# Magneto-Electric Effects in Metal-Organic Quantum Magnet

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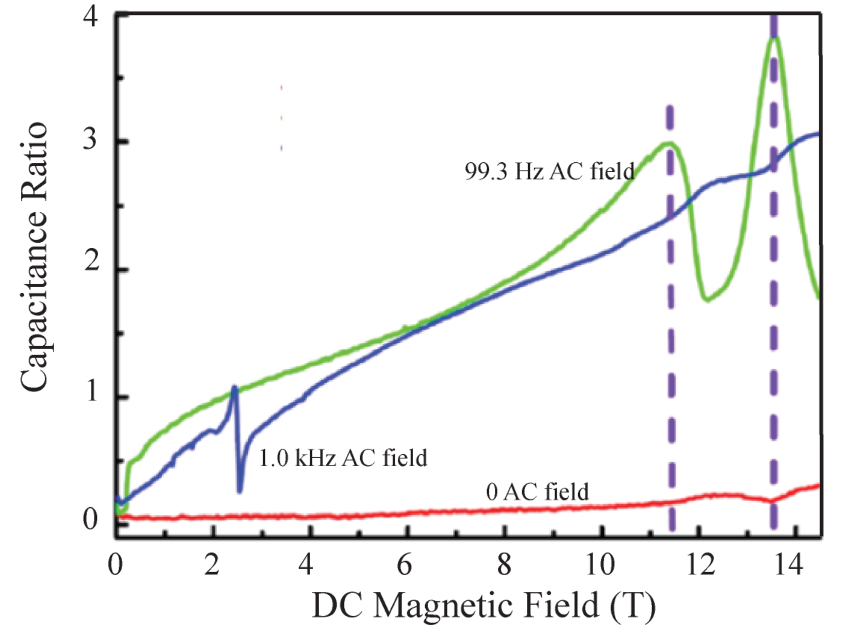
New magneto-electric effects have been observed in molecular-based materials in which the coupling of the magnetization and electrical polarization is very different to that in inorganic oxides. Crystals of the dichloro-tetrakis-thiourea type were recently studied, with a chemical formula of $MCl_2$-$4SC(NH_2)_2$ where M = Ni or Co. The magnetization of these metal-organic quantum magnets arises from the M ions and the electrical polarization results from the polarizable thiourea molecules surrounding each metal ion.

*Magnetic fields drive Bose-Einstein phase transitions of the spin degrees of freedom, evidenced by changes in the electric and magnetic susceptibilities at ultra-low temperatures.* If disorder is introduced, new Bose glass states are formed [1].

The green curve the figure shows the strong magnetic-field-induced changes in the dielectric constant observed at 99 Hz for a single crystal of a Br doped dichloro-tetrakis-thiourea-nickel (DTN) crystal: $NiCl_{1.85}Br_{0.15}$ - $4SC(NH_2)_2$. The quadratic magnetic field dependence of the electric polarization in the magnetically ordered state, from 0.9T < B < 11.3T, is consistent with the observations of Ref. [2]. A sharp drop occurs at the transition to the Bose Glass state from 11.3 < B < 12.4 T. The second peak at B ~ 13.6T is attributed to a transition to the Mott insulator state [1].

There is great interest in systems with large magneto-electric effects, due to potential applications as high sensitivity sensors. Understanding the magneto-electric effect in a well-studied material, such as DTN, is important for establishing the fundamental physics of the far more complex systems at higher temperatures.




Magnetic field induced changes in the dielectric constant of Br-doped DTN at very low temperatures as a function of applied DC magnetic field at 20 mK [3]. Three changes are observed; (i) a sharp dispersive response at the low critical field (B~2.2T), (ii) a peak at the upper critical field (B~11.4T), and (iii) a peak at B~13.6 T, corresponding to the onset of a Mott insulator state.

**Facility used:** Bay 3 of the MagLab's High B/T Facility.

## References

[1] Yu R., *et al.*, *Bose glass and Mott glass of quasiparticles in a doped quantum magnet,* Nature **489**,379 (2012).
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[3] Xia, J.S., *et al.*, *Magneto-electric Effect and Dielectric Susceptibility Measurement Technique at Very Low Temperature,* J. Low Temp. Phys. **18**7,627 (2017).