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To all members of the
Faculty of Physics

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Invitation to the public defense of the doctoral thesis

"Nonuniform magnetic spin textures for sensing, storage and computing applications"

by

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Friday, 28 February 2025, 10:00 a.m.
Ernst-Mach-Hörsaal, 2. Stock, Boltzmanngasse 5, 1090 Wien

For over a century, soft ferro- and ferrimagnetic materials have been essential to modern technology, underpinning devices such as hard disk drives, magnetic field sensors, and logic circuits. While conventional applications rely on uniform magnetization, recent research has shifted towards the study and manipulation of nonuniform magnetic textures, including vortices, chiral domains, skyrmions, and antiskyrmions, which hold promise for future computing, storage, and sensing technologies.
This thesis explores the fundamental properties and applications of these spin textures through a combination of micromagnetic simulations and experimental techniques. Using an in-house Pythonbased micromagnetic solver, we model nonuniform magnetization dynamics, while experimental investigations employ magnetometry, magnetotransport, ferromagnetic resonance, and real-space imaging via Lorentz transmission electron microscopy, magnetic force microscopy, and scanning transmission X-ray microscopy. The materials under study, primarily synthesized via Magnetron sputtering, include $Mn_{1.4}Pt_{0.9}Pd_{0.1}Sn$, Fe/Gd/Ir-based, and Co/Ni-based multilayers.
Our findings reveal that noncollinear coupling in synthetic antiferromagnets arises from atomicscale nonuniform magnetization. We demonstrate the controlled transformation of elliptical skyrmions into antiskyrmions via heat and magnetic fields, as well as the coexistence of multiple spin textures in ferrimagnetic Fe/Gd/Ir multilayers at room temperature—crucial for racetrack memory applications. Additionally, we show that skyrmions can be nucleated from vertical Bloch lines and transported without transverse deflection under electric currents. Beyond storage applications, we propose novel sensing mechanisms leveraging spin-orbit torque symmetry to mitigate zero-field offset in magnetic sensors. Furthermore, we demonstrate that synthetic ferrimagnetic vortices can generate spin waves without microwave antennas, offering new pathways for energy-efficient magnonic devices. This work provides a comprehensive overview of nonuniform spin textures, highlighting their potential for next-generation magnetic applications while addressing challenges in their practical deployment.

Defense committee:
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