

Curvature as a new route to tailor magnetic properties of nanostructures

Artificially created curvilinear magnetic nanoparticles can be of different forms, for instance: helices, planar magnetic spirals, nanoshells and thin films with localized curvilinear defects. Curvilinear magnetism shows a new powerful potential for manipulation with physical properties of such nanoparticles by changing their curvilinear shape. Parameters of geometry-induced interactions can be easier to predict and change by fabrication than the internal microscopic properties of crystals. This creates promising conditions for a wide spectrum of potential applications, in particular in magnetoelectronics, magnetic sensorics, spintronics, magnonics, microrobotics, biophysics and medicine.

Although several experimental works confirm the qualitative conclusions from the theory of curvilinear ferromagnetism, with the main success being an observation of domain-wall pinning on the local bend of curved ferromagnetic wire, the connection between theory and experiment is rather weak. This can be explained by the difficulties in the experimental study of curvilinear effects, but mostly by the shortcomings of the theory. The main drawback of the theory of curvilinear magnetism at the moment is the lack of consideration of the magnetoelastic interactions and magnetostriction, which can play an important role in the physical properties of magnets with a curvilinear shape. Moreover, such experimentally investigated and practically important effect as anisotropic magnetoresistance of ferromagnetic helices, has not yet been theoretically analyzed.

In this project, we plan to perform a comprehensive investigation of curvilinear magnets with a variety of exchange interactions (ferromagnets, antiferromagnets, weak ferromagnets). The aim of our research is to study the role of magnetoelastic and ferroelectric interactions on stability and dynamics of magnetic textures in dependence on curvilinear shapes of such magnets. We plan to combine analytical methods with micromagnetic simulation and experimental improvement of the main results. The research will be performed in collaboration with Spanish and Portuguese groups. We believe that our efforts will serve to build bridges between theory, experiment and practical implementation of curvilinear magnets, and will open new research directions in physics of magnetism, spintronics and magnonics.