NATO Advanced Research Workshop

RPTU

Functional Spintronic Nanomaterials for Radiation Detection and Energy Harvesting

Curvilinear magnetism: fundamentals and perspectives

[1]Denis D. Sheka
[1]sheka@knu.ua, Taras Shevchenko National University of Kyiv, 01601 Kyiv, Ukraine

Recent advances in nanotechnologies have enabled fabrication of the novel class of 3D curved magnetic nanoarchitectures, where the fundamental properties are determined by the geometry [1]. Active exploration of this new material class turns light on the fundamentals of magnetism of nanoobjects with curved geometry and applications of 3D-shaped curved magnetic nanoarchitectures, leading to remarkable developments in shapable magnetoelectronics, magnetic sensorics, spintronics, 3D magnonics, and microrobotics. Today, fundamental and applied research of curved nanoarchitectures and related curvature-induced effects in these objects are united in curvilinear magnetism, which is a rapidly developing research area of modern magnetism aimed to explore geometry-induced effects in curved magnetic wires and films [2].

By exploring geometry-governed magnetic interactions, curvilinear magnetism offers a number of intriguing effects in curved magnetic wires and curved magnetic films. Emergent interactions, induced by the curvilinear geometry manifest themselves in topological magnetization patterning and magnetochiral effects in conventional magnetic materials. These curvature-induced interactions can be not only local (when they stem from the exchange energy) [3] but also non-local (when they are due to magnetostatics) [4]. As a consequence, family of novel curvature-driven effects emerges, resulting in theoretically predicted unlimited domain wall velocities, chirality symmetry breaking etc [5]. Current and future challenges of the curvilinear magnetism will be discussed [6].

Reference list

1. D. Makarov, O. Volkov, A. Kákay, O. Pylypovskyi, B. Budinská, and O. Dobrovolskiy, “New Dimension in Magnetism and Superconductivity: 3D and Curvilinear Nanoarchitectures”, Adv. Mater., **34**, 2101758 (2021).
2. D. Makarov, D. Sheka, “Curvilinear Micromagnetism: From Fundamentals to Applications”. Topics in Applied Physics. (Springer, Cham, 2022).
3. Y. Gaididei, V. Kravchuk, D. Sheka, “Curvature Effects in Thin Magnetic Shells”, Phys. Rev.Lett. **112**, 257203 (2014).
4. D. Sheka, O. Pylypovskyi, P. Landeros, Y. Gaididei, A. Kákay, D. Makarov, “Nonlocal chiral symmetry breaking in curvilinear magnetic shells”, Communications Physics **3**, 128 (2020); O. Volkov, D. Wolf, O. Pylypovskyi, A. Kákay, D. Sheka, B. Büchner, J. Fassbender, A. Lubk, D. Makarov, “Chirality coupling in topological magnetic textures with multiple magnetochiral parameters”, Nature Comms, **14**, 1491 (2023).

5. D. Sheka, O. Pylypovskyi, O. Volkov, K. Yershov, V. Kravchuk, D. Makarov. “Fundamentals of Curvilinear Ferromagnetism: Statics and Dynamics of Geometrically Curved Wires and Narrow Ribbons” (Review), Small, **18**, 2105219 (2022).
6. D. Sheka, “A perspective on curvilinear magnetism”, Appl. Phys. Lett. **118**, 230502 (2021); D. Sheka, “Curvilinear Magnetism”, Encyclopedia of Materials: Electronics (2023)