Curvilinear Condensed Matter: Fundamentals and Applications

717. WE-Heraeus-Seminar

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WILHELM UND ELSE
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Introduction

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Aims and scope of the 717. WE-Heraeus-Seminar:

Extending two-dimensional structures into the three-dimensional (3D) space has become a general trend in multiple disciplines, including electronics, photonics, plasmonics and magnetics. This approach provides means to modify conventional or to launch novel functionalities by tailoring curvature and 3D shape. In the case of 3D curved magnetic thin films and nanowires the physics is driven by the interplay between exchange and magnetostatic interactions, which contain spatial derivatives in their energy functionals. This makes both interactions sensitive to the appearance of bends and twists in the physical space. Theoretical works predict the curvature-induced effective anisotropy and effective Dzyaloshinskii-Moriya interaction resulting in a multitude of novel effects including magnetochiral effects (chirality symmetry breaking) and topologically induced magnetization patterning. Those 3D magnetic architectures are already proven to be application relevant for life sciences, targeted delivery, realization of 3D spin-wave filters, and magneto-encephalography devices to name just a few. To this end, the initially fundamental topic of the magnetism in curved geometries strongly benefited from the input of the application-oriented community, which among others explores the shapeability aspect of the curved magnetic thin films. These activities resulted in the development of the family of shapeable magnetoelectronics which already includes flexible, printable, stretchable and even imperceptible magnetic field sensorics. The balance between the fundamental and applied inputs into the topic of magnetism in curved geometries is rather unique. This stimulates even further the development of new theoretical methods and novel fabrication/characterization techniques. The synergy will definitely enable us surpassing the exploratory research and will pave the way towards novel device concepts, where the geometry of a functional thin film will play a decisive role in determining the device performance.

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Abstracts of Posters

(in alphabetical order)

Ground states of the antiferromagnetic spin rings in strong magnetic fields

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Antiferromagnetic (AFM) materials have distinct advances compared to ferromagnets, that allow to use them in variety of spintronic applications [1,2]. Antiferromagnetically coupled curvilinear spin chains are of fundamental interest as simplest systems possessing interplay between the geometry and magnetic subsystem [3].

In this work, we analyze the ground states of AFM ring-shaped spin chain with the nearest-neighbour Heisenberg exchange and single-ion anisotropy in presence of external magnetic field. The direction of magnetic field coincides with the symmetry axis of the ring. Collinear two-sublattice 1D curved AFM chain with even number of spins is considered, and the hard axis of anisotropy is oriented tangentially to the chain.

Within the classical continuum approach its magnetic state is described by two order parameters, the Néel and ferromagnetism vector fields. In the ground state, the Néel vector is oriented perpendicularly to the ring plane.

The magnetic field applied along the ring normal allows to observe spin-flop and spin-flip orientational phase transitions. We determine the dependency of spin-flop and spin-flip transition fields on the ring curvature and the critical curvature which separates two topologically different ground states above spin-flop transition. The first one with the Néel order parameter within the normal plane is mainly determined by the anisotropy at small curvatures. The second ground state at large curvatures is represented by onion ordering of the Néel vector. With the applied fields larger than critical spin-flip transition field Néel order parameter vanishes, which leads to ferromagnetic ground state. The phase diagram of AFM as a function of applied field intensity and the ring curvature is developed.

References

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