TT 39: Spin Structures/ Skyrmions (jointly with MA)

Time: Wednesday 14:00–16:30 Location: HSZ 04

Invited Talk TT 39.1 Wed 14:00 HSZ 04

Skyrmion crystals and topological transport phenomena — •Yoshinori Tokura — Department of Applied Physics, University of Tokyo, Tokyo, Japan

A class of helimagnet is derived from the Dzyaloshinskii-Moriya(DM) interaction on a non-centrosymmetric crystal; prototypical examples are the B20 type (FeSi type) transition-metal silicide and germanide families. Recently, the Skrymion lattice was confirmed to form in a narrow temperature(T) -magnetic field(B) region near the hlimagnetic to paramagnetic transition boundary. By contrast, thin films of B20 type MSi (M=Mn or Fe1-xCox) or MGe (M=Mn, Fe), whose thickness is smaller than the helical spin modulation period (=10-100nm), ubiquitously form the two-dimensional (2D) Skyrmion crystal with magnetic fields (B) applied normal to the film plane over a wide T-B region. The implication of such a 2D Skyrmion crystal in the magneto-transport properties is discussed, such as the spin-chirality- induced topological Hall effect.

This work was done in collaboration with X.Z. Yu, N. Kanazawa, Y. Onose, Y. Shiomi, Y. Matsui, N. Nagaosa, J.H. Park, J.H. Han, K. Kimoto, W.Z. Zhang, T. Arima, S. Wakimoto, K. Ohoyama, and K. Kakurai

Invited Talk TT 39.2 Wed 14:30 HSZ 04

Discovery of an atomic-scale skyrmion lattice in an ultrathin magnet: Fe/Ir(111) — •S. Heinze[1], K. von Bergmann[2], M. Menzel[2], J. Brede[2], A. Kubetzka[2], R. Wiesendanger[2], G. Bihlmayer[3], and S. Blügel[3] — [1]Institute of Theoretical Physics and Astrophysics, University of Kiel — [2]Institute of Applied Physics, University of Hamburg — [3]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA

Skyrmions are topologically protected field configurations with particle-like properties that play an important role in various fields of science. They have been predicted to exist also in bulk magnets and in recent experiments it was shown that they can be induced by a magnetic field. A key ingredient for their occurrence is the Dzyaloshinskii-Moriya interaction (DMI) which was found to be strong also in ultrathin magnetic films on substrates with large spin-orbit coupling [1]. In these systems the DMI stabilizes spin-spirals with a unique rotational sense propagating along one direction of the surface [1,2]. Here, we go a step beyond and present an atomic-scale skyrmion lattice as the magnetic ground state of a hexagonal Fe monolayer on Ir(111). We develop a spin-model based on density functional theory that explains the interplay of Heisenberg exchange, DMI and the four-spin exchange as the microscopic origin of this intriguing magnetic state. Experiments using spin-polarized scanning tunneling microscopy confirm the skyrmion lattice which is incommensurate with the underlying atomic lattice. [1] M. Bode et al., Nature 447, 190 (2007). [2] P. Ferriani et al., Phys. Rev. Lett. 101, 027201 (2008).

Invited Talk TT 39.3 Wed 15:00 HSZ 04

Skyrmion states in noncentrosymmetric magnets — •Alexei N. Bogdanov, Andrei A. Leonov, and Ulrich K. Rössler — IFW Dresden

Axisymmetric magnetic strings with a fixed sense of rotation and nanometer sizes (chiral magnetic vortices or Skyrmions) have been predicted to exist in a large group of noncentrosymmetric crystals more than two decades ago [1]. Recently these extraordinary magnetic states have been directly observed in thin layers of cubic helimagnet (Fe,Co)Si [2]. In this report we apply our earlier theoretical findings and recent results [3] to review main properties of chiral Skyrmions, to elucidate their physical nature, and to analyse these recent experimental results on magnetic-field-driven evolution of Skyrmions and helicoids in chiral helimagnets. Concentrating on the physical side of the problem rather than on mathematical details we give an elementary introduction into the properties of chiral Skyrmions in magnetism. [1] A. N. Bogdanov, A. D. Yablonsky Sov. Phys. JETP 68 (1989) 101. [2] X. Z. Yu et al. Nature 465 (2010) 901. [3] U. K. Rößler et al., Nature 442 (2006) 797; arXiv:1009.4849; A. A. Leonov et al., arXiv:1001.1992v2.

Invited Talk TT 39.4 Wed 15:30 HSZ 04

Complex Magnetic Phase Diagram of the cubic Helimagnet FeGe — •Heribert Wilhelm — Diamond Light Source Ltd., Chilton, Didcot, OX11 0DE, United Kingdom

Cubic FeGe (B20 structure type) shows helical order below T_c = 278.3 K. Depending on temperature and magnetic field a complex sequence of cross-overs and phase transitions in the vicinity of T_c has been observed in magnetization and ac-susceptibility measurements in fields parallel to the [100] direction. In a narrow temperature range below T_c several magnetic phases have been found before the field-polarized state occurs. Of particular interest is the so-called A-phase. It splits in at least two distinct areas, A_1 and A_2. This has been confirmed by small-angle neutron scattering data. These data also yield a hexagonal scattering pattern, the fingerprint of a Skyrmion lattice, within the A_1 and A_2 regions. Precursor phenomena found above T_c display a complex succession of temperature-driven cross-overs and phase transitions before the paramagnetic phase is reached at T_0. The low-field state for $T_c < T < T_0$ is probably characterized by some kind of magnetic correlations concluded from nuclear forward scattering data. They revealed that this phase exists up to about 27 GPa, although the helical order is already suppressed at 19 GPa. No signatures of magnetic order have been observed above 30 GPa. Within a phenomenological model for chiral ferromagnets, which includes magnetic anisotropy, Skyrmionic phases and 'confined' chiral modulations were obtained. The observed precursor phenomena are then a general effect related to the confinement of localized Skyrmionic excitations.

Invited Talk TT 39.5 Wed 16:00 HSZ 04

Magnetoelectric effects in non-collinear magnets — •Maxim Mostovoy — Zernike Institute for Advanced Materials, University of Groningen, The Netherlands

The coupling of the electric field to the spin degrees of freedom in Mott insulators leads to a variety of spectacular phenomena in multiferroic materials, such as the magnetic field control of electric polarization in spiral magnets, the clamping between the ferroelectric and (anti)ferromagnetic domain walls in orthorhombic and hexagonal manganites and the excitation of magnons by the electric component of light (electromagnon peaks). The microscopic mechanisms of magnetoelectric coupling also allow for the electric field control of non-collinear spin structures in conventional magnets, which may find applications in spintronics. I will discuss the relevance of unusual magnetic multipoles, such as the monopole and toroidal moments, for the linear magnetoelectric effect and electromagnon excitation. I will also discuss the new dynamic magnetoelectric interaction, which can be used to move non-collinear spin textures in ferromagnets with an applied electric field. The effect of this coupling is dramatically enhanced for non-coplanar topological magnetic defects, such as magnetic vortices and Skyrmions.