## Master 2: *International Centre for Fundamental Physics*

## INTERNSHIP PROPOSAL

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Internship location: LPS Orsay
Thesis possibility after internship: (YES)
Funding: NO

**Probing (pseudo-)relativistic effects in Dirac matter**

Interplay between relativity and quantum physics is at the origin of a great number of fascinating phenomena in high-energy physics, such as Klein's paradox, Hawking radiation or the Schwinger effect. They have been theorised ever since the appearance of these two domains of physics more than a hundred years ago. However, the experimental verification of these phenomena is often difficult due to the large energy scales required in high-energy physics. The advent of graphene and other (mainly two-dimensional) quantum materials in which the low-energy electronic properties are equally governed by the quantum-mechanical Dirac rather than the Schrödinger equation has fundamentally changed the experimental accessibility of these effects. Indeed, the characteristic speed of light is downscaled to the Fermi velocity, which is roughly two orders of magnitude smaller, and the mass gap is changed from a MeV to the order of an eV.

One of such effects is the Schwinger effect, which consists of the spontaneous creation of electron-positron pairs in the presence of a strong static electric field. While the effect has never been observed with true electron-positron pairs as a consequence of their large mass gap, recent experiments on mesoscopic quantum transport have unveiled the analogous effect in graphene, within a collaboration led by the LPENS mesoscopic physics group and the theory group at LPS, Orsay. The present Master project aims at a deeper theoretical understanding of the effect, namely if a AC voltage is added to the constant one that creates the strong electric field. Indeed, one expects then a frequency-assisted version of the effect and eventually a crossover to yet another relativistic quantum effect that is the Compton effect. The theoretical approach to these phenomena is mainly analytical. Regular exchange with experimentalists from the mesoscopic quantum physics group (Emmanuel Baudin) at LPENS, Paris, is envisioned.

Condensed Matter Physics: YES Macroscopic Physics and complexity: NO
Quantum Physics: YES Theoretical Physics: YES