Room temperature chiral magnetic skyrmions in ultrathin magnetic 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 magnetization 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 [4,5,6] in ultrathin sputtered magnetic nanotracks have lifted an important bottleneck toward the practical realization of such devices.

In this talk, I will report on the observation of isolated room-temperature magnetic skyrmions in sputtered Pt/Co(1nm)/MgO single multilayer nanostructure [2] and their manipulation using external magnetic field [7] and in-plane currents. Using high spatial resolution X-ray magnetic microscopy technique (XMCD-PEEM), we observed room temperature magnetic skyrmions at zero external magnetic field in magnetic nanostructures and demonstrated their homochiral Néel internal structure [3]. This can be explained by the large strength of the Dzyaloshinskii–Moriya interaction in this thin films as revealed by spin wave spectroscopy measurements. I will also discuss the effect of the lateral confinement and the magnetic field on the skyrmion size and stability in sub-micrometer nanotracks and nanodots. Our experimental results are supported by micromagnetic simulations which well reproduce the magnetic field dependence of the skyrmion size in the different geometries. Notably, we show that the granular structure of the sputtered materials leads to local pinning of the skyrmion which can strongly affect its shape and size [7].

I will also show that skyrmions can be manipulated with in-plane current in nanotracks patterned in this material. Skyrmion velocities up to 60 m/s can be achieved when injecting ns current pulses in magnetic tracks with densities of about J=5x1011 A/m². As the power dissipation due to Joule heating scales with the film thickness, the demonstration of fast skyrmion current-induced motion in a few nm thick multilayer is promising for lower power skyrmion-based memory and logic devices.

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