The 2020 Around-the-Clock Around-the-Globe Magnetics Conference: Invited speakers information

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Title of the talk: **Skyrmion dynamics - from individual ultrafast motion to diffusion and collective crystallization of 2D lattices**

Biography:
Mathias Kläui is professor of physics at Johannes Gutenberg-University Mainz and Director of the Center for Dynamics and Topology. He studied at RWTH Aachen University and 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. Since 2017 he has been Adjunct Professor in the Center for Quantum Spintronics at the Norwegian University of Science and Technology. His work 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 290 articles and given more than 220 invited talks. He is a Senior member of the IEEE and has been elected to the technical and administrative committees of the magnetics society. He is also a Fellow of the IOP and the European Academy of Sciences and has been awarded a number of prizes and scholarships as well as three grants of the European Research Council.
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Abstract:
In our information-everywhere society IT is a major player for energy consumption. 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, such as spin-polarized currents is used [1], for which we develop new highly spin-polarized materials and characterize the spin transport using THz spectroscopy [2].
Firstly, to obtain ultimate stability of states, topological spin structures that emerge due to the Dzyaloshinskii-Moriya interaction (DMI) at structurally asymmetric interfaces, such as chiral domain walls and skyrmions with enhanced topological protection can be used [3-5]. Here we will introduce these spin structures ad we have investigated in detail their dynamics and find that it is governed by the topology of the spin structure [3]. By designing the materials, we can even obtain a skyrmion lattice phase as the ground state [4]. Beyond 2D structures, we recently developed also systems with chiral interlayer exchange interactions that lend themselves to the formation of chiral 3D structures [6].

Secondly, for ultimately efficient spin manipulation, we use spin-orbit torques, that can transfer more than 1ħ per electron by transferring not only spin but also orbital angular momentum. We combine ultimately stable skyrmions with spin orbit torques into a skyrmion racetrack device [4], where the real time imaging of the trajectories allows us to quantify the novel skyrmion Hall effect [5]. Recently, we determined the possible mechanisms that lead to a dependence of the skyrmion Hall effect on skyrmion velocity [7]. We furthermore use spin-orbit torque induced skyrmion dynamics for non-conventional stochastic computing applications, where we have developed a skyrmion reshuffler device [8] based on skyrmion diffusion [8]. Such diffusion can furthermore be controlled by symmetry – breaking in-plane magnetic fields [9].

Finally, we take the next step beyond studying the properties of skyrmions and use them as model systems to study phases and phase transitions in two dimensions. We determine the transition of skyrmions from a disordered "liquid" phase to a "hexatic" phase, which is a particular phase that only exists in 2D [10]. This demonstrates that skyrmion lattices are perfectly 2D systems, opening up an avenue to using skyrmions as model systems to study statistical mechanics, phases and phase transitions [10].

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