MA 53: Focus Session: Topology meets Magnetism

Organized by Jürgen Henk, and Ingrid Mertig (Martin-Luther-Universität Halle)

The assembly of topology and electronic structure theory has brought condensed matter physics to a new summit. Recent highlights are the discoveries of topological insulators as well as Dirac and Weyl semimetals, bringing exotic surface states and transport phenomena into the focus of todays research. Could topology inspire the field of magnetism likewise? This question is answered by leading experts from both experimental and theoretical physics in this session. The subjects comprise Skyrmions as well as topological magnon insulators and semimetals, with foci on transport phenomena and the topological properties of magnons.

Time: Thursday 15:00–17:45 Location: HSZ 01

Invited Talk MA 53.1 Thu 15:00 HSZ 01
Topological phases for magnons and electrons in the skyrmion lattice — •Joaquín Fernandez-Rossier — QuantaLab, International Iberian Nanotechnology Laboratory (INL), Braga, Portugal

In this talk I will present two topological phases driven by a skyrmion lattice. First, I will discuss the electronic Quantum Anomalous Hall phase predicted to occur when graphene is placed on top of a triangular skyrmion lattice [1]. Second, I will show that the spin waves associated to a skyrmion lattice have a finite Berry curvature and a non-zero Chern number, forming thereby a phase topologically different from spin waves in conventional ground states [2]. The skyrmion lattice emerges spontaneously as a competition between ferromagnetic exchange, Dzyalonshinkii-Moriya interactions, Zeeman coupling and uniaxial anisotropy in a triangular lattice. I discuss the properties of the resulting topological spin-wave edge states, most notably their unidirectional propagation.

[1] Quantum Anomalous Hall effect in graphene coupled to skyrmions

J. L. Lado , J. Fernandez-Rossier Physical Review B 92, 115433 (2015)

[2] Topological spin waves in the atomic-scale magnetic skyrmion crystal

A. Roldan-Molina, A. S. Nunez, J. Fernandez-Rossier, New Journal of Physics 18, 045015 (2016)

Invited Talk MA 53.2 Thu 15:30 HSZ 01
Thermal Hall Effect of Spin Excitations in Quantum Magnets — •Max Hirschberger[1], Robin Chisnell[2], Jason W. Krizan[3], Young S. Lee[2], Robert J. Cava[3], and N. Phuan Ong[1] — [1]Department of Physics, Princeton University, USA — [2]Department of Physics, Massachusetts Institute of Technology, USA — [3]Department of Chemistry, Princeton University, USA

In magnetic materials without delocalized electrons, the thermal Hall effect κ_{xy} is a sensitive tool to explore the topological properties of low-energy magnetic (spin) excitations in a magnetic field. For magnetically ordered systems, κ_{xy} is a direct probe of the Berry curvature of the quasiparticle bands. We will illustrate this point using our experimental results for the 2D layered Kagome ferromagnet Cu(1,3bdc). Moreover, we will discuss our measurements of a large κ_{xy} on the frustrated pyrochlore quantum spin ice $Tb_2Ti_2O_7$, and its close relative $Yb_2Ti_2O_7$. Finally, we highlight the absence (to our resolution) of a thermal Hall signal in many other frustrated magnetic systems we have studied recently.

15 min. break

Invited Talk MA 53.3 Thu 16:15 HSZ 01
Magnon-mediated Dzyaloshinskii-Moriya torques, heat pumping, and spin Nernst effect — •Alexey Kovalev — University of Nebraska-Lincoln, USA

We predict that a temperature gradient can induce a magnon-mediated spin Hall response in a collinear antiferromagnet with Dzyaloshinskii-Moriya interactions [1]. To address this problem, we develop a linear response theory based on the Luttinger approach of the gravitational scalar potential which gives a general condition for a Hall current to be well defined, even when the thermal Hall response is forbidden by symmetry. We apply our theory to honeycomb lattice antiferromagnet and study a role of magnon edge states in a finite geometry. As examples, we consider single and bi-layer honeycomb antiferromagnets where the nearest neighbor exchange interactions and the second nearest neighbor DMI are present. From our analysis, we suggest looking for the magnon-mediated spin Nernst effect in insulating antiferromagnets that are invariant under (i) a global time reversal symmetry or under (ii) a combined operation of time reversal and inversion symmetries. In both cases, the thermal Hall effect is zero while the spin Nernst effect could be present. We also consider transport of magnons and its relation to non-equilibrium magnon-mediated spin torques [2]. We apply our theory to the magnon-mediated Nernst and torque responses in systems realizing Weyl magnons.

[1] Phys. Rev. Lett. 117, 217203 (2016)

[2] Phys. Rev. B 93, 161106 (2016)

Invited Talk MA 53.4 Thu 16:45 HSZ 01
Magnon companion pieces to electronic topological materials — •Alexander Mook[1], Jürgen Henk[2], and Ingrid Mertig[1,2] — [1]Max-Planck-Institut für Mikrostrukturphysik, Halle, Deutschland — [2]Martin-Luther-Universität Halle-Wittenberg, Halle, Deutschland

Topology has conquered the field of condensed matter physics with the discovery of the quantum Hall effect. Since then the zoo of topological materials is steadily increasing. In this talk, I demonstrate how to realize different topological phases with magnons: the magnon pendants to topological insulators as well as Weyl and nodal-line semimetals are presented.

Magnon bulk spectra are characterized by topological invariants, dictating special surface properties. For instance, the bulk bands of topological magnon insulators carry nonzero Chern numbers, causing topological magnon edge states that unidirectionally revolve the sample. Magnon Weyl semimetals possess zero-dimensional band degeneracies acting as source and sink of Berry curvature; at their surface they feature "magnon arcs" connecting the surface projections of Weyl points. Magnon nodal-line semimetals exhibit one-dimensional band degeneracies, i.e., closed loops in reciprocal space. Surface projections of these nodal lines host "drumhead" surface states whose details depend strongly on the surface termination.

I discuss possible material candidates and experiments for the identification of these novel states of matter.

Invited Talk MA 53.5 Thu 17:15 HSZ 01
Nonreciprocal propagation of elementary excitations in noncentrosymmetric magnets — •Yoshinori Onose — University of Tokyo, Tokyo, Japan

Simultaneous breaking of spatial inversion and time-reversal symmetries completely lifts the degeneracy between +k and -k states of elementary excitations in solids. In this case, the decay rate and phase velocity depends on the sign of k, and, hence, the propagation of the elementary excitation becomes nonreciprocal. The photonic nonreciprocity, which is denoted as magnetochiral or optical magentoelectric effect, has been investigated extensively in the last two decades. Here, we experimentally study the nonreciprocal propagation of magnons and acoustic waves as well as microwaves in noncentrosymmetric magnets.