Seminar
Dr Giacomo Sala

Department of Materials, ETH Zurich, 8093 Zurich, Switzerland

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Room (2-A013)

Asynchronous current-induced switching of rare-earth and transition-metal sublattices in ferrimagnetic alloys

Rare-earth transition-metal (RE-TM) ferrimagnetic alloys have raised considerable interest because of their ultrafast laser- and current-induced dynamics. Intense laser pulses toggle the RE-TM magnetization in few ps [1,2], and spin-orbit torques drive ferrimagnetic domain walls at record speeds of the order of km/s [3,4]. However, there remain important questions on the current-induced sublattice dynamics and the interaction of the RE and TM magnetic moments with spin-orbit torques. Here, I will present complementary studies of the switching of the RE- TM magnetization that address these open points.

First, time-resolved Hall measurements reveal that the overall switching speed is limited by the nucleation of a seed domain and that this process is influenced by stochastic thermal fluctuations [5]. The speed and reproducibility of the dynamics can be enhanced by reducing the duration of the electric pulses to the sub-ns regime. Second, element-resolved X-ray measurements disclose a variety of dynamics characterized by a variable degree of coupling between the RE and TM sublattices [6]. Surprisingly, they can switch asynchronously in time and inhomogeneously in space and form a transient ferromagnetic state as long as 2 ns. Micromagnetic simulations and atomic-structure measurements show that the asynchronous switching results from the combination of two factors: 1) the weak intersublattice antiferromagnetic coupling, which is strongly dependent on the atomic structure, and 2) the master-agent dynamics determined by the unequal action of spin-orbit torques on the two sublattices. Overall, these studies provide a deeper insight into the ferrimagnetic dynamics induced by spin-orbit torques.

[1] C. Stanciu, Phys. Rev. Lett. **99**, 047601 (2007) [2] L. Radu, Nat. **472**, 205-208 (2011)[3] L. Caretta, Nat. Nano. **13**, 1154-1160 (2018) [4] K. Cai, Nat. Elec. **3**, 37-42 (2020) [5] G. Sala, Nat. Comm. **12**, 656 (2021) [6] G. Sala, Nat. Mat. **21**, 640-646 (2022)

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