EUROPHOTONICS-POESII MASTER COURSE

PROPOSAL FOR A MASTER THESIS

Dates: April 1st, 2016 – September 30th, 2016

Laboratory/Institution: ICFO
City, Country: Castelldefels (Barcelona), Spain

Title of the master thesis: Coupling excitons to a mechanical resonator based on a monolayer semiconductor WSe2.

Name of the tutors of the master thesis: Adrian Bachtold and Antoine Reserbat-Plantey
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Summary of the subject (maximum 1 page) :
Two-dimensional (2D) monolayers have generated a huge research interest in the past years. The discovery of graphene was awarded with the 2010 Nobel Prize in physics. Being the thinnest material possible, 2D monolayers offer unique scientific and technological opportunities as nanomechanical resonators. For instance, they can be employed as ultra-sensitive sensors of mass and of force with unprecedented sensitivities [1,2]. Coupling the mechanical motion of a 2D monolayer to excitons is appealing: it holds promise for the detection of ultra-small displacements (that is, ultra-small amplitude of the vibrational motion of the resonator). Interestingly, in this limit, the physics is governed by the laws of quantum mechanics. Namely, the position and momentum of the resonator have a variance reaching the limit of the Heisenberg uncertainty principle.

There is a lot of interest in the scientific community to study the physics and the potential applications of mechanical motion in this so-called quantum regime [3]. Many research groups are employing resonators microfabricated in semiconducting and metallic materials, while 2D monolayer resonators offer the advantage to have a comparatively large vibrational amplitude in the quantum regime. In addition, mechanical nonlinearities of 2D monolayer resonators are particularly pronounced in comparison to other nanomechanical resonators [4] and might be sizeable in the quantum regime.

One aspect of the project will be to fabricate ultra-clean 2D monolayer resonators. Here the student will have the opportunity to learn how to use an electron beam lithography system, how to produce 2D monolayer devices like the Nobel Prize winners, and how to transfer 2D monolayer with micrometer precision. The device will consist of a 2D monolayer that is

suspended over a trench (see figure). The other aspect of the project is to detect the motion of the 2D monolayer using interferometric methods. The student will also be trained in photoluminescence measurements at cryogenic temperatures (down to 2 K). The student will work in close collaboration with the team.

[1] Chaste, Eichler, Moser, Ceballos, Rurali, Bachtold, Nature Nanotech. **7**, 301 (2012)
[2] Moser, Eichler, Guttinger, Dykman, Bachtold, Nature Nanotech. **9**, 1007-101**1** (2014).
[3] Aspelmeyer, Meystre, Schwab, Physics Today **65**, 29 (2012)
[4] Eichler, Moser, Chaste, Zdrojek, Wilson-Rae, Bachtold, Nature Nanotech. **6**, 339 (2011)

Keywords : Optomechanics, semiconductor monolayer WSe2, photoluminescence, cryogenics, nanofabrication

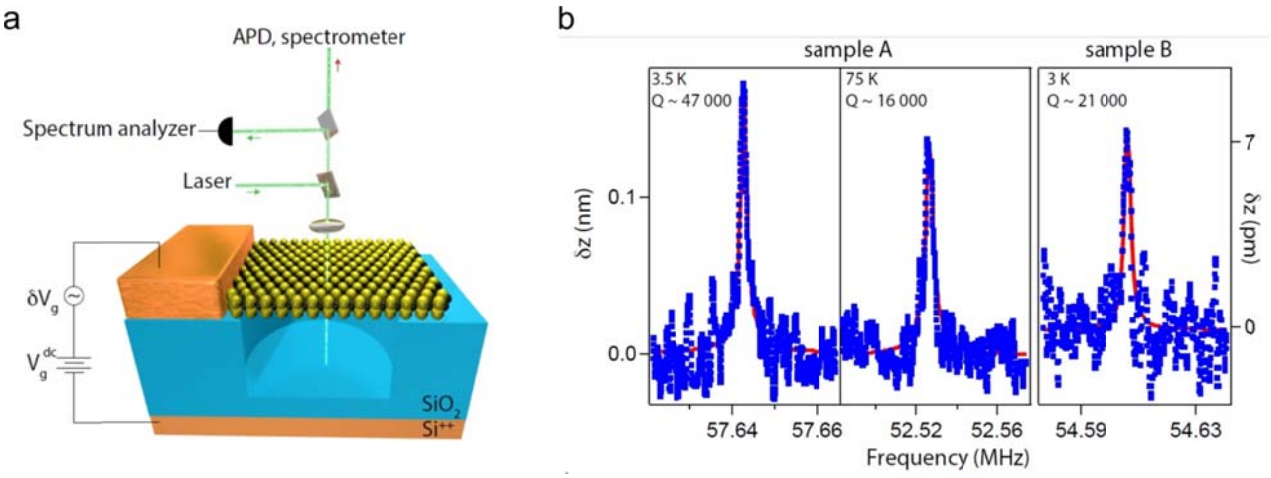

Figure: Nano-optomechanics with WSe2 monolayer resonators. (a) Device layout. (b) Mechanical resonances of WSe2 monolayer resonators.

Additional information:
* Required skills: We are looking for applicants with a strong background in physics.
* Amount of the monthly allowance (if it is the case): up to 600 euros/month
* Miscellaneous: We have the funding to pay the master thesis as well as to continue the work with a PhD.