



Controlling superfluid helium with carbon nanotubes

A study led by ICFO researchers shows how superfluid helium grows onto a carbon nanotube as a series of first-order layering transitions.

May 02, 2019

Carbon Nanotube resonators have shown to be excellent sensing devices for the study of new physical phenomena at the nanoscale (e.g. quantum electron transport, surface science, and light-matter interaction). Superfluid helium is known as a great system for the study of phase transitions, in particular for understanding transitions in two and three dimensions. By combining these two systems, it is possible to study various phenomena at the nanoscale, such as adsorption, supersolidity and superfluidity. In search to understand this last phenomenon, previous works have studied helium superfluidity but only considering configurations when the helium film was planar and not wrapped around a nanotube.

Thus, in a recent study published in *Physics Review Letters* and highlighted in *APS Physics Magazine*, ICFO researchers Adrien Noury and Jorge Vergara-Cruz led by ICFO Prof Adrian

Bachtold, in collaboration with researchers Pascal Morfin, Bernard Placais and Sebastien Balibar from Ecole Normale Supérieure, Maria C. Gordillo from Universidad Pablo de Olavide, and Jordi Boronat from the UPC, report on a controlled layer-by-layer growth process of superfluid helium onto the surface of carbon nanotubes.

In their experiment, the team of researchers took a carbon nanotube, fixed it to two edges so that the nanotube could be stretched and oscillating like a guitar string, placed it inside a chamber and added helium vapour to observe that helium superfluid films were indeed adsorbing onto the surface of the suspended carbon nanotube. As the helium accumulated on the nanotube, the frequency of mechanical vibrations of the nanotube changed as its mass increased. That is, they observed that as the helium adsorbed onto the tube, the resonating frequency changed abruptly, indicating that the stacking of helium onto the nanotube was done layer-by-layer with discontinuities in both the number of adsorbed atoms and the speed of the third sound in the adsorbed film. In such process, they were able to demonstrate the formation of helium layers up to five atoms thick.

The results indicate that the team was able to build helium superfluid films with a number of atomic layers in a perfectly controlled manner, and that these helium multilayers adsorbed on a nanotube are of unprecedented quality compared to previous works. Such findings could open a new pathway into the field of topological phase transitions, aiming to carry out novel research of quantum fluids and solids in reduced geometry.