Manipulation of magnetic skyrmions in ultrathin Pt/Co/MgO nanostructures

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Magnetic skyrmions are nanoscale whirling spin configurations. Their small size, topological protection and the fact than they can be manipulated by small in-plane current densities have opened a new paradigm to manipulate the magnetisation at the nanoscale. This has led to proposal for novel memory and logic devices in which the magnetic skyrmions are the information carriers [1]. The recent observation of room-temperature magnetic skyrmions [2,3] and their current-induced manipulation [4,5] in ultrathin sputtered magnetic nanotrails have lifted an important bottleneck toward the practical realisation of such devices.

Here we report on the manipulation of isolated room-temperature magnetic skyrmions in sputtered single-layered Pt/Co/MgO nanostructures using external magnetic field [6] and in-plane current pulses. Using X-ray Magnetic Circular Dichroism - Photo-Emission Electron Microscopy (XMCD-PEEM), we observed a fast current-induced motion of small skyrmions (~150nm) in µm-wide tracks. In Fig.1.(a-c), we present a series of images showing a magnetic skyrmion after two consecutive 11 ns current pulses with opposite polarities and with an amplitude of 6x10^11 A/m². The skyrmion is dragged back and forth with a motion characteristic of a left-handed Néel skyrmion: it moves against the electron flow with a component of the velocity transverse to it, an effect referred to as the Skyrmion Hall Effect. Mean velocities up to 100 m/s were observed for a current density of about 6.75x10^11 A/m² (Fig 1.(d)).

**Figure 1 :** (a-c) XMCD-PEEM images of a magnetic skyrmion (a) before, (b) after a positive 11 ns in-plane current pulse and (c) after a negative one with |J|=6x10^11 A/m². The applied field is μ₀H₀=-4mT. (d) Average skyrmion velocities measured in 3 µm-wide tracks as a function of the current density.