Propagating Spin-Wave Spectroscopy at ultra-short wavelengths

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The spin waves (or magnons) are the low energy excitations of magnetically ordered materials. In typical ferromagnets, they exist over a range of frequencies (1 GHz – 1THz) and wavelengths (1µm-1nm) which correspond precisely to the time- and length- scales relevant for modern electronics (see figure). This suggests the possibility to use spin waves for developing new architectures for data processing and storage, which motivates the emergence of a new sub-field of nanomagnetism and spintronics called “magnonics” [1]. In this context, we have been developing in the past years at IPCMS an original microwave technique allowing one to measure precisely the propagation of spin waves with sub-micrometer wavelength [2,3]. In this technique, spin waves propagating along a narrow ferromagnetic strip are excited and detected inductively using nanofabricated metal circuits, the so-called spin wave antennas.

We propose to explore different methods for measuring spin waves of even shorter wavelength (100 nm or smaller). These methods include (i) introducing a magnetic inhomogeneity along the propagation path of the spin waves in order to "accelerate" locally the spin waves (ii) designing and fabricating very narrow antennas, likely to couple to spin waves over a broad range of wave-vectors .

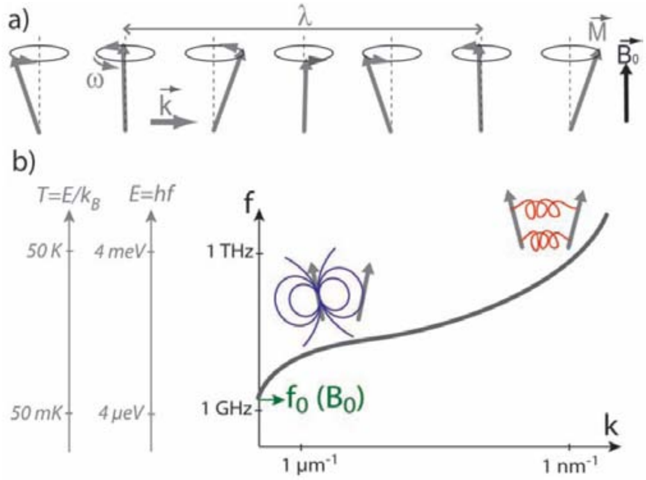

Figure: (a) Sketch of the instantaneous distribution of the magnetization in a spin-wave of wavevector k and angular frequency ω. (b) Sketch of the typical dispersion relation of a spin wave.

If successful, this work will open the way for truly nanoscale measurements of spin-wave propagation, which is an essential step for demonstrating the potential of magnonics for integration into conventional micro-electronics.

[1] B. Lenk et al., cond-mat: http://xxx.lanl.gov/abs/1101.0479 (2011).
[2] V. Vlaminck and M. Bailleul, Science **322**, 410 (2008).
[2] M. Haidar and M. Bailleul, Phys. Rev. B **88**, 054417 (2013).