Centre de Nanosciences et de Nanotechnologies

Soutenance de thèse

Mercredi 16 décembre

14h00
Centre de Nanosciences et de Nanotechnologies
10 boulevard Thomas Gobert
91120 Palaiseau
Amphithéâtre

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“ Coulomb Interaction and electronic quantum coherence in solid-state interferometers”

Lien public : https://u-paris.zoom.us/j/89833292091?pwd=cFZPTVVhNXhLQmRJM1FXeVNha3duZz09

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Abstract :

Electronic transport in low temperature and low scale solid-state devices is governed by the laws of quantum mechanics, where the wavelike nature of electrons cannot be overlooked. The resulting effects are well explained when electronic transport is expressed in terms of elementary conductive channels, that are analogous to optical modes in a waveguide. Quantum Hall edge channels are a direct implementation of such electronic channels and consequently are a platform of choice to study electrical transport at the fundamental level. Notably, they can be used to implement electronic interferometers and in particular, the analogue of a Mach-Zehnder interferometer, which among other realizations, illustrates a promising route toward reproducing quantum optics experiments with electrons. A crucial difference with optics is that Coulomb interaction is ubiquitous in electronic circuits, which both limits the electron quantum coherence and gives rise to exotic correlated phenomena.
In this thesis, quantum Hall edge channels were arranged in a Mach-Zehnder geometry in order to study the effect of Coulomb interaction on the electronic quantum coherence. The obtained results are two-fold. First, a strategy based on the suppression of the Coulomb mediated coupling between co-propagating edge channels to highly increase the coherence length was demonstrated. This resulted in an observed coherence length enhanced by over one order of magnitude, reaching a macroscopic length of 0.25mm, a distance visible to the naked eye, at low temperature (10mK). In a second experiment, a small metallic island was introduced on one of the two paths of an electronic Mach-Zehnder interferometer. An electron remains within such an island much longer than its quantum lifetime, which normally prohibits any quantum coherent propagation of electrons across it. However, when a single channel is connected to this island, and if the latter’s capacitance is small enough to freeze any fluctuation of its global charge, a perfect transmission of the electron quantum state across the island is predicted. This striking prediction was experimentally demonstrated in this thesis. While the first result illustrates how Coulomb interaction can be detrimental to quantum coherence, the second one, on the contrary, shows that it can be harnessed to preserve quantum coherence.