperature at a rate of 0.05 (0.2) T/mn at 100 mK (1 K) and ramping the temperature step-wise at fixed field. Prior to azurite, a Cu standard was measured so as to have an estimate of the order of magnitude of the cell background : $|\Delta L/L| \leq 3.\ 10^{-6}$.

Results and Conclusion

Clear signatures of the transition into the AF long range ordered phase and into the 1/3 magnetization plateau **[2]** are observed in the thermal expansion and magnetostriction curves as seen **Fig.1** allowing for a comprehensive mapping of the phase diagram for the 3 configurations: (*H* // *a*), (*H* // *b*) and (*H* // *c*). The average magnitude of the measured total length change ΔL/L in azurite is 5.10^{-4} in field *vs* 1.10^{-5} in temperature. Data treatment and analysis of the geometry of the lattice change as a function of the direction of the field are underway.

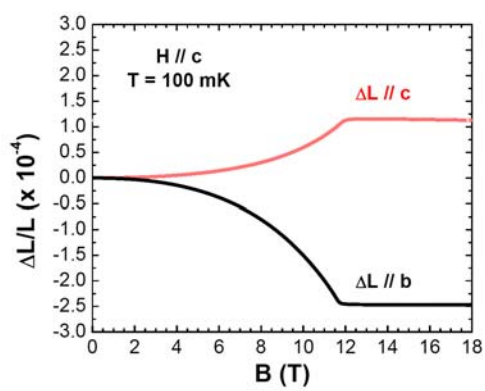

Fig.1. Relative length changes at T = 100 mK for *H* // *c* along the direction *b* of the chains and along *c*

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References

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