GAUGE FIELDS AND SPIN-MOTIVE FORCES

PROJECT/MASTER THESIS 2013/2014

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The Nobel prize in physics in 2007 was awarded to the European researchers Albert Fert and Peter Grunberg for the discovery of the giant magnetoresistance effect in nano-scale layered ferromagnet-normal metal systems. Nanotechnology based on this insight gives sensitive read-out heads for compact hard drives that are widely used (http://www.research.ibm.com/research/gmr.html). The 2013 Buckley prize in physics, the most important prize in condensed matter physics from the American Physical Society, is awarded to Luc Berger and John Slonczewski for their discovery of spin-transfer torques in magnetic materials.

An electron has a spin as well as a charge. The recognition of spin as binary variable analogues to electrons and holes in semiconductors has opened a new field of science and technology, ***SPINTRONICS***, that can continue to revolutionize nanoscale science and information technology.

The research project will explore quantum spin transport in nanostructures. In particular, we are interested in the reciprocal phenomena of spin-transfer torques, spin-pumping and spin-motive forces. A spin-transfer torque is a transfer of angular momentum from currents to the magnetization and can induce magnetization dynamics, for instance it can move domain walls in ferromagnets. Prototypes of magnetic random access memories based on this effect arrived on the market in late 2012. Spin-pumping and spin-motive forces are the reciprocal effect – a dynamical magnetization can induce spin currents that can be detected electrically.

Theoretically, spin-motive forces can be understood as a result of a fictitious gauge field arising from the dynamical magnetization in a certain reference frame. This can be understood as effective electric fields that differ for spin-up and spin-down electrons. In turn, the electrons move in response to these effective electric fields. However, electrons also interact among themselves, and it is presently not clear how these interactions will modify the spin-motive forces (effective electric fields). The goal of the project/master thesis is to discover how electron-electron interactions modify spin-motive forces.

The project/master thesis is well suited for ambitious and talented students who have a strong background and interest in quantum mechanics, mathematics, and modeling.

CONTACT

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