MA 10: Focus Session "Topological Transport in Systems with broken Time Inversion Symmetry", Organization: Stefan Blügel (FZ Jülich)

Time: Monday 15:00–17:15 Location: H 1012

Invited Talk MA 10.1 Mon 15:00 H 1012
Theory of the anomalous Hall effect: from the metallic fully ab-initio studies to the insulating hopping systems — •Jairo Sinova — Department of Physics, Texas A&M University, College Station, Texas 77843-4242, USA

A consistent description of spin-dependent Hall transport in the spin-orbit coupled systems has been a challenge for many decades. The theory of the anomalous Hall effect (AHE) and its non-magnetic counterparts involves a description of transport in multi-band system with inter-band coherent. It is only over the past couple of years that a clear theoretical picture has emerged recently. Within the metallic regime these pictures are robust and there is now an full formulation of the scattering-independent contributions in the metallic regime which is amenable to ab-initio studies [1]. We report on first-principles calculations of the side-jump contribution to the anomalous Hall conductivity directly from the electronic structure of a perfect crystal. We implemented our approach in elemental bcc Fe, hcp Co, fcc Ni, and L10 FePd and FePt alloys and are able to capture systematically the experimental observations [2]. On a different part of the phase diagram of AHE transport, we have developed a full theory of the AHE in the hopping regime [3]. The theory fully captures the observed anomalous scaling behavior in different insulating ferromagnetic thin films, completing the understanding of the AHE phase diagram.

[1] A. A. Kovalev, et al, Phys. Rev. Lett. 105, 036601 (2010). [2] Juergen Weischenberg, et al, Phys. Rev. Lett. 107, 106601 (2011). [3] Xiong-Jun Liu, et al, Phys. Rev. B 84, 165304 (2011).

Topical Talk MA 10.2 Mon 15:30 H 1012
Engineering topological transport via control of the spin-orbit interaction — •Yuriy Mokrousov — Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, Germany

The spin-orbit interaction (SOI) in a crystal plays a central role in various phenomena ranging from spin-relaxation in metals to the emergence of non-trivial topological phases in insulators. Here, we analyze how the origin of SOI, its spin-conserving and spin-non-conserving nature, as well as its interplay with impurity scattering can affect the topological transport properties in metals and insulators. In particular we focus on the case of the anomalous Hall effect in metallic ferromagnets [1, 2] and quantum anomalous Hall effect in two-dimensional topological insulators [3], suggesting how via control of the SOI non-trivial topological states can be stabilized, and their experimental observation made simpler.

[1] H. Zhang, F. Freimuth, S. Blügel, Y. Mokrousov and I. Souza, Phys. Rev. Lett. **106**, 117202 (2011)

[2] J. Weischenberg, F. Freimuth, J. Sinova, S. Blügel and Y. Mokrousov, Phys. Rev. Lett. **107**, 106601 (2011)

[3] H. Zhang, C. Lazo, S. Blügel, S. Heinze and Y. Mokrousov, arXiv:1108.5915v1 (2011)

Invited Talk MA 10.3 Mon 16:00 H 1012
Topological phases with broken time-reversal symmetry in pyrochlore iridates — •Shigeki Onoda — Condensed Matter Theory Laboratory, RIKEN, Wako, Japan

Possible topological phases in pyrochlore iridates are invistigated theoretically. An effective single-orbital tight-binding model is derived by extracting Wannier functions from first-principles band calculations on hypothetical $La_2Ir_2O_7$ with varying crystal parameters, which mimics the changes only in the radius of rare-earth ions R for $R_2Ir_2O_7$. Then, introducing the on-site Coulomb repulsion, we solve the effective Hubbard model with the Hartree-Fock approximation. As a function of the Coulomb repulsion, the bandwidth, and the strength of the trigonal distortion, the ground state can exhibit not only metal and Weyl semimetal but also a canted antiferromagentic insulator showing a nonzero uniform magnetization. This is a so-called Chern insulator in three spatial dimensions and exhibits a quantum anomalous Hall effect. Properties of the phase transitions and relevance to experimental systems are also discussed.

Invited Talk MA 10.4 Mon 16:30 H 1012
Topological Hall effects of electrons and magnons — •Yoshinori Onose and Yoshinori Tokura — Department of Applied Physics, Universtiy of Tokyo, Tokyo, Japan

While the Hall effect is usually driven by the Lorentz force in an external magnetic field, it can also be induced by the Berry phase due to the topological structure of electronic and/or magnetic states. In this talk, we present two examples of such "topological" Hall effects. The first example is the topological Hall effect in Skyrmion crystal phase. Quite recently, the crystallization of Skyrmions, which are the topological magnetic textures with spin chirality, was found in B20 transition metal compounds such as MnSi and $Fe_{1-x}Co_xSi$[1]. In this talk, we present the Hall effect caused by the Berry phase originating from the topological spin arrangement of Skyrmion[2]. The second topic in this talk is our recent finding of the Hall effect of magnons. The Berry phase induced Hall effect is also expected for charge neutral particles such as magnons. Recently, we have succeeded in observing the magnon Hall effect in terms of thermal transport[3]. The effect of the lattice geometry for the magnon Hall effect will also be discussed.

These works were done in collaboration with X. Z. Yu, N. Kanazawa, T. Ideue, H. Katsura, Y. Shiomi, S. Ishiwata, D. Okuyama, S. Wakimoto, T. Arima, J. H. Han, K. Kakurai, and N. Nagaosa.

[1] X. Z. Yu, Y. Onose *et al.,* Nature 465, 901 (2010). [2] N. Kanazawa, Y. Onose *et al.,* Phys. Rev. Lett 106, 156603 (2011). [3] Y. Onose *et al.,* Science 329, 297 (2010).

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