

Non-equilibrium magnetic effects at interfaces for ultrafast dynamics

Representing the future of spintronics, femtosecond spin current (SC) pulses constitute a versatile tool to transfer spin and control magnetization on the ultrafast timescale. It is therefore of paramount importance to understand the kinetics of these pulses and the fundamentals of their interaction with magnetized media. In our work, we demonstrate the key role of interfaces for the SC dynamics in Fe/Au/Fe multilayers. In particular, we argue that both (i) demagnetization caused by a pulse of hot electrons and (ii) spin transfer torque exerted by the orthogonal to the Fe magnetization projection of magnetic moment delivered by SC pulse are localized in the vicinity of the Fe/Au interface. We analyse both processes in details, showing that the SC-driven excitation of the sub-THz spin wave dynamics in Fe film is enabled by the spatial confinement of the exerted spin transfer torque. Moreover, a pulse of hot electrons leads to the efficient demagnetization of the Fe film. By disentangling the magneto-optical Kerr effect (MOKE) transients we demonstrate the strong spatial non-uniformity of this demagnetization. We argue that simultaneous recording of transient MOKE rotation and ellipticity is crucial for drawing such conclusions. Our findings have a twofold impact: firstly, they illustrate rich opportunities of utilizing SC pulses for manipulation of magnetization in ferromagnets and, secondly, they highlight the importance of spatial localization for understanding the ultrafast spin dynamics in multilayers.