Max-Planck-Institut für Struktur und Dynamik der Materie

Max Planck Institute for the Structure and Dynamics of Matter

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CFEL Seminar room III (Bldg. 99)

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Electrical control of quantum spins

Magnetic fields are challenging to localise to short length scales because their sources are electrical currents. Conversely, electric fields can be applied using electrostatic gates on scales limited only by lithography. This has important consequences for the design of spin-based information technologies: while the Zeeman interaction with a magnetic field provides a convenient tool for manipulating spins, it is difficult to achieve local control of individual spins on the length scale anticipated for useful quantum technologies. This motivates the study of electric field control of spin Hamiltonians [1].

Mn2+ defects in ZnO exhibit extremely long spin coherence times and a small axial zero-field splitting. Their environment is inversion-symmetry-broken, and the zero-field splitting shows a linear dependence on an externally-applied electric field. This control over the spin Hamiltonian offers a route to controlling the phase of superpositions of spin states using d.c. electric field pulses, and to driving spin transitions using microwave electric fields [2].
Experiments on Mn defects in ZnO provide insights into how to achieve manipulation of individual spins on surfaces using a scanning tunnelling microscope. A high-frequency voltage applied to the tip can drive electron spin resonance in Fe atoms on MgO surfaces via modulation of the crystal field experienced by the Fe atom [3].
It has been proposed theoretically that frustrated exchange-coupled molecular clusters might offer sensitivity to externally-applied electric fields [4]. Experiments on an antiferromagnetically-coupled Cu3 compound reveal a small linear electric field effect. A comparable sensitivity is exhibited by the heterometallic S = 1 antiferromagnetic ring Cr7Mn, but no effect is found for the S = 1/2 Cr7Ni [5].

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