Force-based absorption spectroscopy at single-nanoparticle level with an AFM

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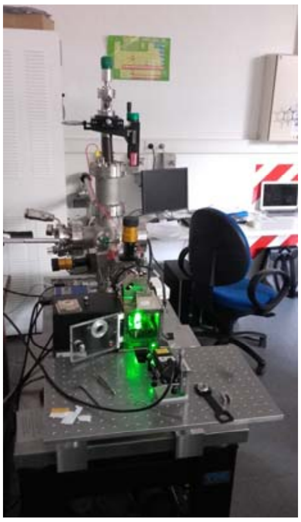
This thesis project focuses on the development of a new spectroscopic technique able to measure photon absorption in visible and near infrared regimes at single nanoparticle level (plasmonic NPs, QDs, molecules). The principle is based on the optomechanical coupling of the oscillatory radiation pressure of coherent photons with the transverse oscillatory modes of sensitive atomic force microscope (AFM) probes. Using high quality mechanical probes - as those recently used to measure weak thermal-induced distributions of van der Waals[1] or frictional forces[2] – in electromagnetic fields above the zero-point fluctuations, the resonant motion of the vibrating modes is altered by the radiation pressure enabling detection. Recent experiments and theories conduced mostly with the purpose of cooling micromechanical oscillators show that the optomechanical coupling can be indeed strong,enough for instance to reach temperatures below 10 K.[3] Our calculations indicate that the force sensitivity of our microscope (figure) is largely sufficient to detect minute changes in the radiation force (femto- to pico-Newtons); as expected to be induced through absorption. Some of our recent experimental results fully supports with this conclusion.



The development of an absorption spectroscopy technique within an atomic force microscope has additional advantages. For instance, the nanoparticles can be imaged very precisely, and moreover they can be nanomanipulated in order to build specifi**c** multiparticle superstructures with well defined interparticle separations (Angstrom resolution).

It is therefore a thesis comprising experimental and theoretical aspects. The candidate must have solid notions of solid state physics and optics. Knowledge about physics and chemistry metal nanoparticles (Au, Ag, …), semiconductors QDs, surface physics, or scanning probe techniques will be appreciated.

1. A.V. Pinon, M. Wierez-Kien, A. D. Craciun, N. Beyer, J. L. Gallani, and M. V. Rastei, Phys. Rev. B 93, 035424, (2016).

2. M.V. Rastei, B. Heinrich, J.L. Gallani, Phys. Rev. Lett. 111, 084301 (2013).

3. M. Aspelmeyer, T. J. Kippenberg, F. Marquardt, Cavity Optomechanics, Springer (2014) and references therein.