TUT 3: Tutorial: Spin Hall Effect and Spin-Orbit Torques (MA)

Organizers: Karin Everschor-Sitte and Matthias Sitte (Johannes Gutenberg Universität Mainz)

In spintronics, magnetic textures are manipulated by spin-polarized currents. A traditional way to obtain a spin-polarized current is by sending an electric current through a ferromagnet. A different option is to exploit the spin Hall effect which is the generation of a spin current perpendicular to an applied charge current. This tutorial provides an introduction into the field of spin Hall effect and spin-orbit torques.

Time: Sunday 16:00–18:30 Location: H17

Tutorial TUT 3.1 Sun 16:00 H17

Introduction to Spin Hall Effect — •Christian Back — University of Regensburg, Regensburg, Germany

We give here an overview of the spin Hall effect. Since its discovery over a decade ago the spin Hall effect has been one of the most researched areas of spintronics, with multiple unexpected new phenomena arising from its studies. Its origins, both intrinsic and extrinsic, have been studied both theoretically and experimentally, giving us now a rich picture of this phenomena which is present in many branches of spintronics. It is connected of course to the anomalous Hall effect, but in recent years it is understood to be linked closely with magnetization dynamics as well as inverse spin Galvanic effect. The fields of Topological Insulators also arose from the spin Hall effect in the limit if large spin-orbit coupling. We summarise the recent review written on the subject that covers most of the developments over the last decade.

15 min. break

Tutorial TUT 3.2 Sun 17:00 H17

Magnetisation of ferromagnetic nanostructures manipulated by spin-orbit torques — •Stefania Pizzini — Institut Néel, CNRS, Grenoble, France

It has been shown recently that spin-orbit torques (SOT) associated to the spin-Hall effect, generated by the flow of an electrical current in the plane of a ferromagnetic/heavy metal bilayer, can be used as an efficient way to manipulate the magnetisation of nanostructures with broken inversion asymmety.

After an introduction to the microscopic origins of the SOT, I will give a review of recent experimental work showing the use of this mechanism to obtain both deterministic switching of nanosized magnets, and efficient propagation of domain walls in nanotracks consisting of ultrathin ferromagnetic layers with perpendicular magnetic anisotropy and strong Dzyaloshinskii-Moriya interaction.

Tutorial TUT 3.3 Sun 17:45 H17

Spin Hall effect and spin-orbit torque from material-specific theory — •Yuriy Mokrousov — Institute for Advanced Simulation, Forschungszentrum Jülich, 52425 Jülich, Germany

The phenomena of spin Hall effect (SHE) in magnetic and non-magnetic materials, and spin-orbit torque (SOT) in magnetic materials with broken inversion symmetry have become major sources of intensive interest for both theoreticians and experimentalists, owing to their importance for future technology based on relativistic effects. In my talk I will present an overview of recent progress in our understanding and description of the SHE and SOT based on the material-specific first principles theory. My particular focus will be both on the intrinsic Berry phase and impurity-driven origins of the SHE and its anisotropy in paramagnets, ferromagnets and antiferromagnets. I will then review the various origins of the SOT in magnetic bilayers, show how the SOT can be understood based on the non-trivial topology of the electronic bands, and outline the relation between the SOT and the spin currents originated in the non-magnetic substrate.