Spin-orbit effects in transport and magnetism

Since the relativistic spin-orbit interaction couples electron's momentum and spin it can lead to a range of effects when the system is brought out of equilibrium by, e.g., applied electric fields. Anisotropic magnetoresistance is a classical example of a relativistic magneto-transport effect, discovered in transition metal ferromagnets more than 150 years ago, that led to the development of the first generation of spintronic magnetic sensors and random access memory chips [1,2]. Remarkably, non-equilibrium spin-phenomena may occur even in non-magnetic spin-orbit coupled conductors. Prime examples are the spin Hall effect and the inverse spin galvanic effect which were experimentally discovered a decade ago as companion effects in normal semiconductors [3]. In the spin Hall effect, an electrical current passing through a material with relativistic spin-orbit coupling can generate a transverse pure spin-current. In the inverse spin galvanic effect, a non-equilibrium spin-density of carriers is generated in spin-orbit coupled systems which lack inversion symmetry. Recently discovered relativistic spin torques in ferromagnets, originating from the spin Hall and inverse spin galvanic effects, are a subject of an intense research and are a candidate spintronic technology for a new generation of electrically-controlled magnetic memory and logic devices. Apart from paramagnets and ferromagnets we will show in the lecture that the relativistic magneto-transport phenomena provide means for realizing spintronic functionalities also in antiferromagnets.

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