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Physikalisches Kolloquium

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13:00 Uhr
MC 122 und Zoom

https://uni-due.zoom.us/j/61481460592?pwd=NTBkdk1xNWtFdnk1TTdtZkI0UllzUT09 (gilt für alle Vorträge)

Why moving magnetic bubbles straight forward is not straightforward

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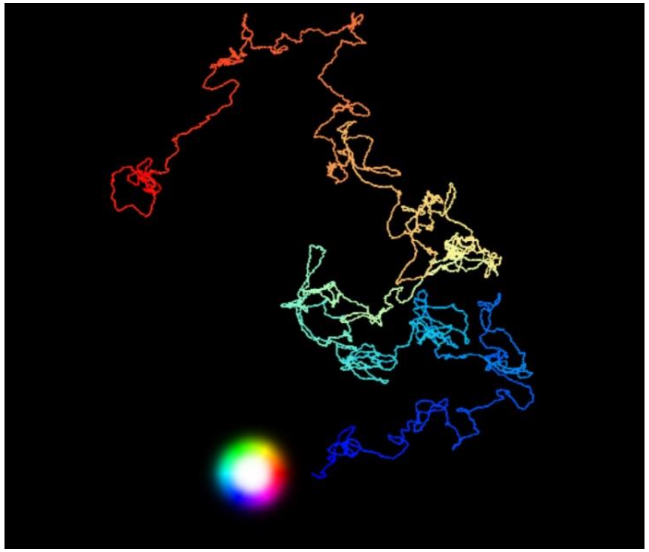

The dynamics of magnetic skyrmions are governed by the complex interplay between driving forces, thermal fluctuations and material disorder. This interplay leads to rich behavior, e.g. a creep motion that persists up to almost 100 m/s, which needs to be fully understood before skyrmions can be reliably used in technological applications like the racetrack memory [1].
To assist in this understanding, there exist theoretical approaches which rely on the assumption that skyrmions are rigid objects. However, especially in the technologically relevant regime where skyrmions are under the constant influence of disorder and temperature, they do not behave as rigid objects, making micromagnetic simulations indispensable to bridge theoretical models and experimental results. To this end, we developed an algorithm offering a twentyfold speedup without a loss of accuracy to perform simulations at nonzero temperatures [2]. After validating this methodology against theoretical results for skyrmion diffusion [3], we use it in a large-scale study of the impact of temperature and disorder on the skyrmion motion and compare the results against experimental data of the velocity and skyrmion Hall (SkH) angle as function of the driving force [4].

Our results show that the skyrmion velocity as a function of current density falls on a universal curve when the the temperature dependence of the spin-orbit torques is accounted for. This allows the skyrmion trajectories in a device to be engineered, although the problem remains that high velocities are accompanied by large SkH angles, which could eventually lead to the annihilation of the skyrmion after a collision with the edge of the racetrack.

Recently, it was suggested that this problem could be mitigated by replacing skyrmions by topologically trivial structures like two coupled skyrmions in a synthetic antiferromagnet or a skyrmionium. Both structures have no net topological charge, which in the case of spin-transfer torque driven motion also results in a zero SkH angle. However, we show that this notion is generally false for spin-orbit torque driven objects [5]. Instead, the SkH angle is directly related to the objects' helicity and imposes an unexpected roadblock for developing faster and low-power racetrack memories based on spin-orbit torques.

References

*All presented results were obtained in collaborations with the authors of refs. [2], [4] and[5].

[1] A. Fert, et. al, Nature Nanotechnology 8, 152156 (2013)
[2] J.Leliaert, et al,. AIP Advances 7, 125010 (2017)
[3] J. Miltat, et al., Physical Review B 97, 214426 (2018)
[4] K. Litzius, et al., Nature Electronics 3, 30-36