Inertial displacement of a domain wall excited by ultra-short circularly polarized laser pulses

Researchers from the Institute of Physics and the Charles University in Prague and the Hitachi Cambridge laboratory in United Kingdom have transformed light polarisation into the position of a magnetic domain wall by moving it light helicity dependent along a magnetic race track bar by ultra-short laser pulses.

Their observation is a prerequisite for envisaged low-power spintronics combining storage of information in magneto- electronic devices with high speed and long distance transmission of information encoded in circularly polarized light. They demonstrate the conversion of the circular polarization of incident femtosecond laser pulses into inertial displacement of a domain wall in a ferromagnetic semiconductor. The researchers combined electrical measurements and magneto-optical imaging of the domain wall displacement with micromagnetic simulations. The optical spin transfer torque (oSTT) acts over a picosecond recombination time of the spin-polarized photo-carriers which only leads to a deformation of the internal domain wall structure. They show that subsequent depinning and micrometer distance displacement without an applied magnetic field or any other external stimuli can only occur due to the inertia of the domain wall. The work is currently under peer review at Nature Communications and can be accessed under https://arxiv.org/abs/1606.05212.

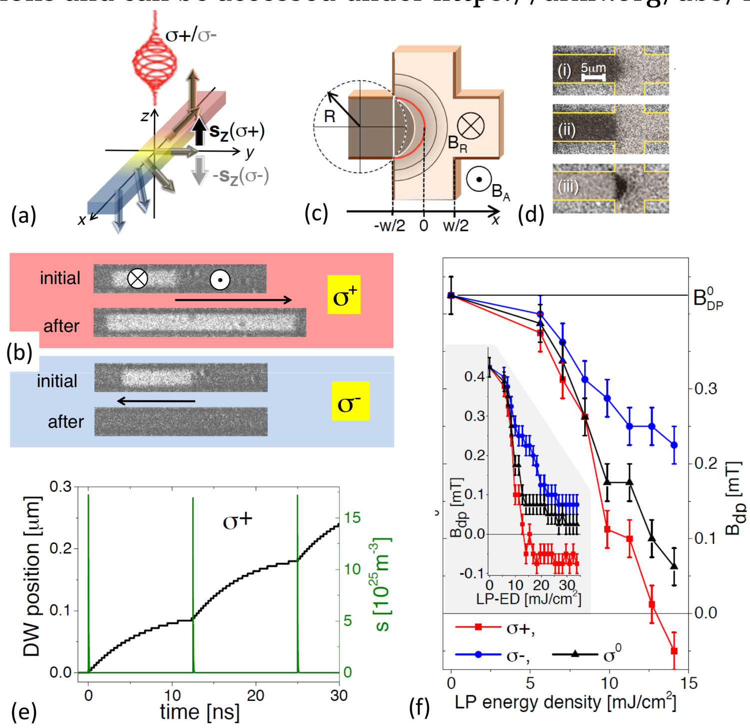

Figure 1: (a) Sketch of light-helicity dependent optical spin transfer torque on a DW: Op- tically generated spin-polarised photoelectrons exert spin-transfer torque only on the rotating magnetization of the DW in the perpendicular magnetised film. Outside the DW, electron spin- polarization and magnetization are collinear. (b) MOKE images of initial and final DW position after DW was irradiated with circularly polarised light. The DW is driven to the right/left at σ+/σ- polarisation of the laser light. (c) Schematic sketch of geometric pinning of an elastic DW within a symmetrical cross under the application of a magnetic field: The domain wall stays pinned on the input corners until it reaches the cross center (red half-circle). The geometrical pinning is exploited in the optically driven DW experiments. (d): The bubble like domain expansion caused by the geometrical pinning is verified by differential MOKE images of a 6μm wide device at small magnetic field smaller than depinning field (i), after the field is switched off (ii); (iii): subtracting (ii) from (i). (e): DW position as a function of time for the first three σ+ polarized LPs the DW propagates after the pulse was applied. (f): Depinning field B_{DP} as a function of LP energy density for circularly left (red), linearly (black) and circularly right (blue) polarized light. The inset shows B_{DP} for linearly and circularly polarised light up to the highest LP energy density where the temperature increase due to LP heating does not exceed the Curie temperature of the magnetic film. Depinning at zero applied field is only observed if the oSTT is generated by σ+ polarised LPs.