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Investigation of Ferromagnetic Semiconductors through Depth Resolved Spin Resonance Techniques

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Ferromagnet-Semiconductor heterostructures show immense promise for device applications, in particular for the injection of polarised spins into a semiconducting substrate. More fundamentally, prototypical systems like the III-V semiconducting materials Ga1−xMnxAs/GaAs or EuO1-x/doped Si exhibit unusual long range indirect exchange interactions mediated by charge carriers in the semiconductor host. By contrast, the dominant mechanism of exchange in magnetic insulators is usually superexchange. Large changes in the electronic structure occur as the temperature is reduced through the Curie temperature, caused by an exchange splitting of the conduction band in the ferromagnetic state.

This unusual interplay between magnetism and transport properties opens up interesting and potentially technologically useful possibilities of modulating magnetic behaviour by controlling the charge carrier properties and vice versa. Artificial heterostructures based on these ferromagnetic semiconductors may be produced in thin film form using nonequilibrium molecular beam epitaxy techniques. Investigations using local probes which are sensitive to magnetic structure on a nanometre depthscale are therefore invaluable. I will discuss our recent studies of the internal magnetic field distribution and spin fluctuations in these model materials for spintronic devices using depth resolved Low Energy μSR and β-detected Nuclear Magnetic Resonance, complementary spin resonance techniques.

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