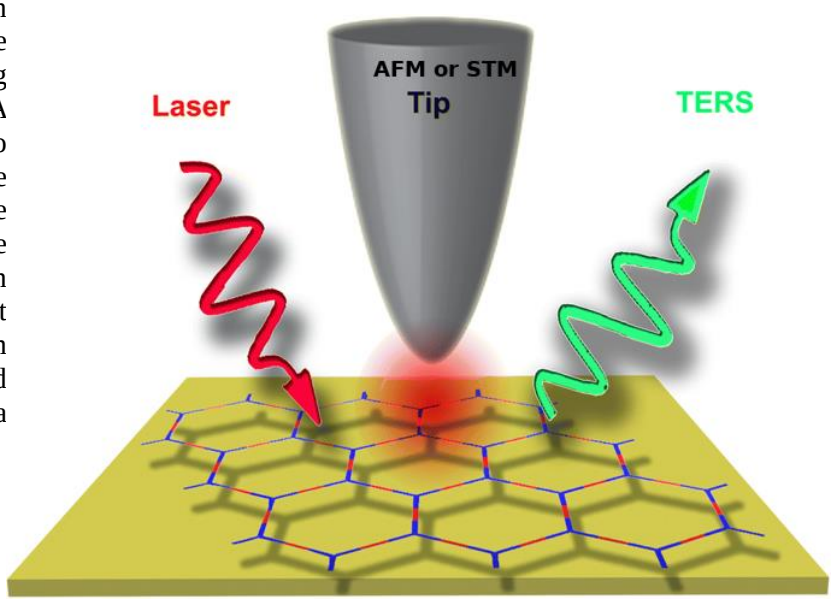
Experimental project for Master in Physics, LION.

Atomic force microscopy and tip enhanced Raman spectroscopy to characterize functionalized graphene edges.

Atomic Force Microscopy (AFM) is a powerful and versatile technique which can achieve sub-nanometer resolution on both metallic and insulating surfaces. It is a very frequently used tool in nanotechnology, for highly resolved surface morphology of samples and devices. It can also provide extra information on the nanoscale like mechanical, magnetic and conducting properties. AFM, however, cannot identify the chemical composition of a given material. Raman spectroscopy, instead, has emerged as a crucial technique in the field of chemical characterization, accurately identifying and classifying chemical composition of materials. The combination of the two techniques is called Tip Enhanced Raman Spectroscopy (TERS). Here the Raman signal can be locally enhanced by several thousands times because of the sharp AFM probe due to a combination of electric-field enhancement and plasmonic resonance [1], thereby boosting the resolution of a Raman microscope well beyond the optical diffraction limit. TERS therefore provides an effective means to detect the presence of very few or even single molecules of a specific species within a 50-100 nm radius around the apex of the AFM tip.

A current avenue of research in the van Ruitenbeek Lab is the testing of the viability of a tunneling junction consisting of two graphene edges for DNA Sequencing purposes. Here we aim to control the chemical makeup of the molecular termination of the graphene edges to potentially increase the transmission through DNA nucleotides in the Graphene edge junction. In this context a functional TERS setup will help confirm the attachment of specifically designed molecules exclusively to the edge of a Graphene sheet.



Aim of the project:

The 2 main aims of this project are:

1) Integrate and improve a home build a Raman Microscope with a commercial AFM. You will optimize the home-built Raman setup by characterizing the noise, stability and resolution of the setup. You will design and implement the integration of the Raman microscope with a (available) Bruker MultiMode AFM and test the functionality with calibration samples.

2) Detect different Raman signals from the basal plane of a graphene sheet and from the edge of the graphene sheet which has been functionalized with molecules.

The research group:

The project will take place in the group of Prof. Jan van Ruitenbeek in Leiden. You will work in a team composed by a PhD student (N. Bluemel), research technician (F.Galli), mechanical department (C.Pen) and possibly together with a bachelor student.

[1] N. Kumar, S. Mignuzzi, W. Su, and D. Roy, Tip-enhanced Raman spectroscopy: principles and applications, EPJ Techniques and Instrumentation 2 (2015).

Contact:
Prof Jan van Ruitenbeek: ruitenbeek@Physics.LeidenUniv.nl
Dr. Federica Galli: Galli@Physics.LeidenUniv.nl
Norman Blümel: Bluemel@physics.leidenuniv.nl