# ***INTERNSHIP PROPOSAL***

Laboratory name: Laboratoire Charles Coulomb (L2C)
CNRS identification code: UMR 5221
Internship director'surname: Adrien NOURY
e-mail: adrien.noury@umontpellier.fr Phone number: 04 67 14 42 30
Web page: https://nanomechanics.fr
Internship location: Montpellier
Thesis possibility after internship: **YES**
Funding: YES If YES, which type of funding: ANR

**Nanofluidics and nanomechanics with a carbon nanotube**

**Context:**
Being the primordial solvent of life, water is essential to living organisms and to human societies. Because it is abundant on earth, it is at the core of essential emerging technological developments, including green chemistry, blue energy harvesting and so on. The primordial role of water can be related to its structural properties that are unique in nature (hydrogen bond network and dipolar moment). Any modification of the water structure, either in the liquid or solid states, has a huge impact on its properties.
In extreme confinement situation, water can still fit into narrow channels such as carbon nanotubes (which diameter is lower than 1 nm) but at the cost of a modification of its structure. This yields structures of solid, but also structures of liquid water, that are different from the bulk [1,2], a rich phase diagram [3,4] and anomalous transport properties [5], i.e. when the laws of continuum fluid dynamics (Navier Stokes) do not hold anymore [6]. It is currently a very active research field thanks to the rapid development of new methodologies focused on the investigation of single/isolated nano-object.
Up today, most experimental studies are struggling with the problem of sensitivity. Indeed, investigating individual carbon nanotubes is a challenge, owing to their small dimensions. To tackle this issue, we propose to use nanomechanics as an ultimate tool to investigate the properties of water confined inside a suspended, individual, carbon nanotube.

[1] T. A. Pascal, W. A. Goddard and Y. Jung, Proc. Natl. Acad. Sci. U.S.A. 108 (2011)
[2] E. Paineau, P.-A. Albouy, S. Rouzière, A. Orecchini, S. Rols and P. Launois, Nano Lett. 13 (2013)
[3] D. Takaiwa, I. Hatano, K. Koga and H. Tanaka, Proc. Natl. Acad. Sci. U.S.A. 105 (2008)
[4] K. V. Agrawal, S. Shimizu, L. W. Drahushuk, D. Kilcoyne and M. S. Strano, Nat. Nanotechnol. 12 (2017)
[5] K. Falk, F. Sedlmeier, L. Joly, R. R. Netz and L. Bocquet, Nano Lett. 10 (2010)
[6] L. Bocquet and E. Charlaix, Chem. Soc. Rev. 39 (2010)

**Scientific and technical work:**
The internship aims at experimentally probing the mechanical properties of carbon nanotubes, as well as the use of such properties to investigate the physics of confined water: unique water structures under confinement, phase diagram and anomalous flow.
The project will involve the following experimental techniques: I-V pre-characterization (probe station), mechanical spectra (low-noise electronics), time-resolved frequency tracking (PID/PLL), and computer analysis tools (Python/Origin).

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: YES
Quantum Physics: NO Theoretical Physics: NO