2D magnonics

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Planar meshed models with vectorial degrees of freedom, interacting with each other at each node, are ideal systems in statistical physics (Ising, XY, Heisenberg). The existence of a magnetic order in atomically-thin van der Waals materials has been demonstrated experimentally only in 2016-2017. Anisotropies and exchange interactions between spins depend intrinsically on the material and extrinsically on its environment through proximity effects, doping or induced lattice distortions.

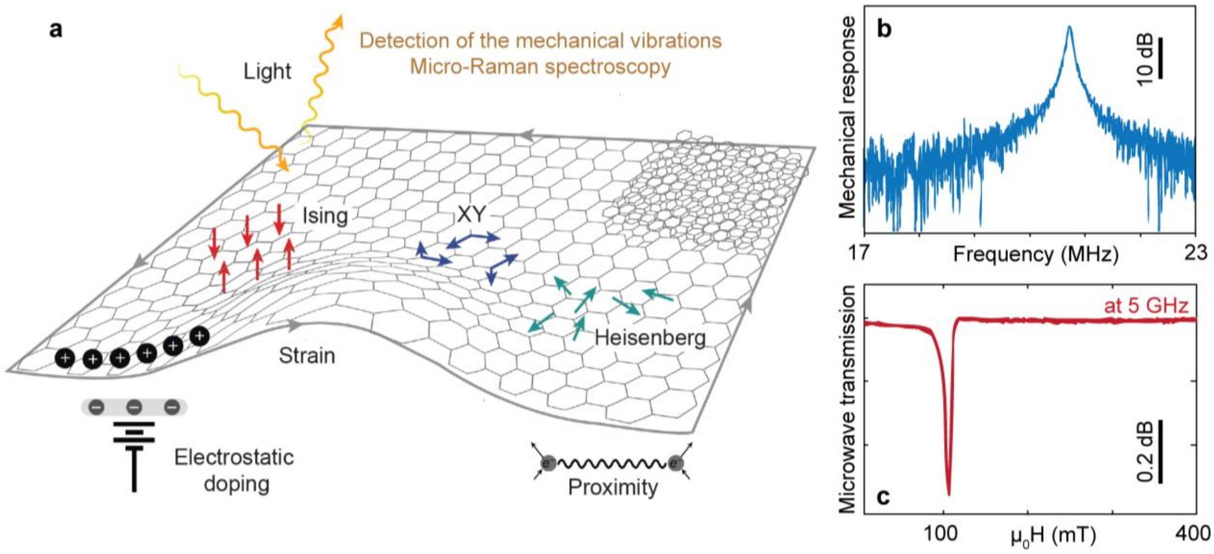

Figure 1: (a) Overview of the degrees of freedom available in magnetic 2D materials physics [1]. (b) Optical detection of the mechanical vibrations of a suspended magnetic van der Waals heterostructure in our team [2]. (c) Microwave transmission through a waveguide revealing an antiferromagnetic resonance in bulk $CrCl_3$ [4].

We are building an optomechanical platform, associated with an optical spectrometer, in which the drum-like vibrations of a micrometric suspended magnetic membrane can be optically monitored by interferometry to observe and control its magnetic order [2].
These magnetic materials can also host collective spin excitations [3], in particular antiferromagnetic magnons in the microwave range [4]. This PhD aims at exploring magnonics in 2D, down to the bilayer limit. Future prospects include investigating proximity effects with light-emitting monolayers [5], as well as controlling spin waves through light and mechanical vibrations. The experiment will take place in a new cryostat (300 K – 4 K) with optical and microwave accesses, embedding a magnetic field up to 7 T recently installed. The understanding and control over these delicate atomically-thin magnetic materials will enable in-depth investigations of magnetism in 2D, the design of new magnetic nanodevices and new paradigms in hybrid optomechanics.

[1] K. Burch et al. Nature **563**, 47–52 (2018)
[2] J. Wolff et al., in preparation (2022)
[3] D. Lachance-Quirion et al., Appl. Phys. Express **12,** 070101 (2019)
[4] D. MacNeill et al., Phys. Rev. Lett. **123**, 047204 (2019)
[5] A. Gloppe et al., Phys. Rev. B **105**, L121403 (2022)