ICFO

INSIGHT SEMINAR: Fractional statistics of anyons in mesoscopic colliders

GWENDAL FEVE

May 02, 2024

12:00 to 13:00

Seminar Room

BIO:

Gwendal Feve has focused his research activity on the realization of electron quantum optics experiments in quantum conductors. Inspired by photon quantum optics, electron optics relies on the manipulation of single electrons in the edge channels of the quantum Hall effect. GF uses single-electron sources that he introduced during his PhD, quantum point contacts beam-splitters for electronic waves, and extremely fine noise measurements to characterize the subtle electronic quantum states thus prepared. He started his interest on this research topic during a long master internship in years 2000 and 2001 at Stanford University under the supervision of Y. Yamamoto, where he was introduced to the realization of optics-like experiments with electrons propagating in condensed matter. He then defended his PhD in 2006 at Laboratoire Pierre Aigrain (Ecole Normale Superieure) under the supervision of C. Glattli and B. Placais. During his PhD, he developed triggered single electron emitters, analogous to single photon sources. After a postdoctoral stay at C2N in Marcoussis, he was hired as assistant professor at Ecole Normale Superieure in 2008 and Professor at Sorbonne University in 2013. In the space of ten years, GF has carried out several seminal electron quantum optics experiments. In 2013, he realized the first electronic Hong-Ou-Mandel experiment, demonstrating fermionic antibunching between two single electrons emitted by two independent sources, and paving the way for future applications with exotic quasiparticles of fractional statistics. Beyond the experimental feat of simply reproducing the pioneering experiments in photonic quantum optics with fermions, these experiments enabled GF to finely characterize phenomena specific to condensed matter, such as decoherence and interactions. In 2018, he reoriented his activity by applying these techniques for the characterization of the fractional excitations of the Quantum Hall effect, known as anyons. He realized in 2020 one of the two first experiments highlighting their fractional statistics. In order to develop his research, G. Feve was awarded an ERC consolidator grant in 2014 and an ERC advanced grant in 2023. He also obtained the Louis Ancel prize of the French Physical Society in 2020 for the development of electron quantum optics experiments in quantum conductors.

ABSTRACT:

In three-dimensional space, elementary particles are divided between fermions and bosons according to the properties of symmetry of the wave function describing the state of the system when two particles are exchanged. When exchanging two fermions, the wave function acquires a phase, . On the other hand, in the case of bosons, this phase is zero, . This difference leads to deeply distinct collective behaviors between fermions, which tend to exclude themselves, and bosons which tend to bunch together. The situation is different in two-dimensional systems which can host exotic quasiparticles, called anyons, which obey intermediate quantum statistics characterized by a phase varying between and [1,2
. For example in the fractional quantum Hall regime, obtained by applying a strong magnet
c field perpendicular to a two-dimensional electron gas, elementary excitations carry
a fractional charge [3,4] and have been predicted to obey fractional statistics [1,2] with
n exchange phase (where is an odd integer). Using metallic gates deposited on top of
the electron gas, beam-splitters of anyon beams can be implemented. I will present how
the fractional statistics of anyons can be revealed in collider geometries, where anyon sou
ces are placed at the input of a beam-splitter [5,6]. The partitioning of anyon beam
is characterized by the formation of packets of anyons at the splitter output. This results in
the observation of strong negative correlations of the electrical current, which value is gove
ned by the anyon fractional exchange phase [5
7].

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Hosted by: Prof. Dr. Adrian Bachtold