MA 53: Magnonics II

Time: Thursday 15:00–16:45 Location: HSZ 401

MA 53.1 Thu 15:00 HSZ 401

Quantum spin transfer due to spin shot noise — •Alireza Qaiumzadeh and Arne Brataas — Center for Quantum Spintronics, Norwegian University of Science and Technology

Recent measurements in current-driven spin valves demonstrate magnetization fluctuations that deviate from semiclassical predictions. We posit that the origin of this deviation is spin shot noise. On this basis, our theory predicts that magnetization fluctuations asymmetrically increase in biased junctions irrespective of the current direction. At low temperatures, the fluctuations are proportional to the bias, but at different rates for opposite current directions. Quantum effects control fluctuations even at higher temperatures. Our results are in semiquantitative agreement with recent experiments and are in contradiction to semiclassical theories of spin-transfer torque [1].

[1] Phys. Rev. B 98, 220408(R) (2018)

MA 53.2 Thu 15:15 HSZ 401

Spin transport through insulating multilayers — •Verena Brehm[1], Ulrike Ritzmann[2], Martin Evers[1], and Ulrich Nowak[1] — [1]University of Konstanz, D-78457 Konstanz — [2]Freie Universität Berlin, D-14195 Berlin

Spin transport in magnetic insulators allows transport without Joule heating. Furthermore, many magnetic insulators are oxides with exceptionally low damping, giving rise to energy efficient transport for future spin-wave based technology. The design of spin-transport based devices such as transistors or spin valves often requires multilayer systems composed of different magnetic materials [1]. Thus, the understanding of the behavior of a spin current propagating across interfaces is crucial.

We study spin transport in two and three layer systems composed of ferro- and antiferromagnets within a classical atomistic spin model numerically. The focus of this talk is on the transmission of a spin current across the interfaces depending on the magnon frequency and on the interface and bulk properties. Furthermore, we investigate the temperature dependence of this transport, in particular for structures where the critical temperature varies significantly between the layers. This allows to study spin transport in the vicinity of the critical temperature, as demonstrated in recent experiments [2].

[1] Cramer et al.: Nat. Commun. **9**, 1089 (2018)
[2] Schlitz et al.: Appl. Phys. Lett. **112**, 132401 (2018)

MA 53.3 Thu 15:30 HSZ 401

Magnon-magnon interactions and how to calculate them in a magnetic film — •Halyna Yu. Musiienko-Shmarova[1], Vasyl S. Tyberkevych[2], Andrey N. Slavin[2], Alexander A. Serga[1], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaisersalutern, Germany — [2]Department of Physics, Oakland University, Rochester, Michigan 48309, USA

Elementary magnetic excitations, often called spin waves or magnons, are widely used in spintronics and magnonics signal processing devices, as they are able to transport energy and spin angular momentum over long distance. Furthermore, recently, fundamental phenomena such as magnon Bose-Einstein condensation, magnonic supercurrents, and Bogoliubov waves were discovered in the field of spin-wave physics. Such processes strongly depend on the interactions between magnons, which can be described using corresponding nonlinear coefficients (nonlinear energy terms of spin-wave Hamiltonian). Besides, the values of these coefficients crucially influence the formation of nonlinear spin-wave objects such as solitons, bullets and droplets. Here, we present a new theoretical approach for the description of weakly nonlinear magnetization excitations. This method allows to directly determine the values of eigenfrequencies and eigenmodes of magnetic excitations and magnon-magnon interaction coefficients in yttrium iron garnet films of different thicknesses for different values and directions of the external magnetic field. Financial support from the ERC Advanced Grant "SuperMagnonics" is acknowledged.

MA 53.4 Thu 15:45 HSZ 401

Stabilizing Bose-Einstein condensation of magnons in ultrathin films using spatial confinement — •Morteza Mohseni[1], Alireza Qaiumzadeh[2], Alexander A. Serga[1], Arne Brataas[2], Burkard Hillebrands[1], and Philipp Pirro[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Center for Quantum Spintronics, Department of Physics, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway

A high density of interacting quasi particles (QPs) can undergo a phase transition to form a new phase of matter known as the Bose Einstein condensate (BEC). It has been predicted that a magnon BEC cannot be stabilized in extended ultrathin insulating magnets of yttrium iron garnet (YIG) [1]. Here, we introduce a new way to stabilize a magnon BEC in an ultrathin film by spatial confinement. Using numerical simulations, we present the formation of a magnon BEC in an ultrathin YIG microconduit and explore the nonlinear scattering processes behind the BEC formation in our system. We show how quantized thermalization channels allow the BEC formation in our confined element. Moreover, we investigate the role of dipolar interactions on the BEC stability in our system. Our results provide new insight into strongly nonlinear spin dynamics in ultrathin films, and further introduce a nontrivial mechanism to obtain BEC stability in nanoscale devices. 1. I. S. Tupitsyn, et al., Phys. Rev. Lett. 100, 257202 (2008)

