Ferromagnetism of mobile electrons in a two-dimensional semiconductor

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Project description

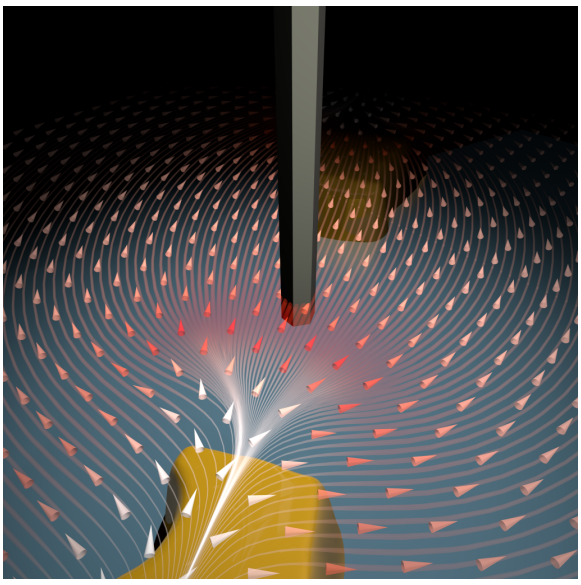
Felix Bloch suggested many years ago that mobile electrons in a metal should form a ferromagnetic state at low density.

Ferromagnetism means in this context that the electron spins all point in the same direction. The ferromagnetism is a consequence of the repulsion of the individual electrons via the Coulomb force along with the Pauli principle. This ferromagnetic state is irrelevant for normal metals – the electron density is too high – and elusive in conventional semiconductor such as silicon – at the relevant densities, the electrons become trapped in space ("localised") by disorder even in the cleanest samples.

The situation changes radically in a two-dimensional semiconductor such as MoS_2. The repulsion between the electrons is particularly strong largely because there is so little material to screen the Coulomb force such that the ferromagnetic state may form at accessible electron densities.

Initial optical experiments suggest that the electrons do indeed form a ferromagnetic state. However, the optical probe is an indirect measure of the spin states of the electrons.

The ultimate goal of this project is to detect ferromagnetism of electrons in a two-dimensional semiconductor in a direct and unambiguous way using an ultra-sensitive nano-magnetometer. The project involves the fabrication of ultra-clean two-dimensional semiconductors, their characterisation with optical techniques (local measurements of both photoluminescence and the optical susceptibility), and an investigation of their magnetic properties using state-of-the-art nano-magnetometers. The project aims at establishing a new direction in magnetism, and to demonstrate the efficacy of an exquisitely sensitive and versatile magnetic nano-probe.



Magnetic nanowire as local magnetic field sensor (Department of Physics, University of Basel)