Thermal Expansion of Azurite between 3 and 110 K in Magnetic Fields up to 15 T

S. Francoual, F. Wolff-Fabris, V. Zapf (NHMFL-LANL)

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 and a plateau at 1/3 of the saturation magnetization in M vs H curve suggests a picture for this compound in which two groups of spins can be defined **[1]** and the model structure is the 1D 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]**, indicating a non frustrated structure with J3 < 0 and J1 ~ 0 below 1.8 K **[4]**. Previous dilatometry measurements at NHMFL-LANL have allowed us to map out the phase diagram associated with the long range AF order for the field applied along the 3 crystallographic axis *a*, *b* and *c*. In the present series of measurements, the volume thermal expansion is measured in a more extended temperature range from 3 K to 110 K at fixed fields applied along *c*.

Experimental

The lattice length changes were measured using a Ti dilatometry parallel-plate capacitive cell **[5]**. In the present set-up, the cell and sample sit in vacuum in a conical seal in the sample space of a 15T superconducting magnet equipped with a VTI. Measurements consisted at sweeping the temperature at fixed fields with a variable rate (≤ 0.1 K/mns for T ≤ 50 K, 0.2 K/mns for 50 K ≤ T ≤ 100 K and 0.4 K /mns for T ≥ 100 K) and pumping on the He^4 at a rate of 3.5 Torr.

Results and Conclusion

Fig. 1 shows the thermal expansion coefficient of Azurite measured along the three crystallographic directions in zero field. Expansion along *a* and *c* axes has a similar behavior over the entire temperature range. Expansion along *b* axis has opposite behavior as compared to the other two crystalline directions which points to the Poisson effect. As the compound is cooled down below 60 K, spin-spin correlations makes the *a* and *c* axis to expand and the *b* axis to shrink. An extremum is observed at about 20 K along all three crystallographic directions which extremum can be related to a maximum in the magnetic susceptibility previously observed which was associated with the formation of the dimers **[2]**. Interestingly, as the temperature is further lowered, a sign change of the thermal expansion coefficient is seen at 9 K, which indicates a different magneto-elastic coupling upon switching on the interaction between monomers on the Cu(1) sites. Another extremum of the expansion along 3 axes is visible around 4.5 K. Effect of the magnetic field on the thermal expansion curves is of importance below 20 K (not shown here). Analysis of the magneto-elastic coupling as a function of field and temperature and of the implication for the nature of spin-spin correlations and exchange parameters is underway.

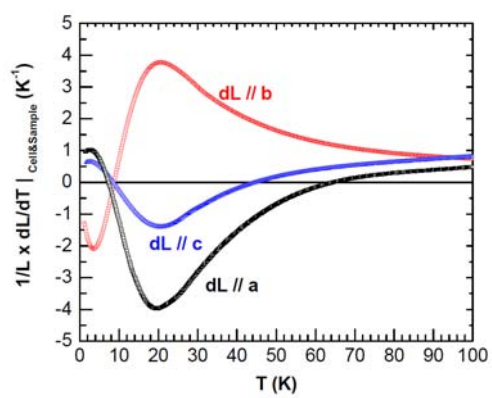

Figure 1 – Thermal Expansion coefficient in Azurite along *a*, *b* and *c* at 0 T (Cell effect not corrected)

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References

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