H28年度カデットプログラム後援セミナー報告書

日　時：　2016年8月1日(月)　16：30〜18：00

場　所：　理学研究科 H棟6階 H601

講師名：　Professor Gwendal Fève

講師所属：　CNRS - Laboratoire Pierre Aigrain

講演タイトル：　Electron quantum optics in ballistic conductors

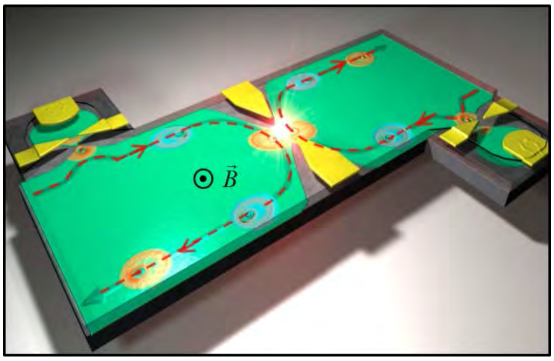
参加者：　16名

Quantum effects have been studied on photon propagation in the context of quantum optics since the second half of the last century. In particular, using single photon emitters, fundamental tests of quantum mechanics were explored by manipulating single to few photons in Hanbury-Brown and Twiss and Hong Ou Mandel experiments.

In nanophysics, there is a growing interest to translate these concepts of quantum optics to electrons propagating in nanostructures. In particular, in ballistic quantum conductors, the propagation of electrons is not hindered by collisions and the phase of the wavefunction is preserved on a few microns which corresponds to the typical size of the conductor. One can then manipulate and study the coherence properties of electron beams in the electronic analog of quantum optics experiment. However, electron optics experiments differ strongly from their optical counterpart as electrons are interacting fermions.

After briefly reviewing the framework of electron quantum optics [1], I will illustrate it with experimental realizations in two-dimensional electron gases where the electronic propagation can be guided along one-dimensional channels by applying a strong magnetic field perpendicular to the sample. Using metallic gates as electronic beam-splitters, electronic interferometers can then be implemented. I will more specifically discuss the realization of the electronic analog of the Hong-Ou-Mandel interferometer [2,3] (see Figure) where single electronic excitations emitted on demand collide on a beam-splitter. Two-particle interferences between two indistinguishable single electrons can then reveal the coherence properties of single electron states.

[1] E. Bocquillon et al., Annalen der Physik, 526, 1–30, (2014)
[2] E. Bocquillon et al., Science 339, 1054 (2013).
[3] V. Freulon et al., Nature Communications, 6 6854 (2015).



Artistic representation of the electronic Hong-Ou-Mandel experiment. The experiment is realized in a two dimensional electron gas (pictured in green). Electrons are propagating along the edge channels of the quantum Hall effect (red dashed line) located on the edges of the sample. Metallic gates deposited on top of the electron gas are represented in gold. A single electron source is placed at each input arm of a metallic split gate used as an electronic beam-splitter. Two particle interferences occur when two electron synchronously collide on the splitter. They are revealed by the measurement of current fluctuations (noise) at the splitter output.

＜講義の様子＞

＜主催した先生からの感想＞

講師の Fève 先生は単一「電子」を用いた量子「光」学の実験で世界をリードしていらっしゃいます。本セミナーでは、半導体物理、メゾスコピック系、スピントロニクス、量子情報、量子光学等、多岐にわたる重要な概念が丁寧に説明されました。さらに、Fève グループの最先端の研究成果について、その意義をご紹介いただきました。聴衆との間で活発な質疑応答が行われ、有意義なセミナーとなりました。

（理学研究科　教授　小林 研介）