GP-Spin Seminar

Tuesday, April 18

4:30 pm – **6:00** pm

Tutorial Part I: Spin-Orbitronics and Applications in low power Memory

Wednesday, April 19

10:00 am – **11:30** am

Antiferromagnetic Spintronics: Writing, Reading and Transporting Information for next generation devices

Tuesday, April 20

4:30 pm – **6:00** pm

Tutorial Part II: Skyrmions and Applications in Unconventional Computing

PROF. DR.

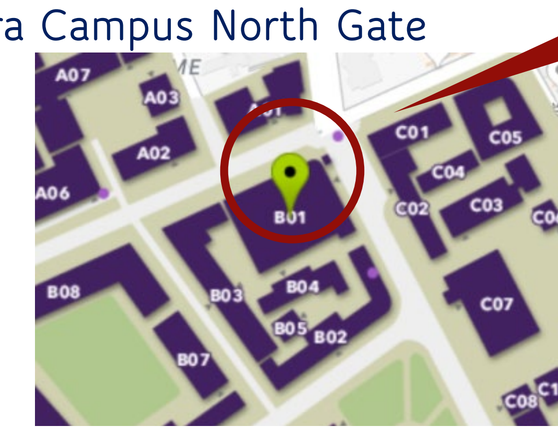
MATHIAS KLÄUI

Instutute of Physics & Materials Science in Mainz, Johannes Gutenberg Universiy

Venue: Seminar Room, 2nd floor, AIMR Main Building

Katahira Campus, Tohoku University

Katahira Campus North Gate



AIMR Main Building

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Tutorials on Spin-Orbitronics and Skyrmionics – novel science and applications in memory & unconventional computing for GreenIT

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Novel spintronic devices can play a role in the quest for GreenIT if they are stable and can transport and manipulate spin with low power. Devices have been proposed, where switching by energy-efficient approaches is used to manipulate topological spin structures [1,2].

We combine ultimate stability of topological states due to chiral interactions [3,4] with ultra-efficient manipulation using novel spin torques [3-5]. In particular orbital torques [6] increase the switching efficiency by more than a factor 10 enabling low power memory devices.

We use skyrmion dynamics for non-conventional stochastic computing applications, where we developed skyrmion reshuffler devices [7] based on skyrmion diffusion, which also reveals the origin of skyrmion pinning [7]. Such diffusion can furthermore be used for Token-based Brownian Computing and Reservoir Computing [8].

References

[1] G. Finocchio et al., J. Phys. D: Appl. Phys., vol. 49, no. 42, 423001, 2016.
[2] K. Everschor-Sitte et al., J. Appl. Phys., vol. 124, no. 24, 240901, 2018.
[3] S. Woo et al., Nature Mater., vol. 15, no. 5, pp. 501–506, 2016.
[4] K. Litzius et al., Nature Phys., vol. 13, no. 2, pp. 170–175, 2017.
[5] K. Litzius et al., Nature Electron., vol. 3, no. 1, pp. 30–36, 2020.
[6] S. Ding et al. Phys. Rev. Lett. 125, 177201, 2020; Phys. Rev. Lett. 128, 067201, 2022.
[7] J. Zázvorka et al., Nature Nanotechnol., vol. 14, no. 7, pp. 658–661, 2019;
R. Gruber et al., Nature Commun. vol. 13, pp. 3144, 2022.
[8] K. Raab et al., Nature Commun. vol. 13, pp. 6982, 2022;
M. Brems et al., Appl. Phys. Lett. 119, 132405, 2021.

Antiferromagnetic Spintronics: Spintronics without magnetic fields

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While known for a long time, antiferromagnetically ordered systems have previously been considered, as "interesting but useless". However, since antiferromagnets potentially promises faster operation, enhanced stability and higher integration densities, they could potentially become a game changer for new spintronic devices. Here I will show how antiferromagnets can be used as active spintronics devices by demonstrating the key operations of "reading" [1], "writing" [2], and "transporting information" [3] in antiferromagnets. Beyond typical bulk and thin film systems, recently also antiferromagnetic van der Waals materials have been discovered [4], which bode particularly well for manipulation by efficient interface effects.

[1] S. Bodnar et al., Nature Commun. **9**, 348 (2018); L. Baldrati et al., Phys. Rev. Lett. **125**, 077201 (2020)
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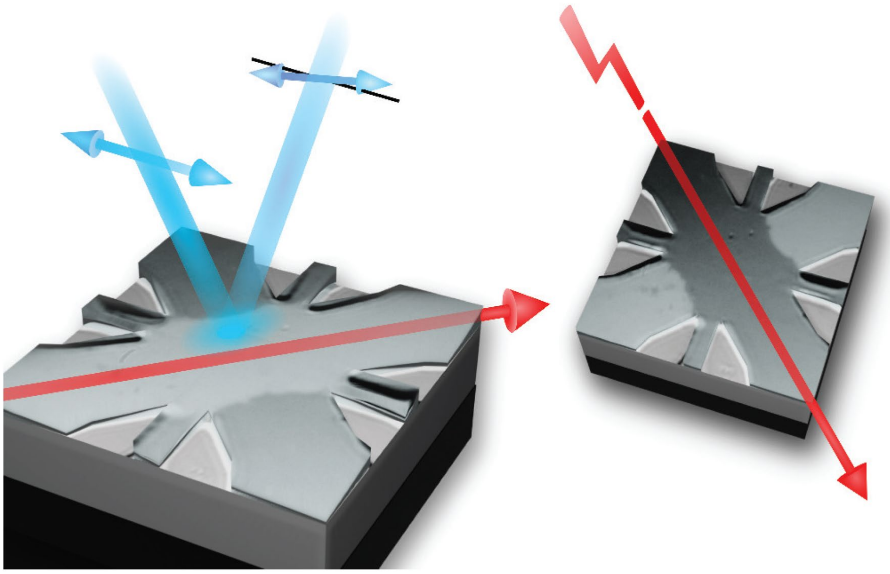
[3] R. Lebrun et al., Nature **561**, 222 (2018). R. Lebrun et al., Nature Commun. **11**, 6332 (2020). S. Das et al., Nature Commun. 13, 6140 (2022).
[4] R. Wu et al., Phys. Rev. Appl. **17**, 064038 (2022).



Mathias Kläui is professor of physics at Johannes Gutenberg-University Mainz and adjunct professor at the Norwegian University of Science and Technology.
He received his PhD at the University of Cambridge, after which he joined the IBM Research Labs in Zürich. He was a junior group leader at the University of Konstanz and then became associate professor in a joint appointment between the EPFL and the PSI in Switzerland before moving to Mainz. His research focuses on nanomagnetism and spin dynamics on the nanoscale in new materials. His research covers from blue sky fundamental science to applied projects with major industrial partners. He has published more than 300 articles and given more than 200 invited talks. He is a Fellow of the IEEE, IOP and APS and has been awarded a number of prizes and scholarships. He was also a visiting professor at Tohoku University in 2016 and he has been one of the 2020/2021 IEEE Magnetics Society Distinguished Lecturers.

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