Quantum coherent spin-electric control in molecular nanomagnets

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Electrical control of spins at the nanoscale offers significant architectural advantages in spintronics, because electric fields can be confined over shorter length scales than magnetic fields. Thus, recent demonstrations of electric-field (E-field) sensitivities in molecular spin materials are tantalising, raising the viability of the quantum analogues of macroscopic magneto-electric devices.[1] However, the E-field sensitivities reported until recently are rather weak, prompting the question of how to design molecules with stronger spin-electric couplings. Here we show that one path is to identify an energy scale in the spin spectrum that is associated with a structural degree of freedom with a significant electrical polarisability. We study an example of a molecular nanomagnet in which a small structural distortion establishes clock transitions (i.e. transitions whose energy is to first order independent of magnetic field) in the spin spectrum; the fact that this distortion is associated with an electric dipole on the molecule allows us to control the clock transition energy to an unprecedented degree.[2] We demonstrate coherent electrical control of the quantum spin state and exploit it to manipulate independently the two magnetically-identical but inversion-related molecules in the unit cell of the crystal. Theoretical modelling allowed us to rationalize the experimental observations on the basis of the control of the molecular geometry (Fig. 1). Although current experiments are on single-crystal rather than single-molecule, our findings pave the way for the use of molecular spins in quantum technologies and spintronics.

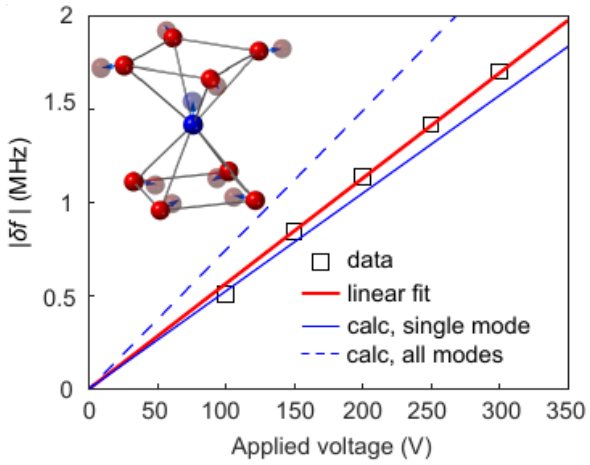

Fig.1: Electric field coupling to the transition frequencies between spin states at the “clock transition”.

References

[1] Liu, J. et al. Electric Field Control of Spins in Molecular Magnets. *Phy. Rev. Lett.* **122**, 037202 (2019).

[2] Liu, J. et al., Quantum coherent spin-electric control in molecular nanomagnets, arXiv:2005.01029