Laser induced ultrafast demagnetization and spin current generation

Karel Carva

Department of Condensed Matter Physics, Charles University; Prague, Czech Republic.

Magnetization can be changed by means of a very strong laser light on the femtosecond timescale. This effect has a high application potential but it is also very interesting from the theoretical point of view due to reaching a previously unexplored nonequilibrium states of magnetic materials. Femtosecond laser triggers not only the ultrafast demagnetization of a ferromagnet, but also gives rise to spin current pulses. Their very short duration is unprecedent in spintronics. In noncolinear systems they can exert spin transfer torque on an adjacent magnetic layer [1].
In transition metals a laser pulse can excite electrons from the spin polarized *d* band into the conduction *s* band with a higher electron mobility. The nonequilibrium hot charge carriers migrate away from the laser spot and reduce the local magnetic moment as described by the spin transport model [2]. We study theoretically the spin transfer torque and magnetization dynamics induced by femtosecond laser pulse in a spin valve consisting of two magnetic layers with perpendicular magnetizations separated by a nonmagnet [3].
In such spin valves it is possible to achieve spin manipulation within sub-ps resolution, and the perturbation of magnetization is localized on the scale of several nm. Therefore we also perform a more accurate atomistic spin dynamics simulations to study the magnon dynamics induced by the spin current. Our calculations confirm that pulses are short enough to excite coherent magnons with frequencies reaching 1 THz, a range out of reach for current induced spin-transfer torque. Recently, such generation of high frequency magnons has been demonstrated experimentally [4]. Our method allows to examine the effect of the trilayer composition on the generated magnon spectrum. We also directly relate the distribution of higher frequency modes and the spin penetration depth.

[1] A.J. Schellekens et al., Nat. Comm. 5, 4333 (2014);
[2] M. Battiato, K. Carva, P. Oppeneer Phys. Rev. Lett. 105, 027203 (2010)
[3] P. Baláž et al., J. Phys.: Cond. Matter 30, 115801 (2018)
[4] I. Razdolski et al., Nat. Comm. 8, 15007 (2017)