Spin-wave propagation at variable temperature

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Understanding the interplay between spin dynamics and electron transport in itinerant ferromagnetic metals such as Fe, Co and Ni remains a very challenging task [1] because of the strong intrication of magnetism and electron band structure in these materials. This type of physics can be addressed with the help of propagating spin-wave spectroscopy (PSWS), which allows one to probe directly the nature of the interaction between spins [2] and its interplay with external electrical currents [3-5].

In this PhD project, we propose to perform accurate PSWS measurements (1-50 GHz) at variable temperature (5-300K) using a newly developped set-up (see figure). First, we will address the unexplored “anomalous” regime of spin transport in which the lengthscale of the magnetization gradient (here the spin-wave wavelength) becomes smaller than that of electron transport (the electron mean free path). For this purpose, we will resort to single crystalline pure iron films and extend our technique of current-induced spin-wave Doppler shift [3-4] to shorter wavelength using magnonic grating couplers [5]. Next, we will consider ferromagnetic metal thin film with a low symmetry B20 crystal structure to quantify their peculiar spin-orbit related antisymmetric exchange interaction [2] and explore the unconventional magnetic skyrmion phase, which appears at low temperature [6].

The proposed project is mainly experimental. The focus will be put on nanofabrication and microwave measurements in a newly installed cryogenic environment. The young researcher will acquire experience in instrumentation and a very strong background in magnetization dynamics and spin-polarized transport.

[1] Liu et al., Phys. Rev. B 91, 220405(R) (2015)
[2] Seki et al., Phys. Rev. B 93, 235131 (2016)
[3] Vlaminck & Bailleul, Science 322, 410 (2008)
[4] Gladii et al., Phys. Rev. B 96, 174420 (2017)
[5] Liu et al., Nature Comm 9, 738 (2018)
[6] Garst et al., J. Phys. D: Appl. Phys. 50, 293002 (2017)

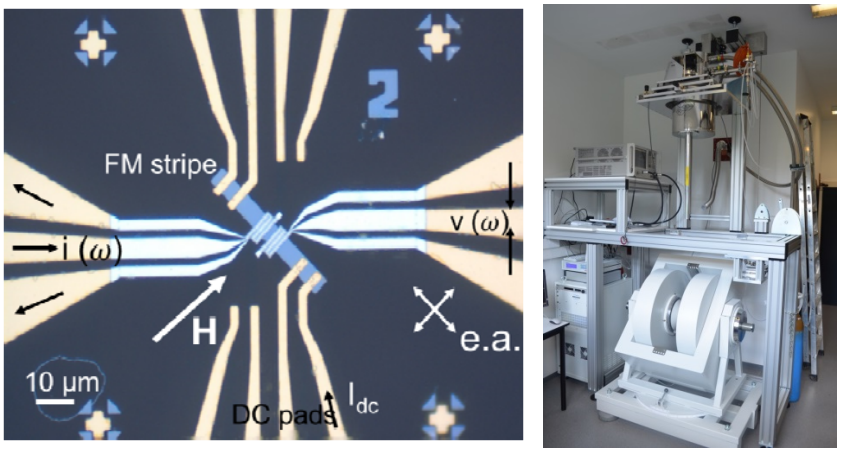

Figure: (Left) Optical microscope picture of a typical propagating-spin-wave-spectroscopy device, where a pair nano-antennae (in white) allows one to excite and detect spin-waves with a wave-length of about 1 µm. (Right) Photograph of the experimental set-up essentially composed of an electromagnet (bottom), a cryostat (top) and a microwave network analyzer (top left).