SYCL 2: Curvilinear condensed matter 2

Time: Wednesday 11:15–12:45 Location: Audimax 2

Invited Talk SYCL 2.1 Wed 11:15 Audimax 2

Superconductors and nanomagnets evolve into 3D — •Oleksandr Dobrovolskiy — Superconductivity and Spintronics Laboratory, Nanomagnetism and Magnonics, Faculty of Physics, University of Vienna, Währinger Str. 17, 1090 Vienna, Austria

Patterned superconductors and nanomagnets are traditionally 2D planar structures. However, recent work is expanding superconductivity and nanomagnetism into the third dimension [1]. This expansion is triggered by advanced synthesis methods and the discovery of novel geometry- and topology-induced effects. In addition to self-assembled systems, a high level of maturity is now reached in direct-write nanofabrication by focused electron and focused ion beam induced deposition (FEBID and FIBID, respectively) [2, 3].

In this overview talk, a selection of shape- and curvature-induced effects in 3D superconducting and ferromagnetic structures will be outlined. A particular focus will be on the effects relevant for novel spintronic functionalities relying upon (i) the dynamics of Abrikosov vortices in superconductors [4], (ii) the dynamics of spin waves in ferromagnets [5], and (iii) the interplay of superconductivity and magnetism in heterostructures [6].

[1] D. Makarov *et al.*, Adv. Mater. **33** (2021) 2101758.
[2] M. Huth *et al.*, Microelectron. Engin. **185-186** (2018) 9.
[3] A. Fernandez-Pacheco *et al.*, Mater. **13** (2020) 3774.
[4] O. Dobrovolskiy *et al.*, Appl. Phys. Lett. **118** (2021) 132405.
[5] O. Dobrovolskiy *et al.*, Nat. Commun. **11** (2020) 3291.
[6] O. Dobrovolskiy *et al.*, Nat. Phys. **15** (2019) 477.

Invited Talk SYCL 2.2 Wed 11:45 Audimax 2

Properties of domain walls and skyrmions in curved ferromagnets — •Volodymyr Kravchuk — Karlsruhe Institute of Technology, Germany. — Bogolyubov Institute for Theoretical Physics, Kyiv, Ukraine

In the presence of the curvature, the topological magnetic solitons (domain walls, skyrmions, vortices) gain a number of new properties. A spatially localized curvature defect can generate the pinning as well as the repulsion potential for domain walls and skyrmions (depending on the signs of the curvature and topological charge of the soliton and also on its helicity). For a large amplitude defect, the pinned skyrmion demonstrates a multiplet of equilibrium states forming the ladder for the energy levels. The transitions between the levels can be controlled by pulses of the external magnetic field. Curvature drastically changes the dynamical properties of the topological solitons: the current-driven domain wall can demonstrate the negative mobility in three-dimensional curvilinear wire with torsion; the curvature gradients result in the driving force acting on domain walls and magnetic skyrmions; curvature enriches the spectrum of the spin eigenexitations of the skyrmion. Curvature generally couples the geometrical chirality of the magnet and spin chirality of the magnetic texture. This results in the chirality symmetry breaking effects, e.g. for the domain wall on the Moebius stripe, in the core switching process for a magnetic vortex on a spherical shell.

Invited Talk SYCL 2.3 Wed 12:15 Audimax 2

X-ray three-dimensional magnetic imaging — •Valerio Scagnoli — Laboratory for Mesoscopic Systems, Department of Materials, ETH Zurich, Zurich, Switzerland — Paul Scherrer Institute, Villigen, Switzerland

Three dimensional magnetic systems hold the promise to provide new functionality associated with greater degrees of freedom. Over the last years we have worked towards developing methods to fabricate and characterize three dimensional magnetic structures. Specifically, we have combined X-ray magnetic imaging with new iterative reconstruction algorithms to achieve X-ray magnetic tomography and laminography [1-4]. In a first demonstration, we have determined the three-dimensional magnetic nanostructure within the bulk of a soft GdCo2 magnetic micropillar and we have identified the presence of Bloch points of different types [1] as well as three-dimensional structures forming closed vortex loops [3]. Subsequently, we have used the flexibility provided by the laminography geometry to perform time resolved measurements of the magnetization dynamics in a two-phase micrometer size GdCo disk. Therefore, X-ray magnetic three-dimensional imaging, with its recent extension to the soft X-ray regime [5], has now reached sufficient maturity that will enable to unravel complex three-dimensional magnetic structures for a range of magnetic systems.

[1] C. Donnelly et al., Nature 547, 328 (2017) [2] C. Donnelly et al., New J. Phys. 20, 083009 (2018) [3] C. Donnelly et al., Nat. Phys. 17, 316 (2021) [4] C. Donnelly et al., Nat. Nanotechnol. 15, 356 (2020) [5] K. Witte et al., Nano Letters 20, 1305 (2020)