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## Guiding Dirac Fermions in Graphene with a Carbon Nanotube


**Abstract:** Relativistic massless charged particles in a two-dimensional conductor can be guided by a one-dimensional electrostatic potential, in an analogous manner to light guided by an optical fiber. In this seminar, I will present how we use a carbon nanotube to generate such a guiding potential in graphene and create a single mode electronic waveguide. In our architecture, the nanotube and graphene are separated by a few nanometers and can be controlled and measured independently. As we charge the nanotube close to the surface of graphene, we observe in the latter the formation of a single guided mode that we detect using the same nanotube as a probe. I will discuss why the small dimensions of the nanotube and the linear dispersion relation of Dirac fermions gives these electronic waveguides promising characteristics for potential applications. I will also show that, in presence of magnetic field, our electronic waveguides host discrete electronic levels resembling Landau levels of 2D Dirac particles but with no C-symmetric counterpart, i.e. they exist only for one sign of energy, positive or negative, depending on the voltage applied on the nanotube. This unusual behavior is a generic signature of Dirac surface states, which are predicted to be protected to a great extent to surface disorder.


**Bio:** Jean-Damien graduated from École Normale Supérieure (2005), where he specialized in quantum and condensed matter physics. This academic training enabled him to carry out a Ph.D. in the Quantronics Group of the CEA Saclay, under the supervision of Philippe Joyez. There he realized experiments in the field of mesoscopic superconductivity. By measuring microscopic excitations in a carbon nanotube, Jean-Damien demonstrated experimentally the existence of "the Andreev bound states", quantum electronic states at the origin of the Josephson effect in superconductors. Jean-Damien’s discoveries continued during three successive postdocs at ENS, Columbia University and College de France. At ENS, in the group of Benjamin Huard, he realized a quantum limited amplifier for the measurements of superconducting qubits. He also contributed to the realization of a superconducting quantum node for entanglement and storage of microwave radiation. At Columbia university, in the group of Philip Kim, the young researcher explored the physics of hybrid one and two-dimensional materials, in which quantum physics plays a key role. In College de France, Jean-Damien carried out theoretical work, in which he proposed the “Andreev molecule,” a new artificial quantum system composed of two closely spaced Josephson junctions.Since 2017, Jean-Damien Pillet has joined the École Polytechnique to build up a new research group with his colleague Landry Bretheau. This group, called Quantum Circuits & Matter (QCMX), aims to explore the quantum properties of hybrid systems based on low-dimensional conductors and superconducting circuits.