MA 53.5 Thu 16:00 HSZ 401

Room-temperature magnon Josephson oscillations — •Alexander J. E. Kreil[1], Anna Pomyalov[2], Victor S. L'vov[2], Halyna Yu. Musiienko-Shmarova[1], Gennadii A. Melkov[3], Alexander A. Serga[1], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Department of Chemical and Biological Physics, Weizmann Institute of Science, Rehovot 76100, Israel — [3]Faculty of Radiophysics, Electronics and Computer Systems, Taras Shevchenko National University of Kyiv, Kyiv 01601, Ukraine

The alternating current (ac) Josephson effect is known as a rapidly oscillating current, which appears between weakly coupled macroscopic quantum states, such as superconducting states subject to an external dc voltage. So far, this phenomenon was observed at cryogenic temperatures in superconductors, in superfluid helium, and in Bose-Einstein condensates (BECs) of trapped atoms. A similar effect is expected in a magnon BEC at room-temperature. Here, we report on the experimental discovery of the ac Josephson effect in a magnon BEC carried by a room-temperature ferrimagnetic film. We suggest a theoretical model that adequately describes the observed supercurrent flow, which itself manifests as oscillations in the magnon BEC density and supports the findings.

MA 53.6 Thu 16:15 HSZ 401

Amplification of propagating spin waves by rapid cooling — •Michael Schneider[1], David Breitbach[1], Bert Lägel[1], Carsten Dubs[2], Halyna Musiienko-Shmarova[1], Dmytro A. Bozhko[3], Alexander A. Serga[1], Andrei N. Slavin[4], Vasyl S. Tiberkevich[4], Burkard Hillebrands[1], and Andrii V. Chumak[5] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, Kaiserslautern, Germany — [2]INNOVENT e.V. Technologieentwicklung, Jena, Germany — [3]Department of Physics and Energy Science, University of Colorado at Colorado Springs, Colorado Springs, USA — [4]Department of Physics, Oakland University, Rochester, USA — [5]Faculty of Physics, University of Vienna, Austria

Recently we reported on the formation of a magnon Bose-Einstein Condensate triggered by a non-equilibrium between the magnon and the phonon system, achieved by rapid cooling of magnonic nano-structures. Here we report on the interaction of a propagating spin-wave with such a non-equilibrated system. The rapid cooling of a preheated, confined region of a micro scaled waveguide results in a redistribution of magnons to lower energies. During this, a spin-wave pulse propagating through the rapidly cooled area gets amplified. This amplification process is investigated with respect to the strength of the non-equilibrium and the delay between the spin-wave packet and the formation of the non-equilibrium. This research has been supported by ERC StG 678309 MagnonCircuits, ERC AdG 694709 SuperMagnonics and DFG Grant DU 1427/2-1.

MA 53.7 Thu 16:30 HSZ 401

Twisting and tweezing the spin wave: on helical waves, and the magnonic spiral phase plate — •Alexander F. Schäffer[1], Decheng Ma[2], Chenglong Jia[2], and Jamal Berakdar[1] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06120 Halle (Saale), Germany — [2]Key Laboratory for Magnetism and Magnetic Materials of the Ministry of Education & Institute of Theoretical Physics, Lanzhou University, China

Spin waves are the low-energy excitations of magnetically ordered materials. They are key elements in the stability analysis of the ordered phase and have a wealth of technological applications. Recently[1], we showed that spin waves of a magnetic nanowire may carry a definite amount of orbital angular momentum components along the propagation direction. This helical, in addition to the chiral, character of the spin waves is related to the spatial modulations of the spin wave phase across the wire. It, however, remains a challenge to generate and control such modes with conventional magnetic fields. Therefore, we propose a magnetic heterostructure that acts as a magnetic spiral phase plate by appropriately synthesizing two magnetic materials that have different speeds of spin waves[2]. In this contribution, we discuss the key features of helical spin waves and demonstrate the functionality of the magnonic spiral phase plate with micromagnetic simulations.

[1] C. Jia, D. Ma, A. F. Schäffer, J. Berakdar, Nat. Commun. 10, 2077 (2019).
[2] C. Jia, D. Ma, A. F. Schäffer, J. Berakdar, J. Opt. 21, 12 (2019).