Spin Transfer Torque, Spin Orbit Torque and pure spin current

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In Spintronics, spin transfer torque (STT) and spin orbit torque (SOT) play active role to manipulate local magnetizations, which are controlled by external magnetic field traditionally. The advantage of these spin torque effects is that the required current is scalable with magnetization dimension. The STT refers to the effect by spin polarized charge current in magnetic materials when there is magnetization spatial gradient. The SOT results from pure spin currents, with no net charge currents, which are generated by the spin Hall effect, the spin pumping effect, the spin Seebeck effect, magnon transport etc.

We will present our experimental works on the STT in magnetic micron and sub-micron structures; the spin pumping effect in Topological Insulator/magnetic material bilayers; the generation and propagation of spin wave (SW); and some simulation about the SOT of SW acting on magnetic domain walls.

Employing a micro-focused Brillouin light scattering spectroscopy (BLS) setup, we experimentally realize a spin-wave (SW) generator, capable of frequency modulation, in a magnonic waveguide. The emission of spin waves was produced by the reversal or oscillation of nanoscale magnetic vortex cores in a NiFe disk array. The vortex cores in the disk array were excited by an out of plane radio frequency (rf) magnetic field. The dynamic behaviors of the magnetization of NiFe were studied. In addition to the discrete ferromagnetic resonance (FMR) signals above external dc saturation magnetic field, we observed clear signals at zero magnetic field where vortex cores are present.

We performed simulations in a quasi-one-dimensional ferromagnetic strip and have found that the SW shows highly anisotropic transmission through different orientations of magnetization inside a domain wall (DW) at a relatively low frequency. When the SW amplitude is large, it induces an effective field torque leading to the rotation of the DW plane and the DW motion. The forward DW motion is a contribution of the demagnetization field due to the increase of the transverse components of magnetization in the DW region, and thus yields an increase of the magnetization orientation of $\delta\varphi$. The backward motion is attributed to the conservation of the spin angular momentum. The transmission ratios of the SW are in turn determined by $\delta\varphi$ of the DW and show complicated dependence at low frequencies. We can thus manipulate the DW motion by selecting the SW frequency and/or controlling the SW amplitude through adjusting the DW angles.