ESR Studies of the Natural Mineral Azurite, a Spin-1/2 Antiferromagnet with Distorted Diamond Structure

S. Zvyagin, D. Kamensyi, M. Ozerov, J. Wosnitza (Dresden High Magnetic Field Laboratory, HZDR), J. Krzystek (NHMFL)

Introduction

The natural mineral azurite, $Cu_3(CO_3)_2(OH)_2$, is the best known realization of a spin-1/2 antiferromagnet with a distorted-diamond chain structure, in which the combined effect of frustrations and dimensionality can be studied. One of the most prominent features of its magnetic properties is a magnetization plateau at one third of the saturation magnetization. For magnetic field applied perpendicular to *a* axis, the presence of the plateau was revealed between H_{c1} = 11.4 T and H_{c2} = 31 T, while the magnetization becomes almost fully saturated at H_{c3} = 34 T [1]. Such behavior was explained employing an effective model with two interpenetrating but effectively isolated (or weakly-interacting) magnetic sublattices, formed by spin dimers and monomer chains [2]. The experimental program has proposed to study the excitation spectrum of azurite by means of electron spin resonance (ESR) in magnetic fields up to 25 T, which would allow us to test the proposed model employed previously for the description of magnetic properties of azurite.

Experimental

The experiments were performed in magnetic fields up to 25 T using the Keck resistive magnet (cell 6) in the combination with the set of Backward Wave Oscillators covering the frequency range ca 100 – 1000 GHz and at a temperature of 1.4 K.

Results and Discussion

The experiments were performed with magnetic field applied along *a* and *c* axes. Five ESR modes were observed. The frequency-field diagrams of the observed ESR modes for H II *a* are shown in **Figure 1**. Although the detailed interpretation of the obtained frequency-field diagram of magnetic excitations in azurite remains an open question, the presence of these modes as well as unusual ESR modes parameters (for instance, g-factor of modes A and B, g ~ 3.4) clearly illuminate the limitation of the isolated dimer-monomer spin chain model. Theoretical work aimed to describe the ESR excitations spectrum in azurite is in progress.

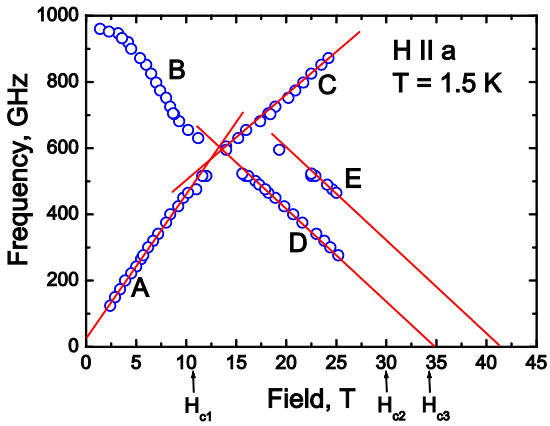

Figure 1. Frequency-field diagram of ESR modes observed in azurite at T = 1.4 K (H II a).

Conclusions

ESR studies of azurite performed in a very broad range of frequencies in magnetic fields up to 25 T revealed a rich excitation spectrum (presumably containing the contributions of dimer, monomer and the dimer-monomer bound states). Our next step will be to perform ESR experiments above H_{c2} and H_{c3} (using the 45 T Hybrid magnet at the NHMFL) in order to clarify the nature of the observed excitations and to study their behavior in the vicinity of the second and the third critical fields.

Acknowledgements

This work was partly supported by the DFG and EuroMagNET (EU contract No. 228043).

References

[1] Kikuchi, H., *et al*., Phys. Rev. Lett., **94**, 227201 (2005).
[2] Eschke, H., *et al*., Phys. Rev. Lett., **106**, 217201 (2011).