Internship offer in MASTER 2 - 2024/2025

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Spectroscopic studies of the 2D and 3D confinement of cesium vapor in a cell of manometric dimensions

The study of the confinement of an alkaline vapor in nanoscale systems offers interest ranging from fundamental physics to the creation of atomic clocks, frequency references or miniaturized magnetometers.... This type of study presents two challenges: the manufacturing of the nanostructured cell and then the measurement and interpretation of the impact of confinement on the atomic vapor. The Atomic Spectroscopy at Interfaces (SAI) group has made high-resolution spectroscopy of atomic vapor near surfaces its specialty. He studied in detail the specific spectroscopic properties of very thin cells [1] (1D confinement) containing an atomic cesium vapor. In these cells, the mean free path of an atom becomes anisotropic, and is limited by the distance between the cell walls. This leads to a relative exaltation of the contribution of slow atoms, hence a sub-Doppler signature in the spectroscopic response. In the linear absorption regime, a coherent Dicke-type spectral narrowing was observed [2] for a cell thickness approximately equal to $\lambda/2$.

To explore the effect of stronger confinement, we worked in collaboration with the Institute of Electronics, Microelectronics and Nanotechnology in Lille and Nathalie Fabre (LPL) on the design of a nanostructured silica cell. The atoms will be confined in the interstices of a periodically nanostructured silica layer. The first prototype includes line networks for 2D confinement and checkerboard type networks for 3D confinement with periods ranging from $\lambda/4$ to 2λ. A first prototype was built (Fig 1).

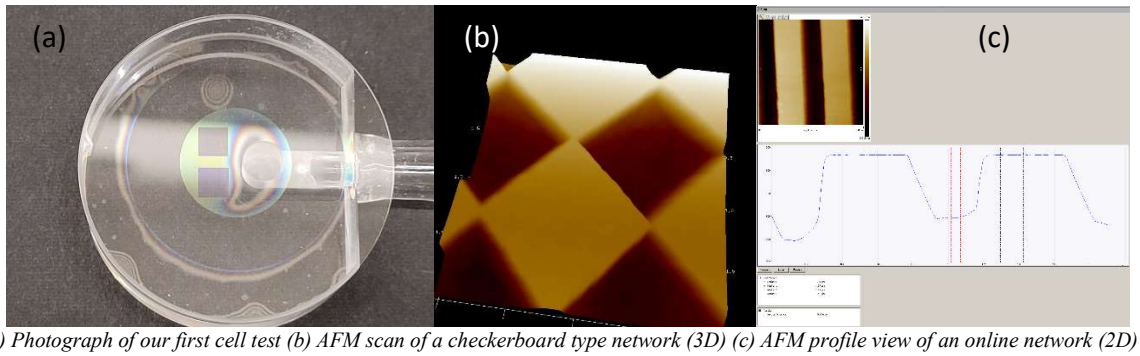

Fig. 1 : (a) Photograph of our first cell test (b) AFM scan of a checkerboard type network (3D) (c) AFM profile view of an online network (2D)

The aim of the course will initially be to optically characterize the different nanostructuring zones. Then, by reflection and transmission spectroscopy on these nanostructures, we will study on the D1 line of cesium (λ=894 nm), the influence of two or three-dimensional confinement, a change in periodicity, angle of incidence as well as polarization…. The proposed internship will consist of being immersed in a research team, setting up a characterization then spectroscopy experiment, setting up the experiment, acquiring data and participating in their interpretation.

Internship period: from March 2025 to July 2025

[1] D. Sarkisyan et al., Opt. Commun. 200, 201 (2001)

[2] G. Dutier et al., Europhys. Lett., 63, 35-41 (2003)