# Optical Phonons in low dimensional systems

Nedjma Bendiab, Institut Néel, UGA-CNRS

Optical phonons, in low dimensional $sp^2$ carbon systems, couple easily with different elementary excitations (electron, acoustic phonon, photon), allowing us to be sensitive to various physical phenomena: mechanical resonances, charge transfer, energy transfer…etc.
More specifically, electron phonon coupling in these systems, lead to change our vision of this low dimensional system regarding the classical model where electrons and phonons can be described separately or together only in peculiar situation like superconductivity. In fact, during the last decade, thanks to Raman spectroscopy measurement of optical phonons, we demonstrate that the adiabatic approximation in low dimension carbon systems failed.
Thus, the huge electron-phonon coupling in low dimension and its dependency with a gate voltage, allow us to detect a few amount of molecules on graphene sheet for example. In this example, the grafted molecules transfer a small charges to graphene thus the frequency of the optical mode is shifted due to a change on the strength of the electron-phonon coupling.

More recently, optical molecules grafted on carbon nanotube, show a huge modification of the optical phonons due to an excitation transferred from the molecule to the nanotube under illumination allowing a transduction effect and opening the way to new optoelectronics at this single nanotube level.

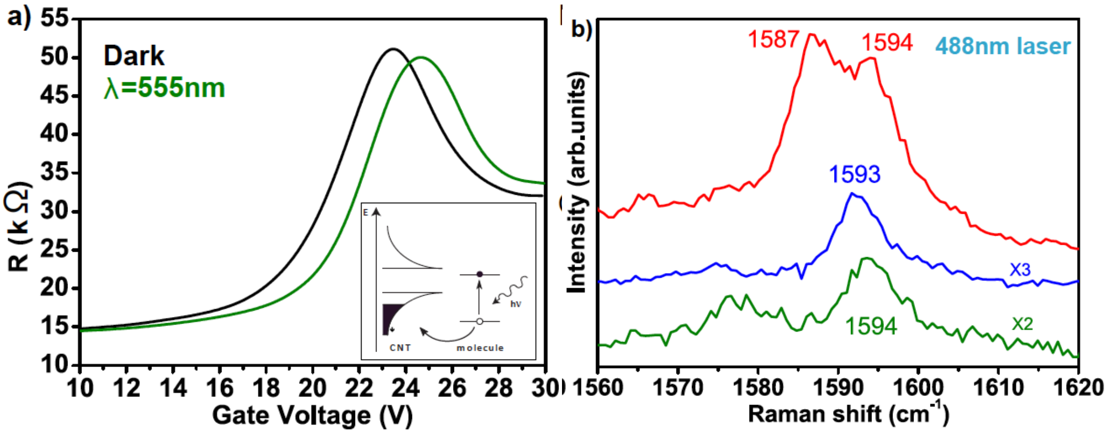


**Figure 1: Transport and Raman measurement under light illumination on single nanotube device grafted by photoactive molecules.**

In this context, Resonant Raman spectroscopy plays a major role in the understanding of the properties of those low dimensional systems. During this practical, we will investigate an individual carbon nanotube with this tool and how it's possible to extract its structural vibrational and electronic properties simply with this non-invasive optical measurement.
Moreover, we will use graphene or any 2D materials in a transistor configuration to probe the coupling between optical phonons and electrons and how we can imagine an optoelectronic device.

The candidate will learn up-to-date Raman spectroscopy from resonant measurements, spatially resolved imaging, and cross measurement with transport.