北京大学量子材料科学中心

International Center for Quantum Materials, PKU

Special Seminar

New Opportunities for Spintronics: Magnetic Skyrmions

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The field of spintronics, or magnetic electronics, is maturing and giving rise to new subfields [1]. An important ingredient to the vitality of magnetism research in general is the large complexity due to competitions between interactions crossing many lengthscales and the interplay of magnetic degrees of freedom with charge (electric currents), phonon (heat), and photons (light) [2]. One perfect example, of the surprising new concepts being generated in magnetism research is the recent discovery of magnetic skyrmions. Magnetic skyrmions are topologically distinct spin textures that are stabilized by the interplay between applied magnetic fields, magnetic anisotropies, as well as symmetric and antisymmetric exchange interactions. Due to their topology magnetic skyrmions can be stable with quasi-particle like behavior, where they can be manipulated with very low electric currents. This makes them interesting for extreme low-power information technologies, where it is envisioned that data will be encoded in topological charges, instead of electronic charges as in conventional semiconducting devices. Towards the realization of this goal we demonstrated magnetic skyrmions in magnetic heterostructures stable at room temperature, which can be manipulated using spin Hall effects [3]. Furthermore, using inhomogeneous electric charge currents allows the generation of skyrmions in a process that is remarkably similar to the droplet formation in surface-tension driven fluid flows [4]. However, detailed micromagnetic simulations show that depending on the electric current magnitude there are at least two regimes with different skyrmion formation mechanisms [5]. Lastly, we demonstrated that the topological charge gives rise to a transverse motion on the skyrmions, i.e., the skyrmion Hall effect, which is in analogy to the ordinary Hall effect originating from the motion of electrically charged particles in the presence of a magnetic field [6].This work was supported by the U.S. Department of Energy, Office of Science, Materials Sciences and Engineering Division. Lithographic patterning was carried out at the Center for Nanoscale Materials, which is supported by DOE, Office of Science, BES (#DE-AC02-06CH11357)

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Axel Hoffmann is currently the Senior Group Leader of the Magnetic Thin Film Group within the Materials Science Division at the Argonne National Laboratory. His research interests encompass a wide variety of magnetism related subjects, including basic properties of magnetic heterostructures, spin-transport in novel geometries, and biomedical applications of magnetism. His main research focus has recently been on pure spin currents investigated by magnetotransport and magnetization dynamic measurements. He has more than 100 publications with combined more than 5000 citations (h-index: 41), four book chapters, and three magnetism-related U.S. patents and he is an Associate Editor for the Journal of Applied Physics. He is a fellow of the American Physical Society and IEEE. Furthermore, he was in 2011 a Distinguished Lecturer for the IEEE Magnetics Society, received in 2015 the Outstanding Researcher Award by the Prairie Section of the American Vacuum Society, and was awarded in 2016 the International Fellowship by the Chinese Academy of Sciences.

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