Laboratoire LEPRINCE-RINGUET
Ecole polytechnique IN2P3/CNRS

Séminaire

Lorentz invariance and atomic collapse simulated with nanotube-graphene devices

Atoms are stable because quantum zero point motion prevents electrons from falling toward the nucleus. For heavy nuclei though, it has been predicted that there exist a maximum size ($Z>137$), beyond which Coulomb attraction leads to the collapse of electrons onto the nucleus, resulting in the emission of positrons. The nature of this effect is relativistic: as electrons approach the nucleus, their velocity saturates close to the speed of light and their kinetic energy is surpassed by Coulomb attraction. This phenomenon has not been seen experimentally due to the difficulty of producing heavy atoms.
In graphene, electrons behave as massless relativistic fermions propagating with a velocity that is 300 times smaller than the speed of light. This makes graphene a powerful platform to explore relativistic quantum mechanics. In our experiment, we realize devices with closely spaced carbon nanotube and graphene, in which a nanotube plays the role of an artificial and tunable nucleus. We first measure the response of graphene electrons to perpendicular electric and magnetic fields illustrating the invariance of Dirac equation under a Lorentz transformation. Then, charging gradually the nanotube, we reach the regime, in which graphene experiences atomic collapse. Our experiment yield exciting perspectives to simulate more complex relativistic phenomena in nanotube-graphene devices including gravitational physics.

Jean-Damien PILLET
LSI, École Polytechnique

Salle conférence du LLR 05-2021

Lundi 12 Février 14h00

seminaires@llr.in2p3.fr

Responsables séminaires

Sami Caroff
Jean-Baptiste Sauvan