**Superfluid helium films on carbon nanotube**

A. Nourya,e\*, J. Vergara-Cruza, P. Morfinb, B. Plaçaisb, M. C. Gordillo Barguenoc, J. Boronatd, S. Balibarb and A. Bachtolda

1. ICFO - Institut De Ciencies Fotoniques, The Barcelona Institute of Science and Technology

Mediterranean Technology Park, 08860 Castelldefels (Barcelona), Spain

1. Laboratoire Pierre Aigrain, Département de physique de l'École normale supérieure (ENS), PSL Research University, Université Paris-Diderot, Sorbonne Paris Cité, Sorbonne Universités, UPMC Université Paris-6, CNRS

75005 Paris, France

1. Departamento de Sistemas Físicos, Químicos y Naturales, Universidad Pablo de Olavide

Carretera de Utrera, km 1, E-41013 Sevilla, Spain

1. Departament de Física i Enginyeria Nuclear, Universitat Politècnica de Catalunya

B4-B5 Campus Nord, 08034 Barcelona, Spain

1. Author present address: Laboratoire Charles Coulomb (L2C), Univ Montpellier, CNRS, Montpellier, France

\* adrien.noury@umontpellier.fr,adrian.bachtold@icfo.eu

Helium-4 atoms are bosons, with the capability to turn superfluid at very low temperature. Remarkably, this property is conserved even when the thickness of the Helium film is reduced down to few atoms thick only. The study of 2D helium films has led to several breakthrough in condensed matter physics including the study of third sound and topological phase transitions, the latter being rewarded by the 2016 Nobel Prize.

In most experimental studies helium was adsorbed on large scale substrates, such as mm2 scale grafoil plates or Mylar. Recent advances in the field of optomechanics and nanomechanics now opens up the possibility to study fluids and superfluids of smaller dimensions.

In this talk, we present our recent experiments on helium films probed through the mechanical vibrations of a carbon nanotube. We observed a strong discontinuity in the adsorption of He on the nanotube surface, that we attributed to a layering transition. In addition, the low-temperature dependence of the mechanical mode of the nanotube exhibit a mode softening. Thanks to the tunability of the nanotube resonator, we confirmed the spring nature of this effect and drawn a link with the propagation of third sound in He 2D films.