Electron quantum optics in quantum Hall edge channels

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The ballistic propagation of electronic waves along the quantum Hall edge channels of a two dimensional electron gas bears strong analogies with photon optics, inspiring a whole set of experiments [1, 2] and providing an efficient tool to understand the electronic propagation in quantum conductors. I will present optics-like experiments [3, 4] with electrons that push these analogies down to the single particle scale, where a single electronic excitation is emitted on-demand in the conductor.

In particular, using two independent on-demand electron sources, we trigger the emission of two single-electron wavepackets at different inputs of an electronic beamsplitter. Whereas classical particles would be randomly partitioned by the splitter, we observe two-particle interferences [4] resulting from quantum exchange in this electronic analog [5, 6] of the optical Hong-Ou-Mandel [7] experiment. Both electrons, emitted in indistinguishable wavepackets with synchronized arrival time on the splitter, exit in different outputs as recorded by the low frequency current noise. Full random partitioning is recovered when the arrival of one electron is delayed with respect to the other. This two-electron interference experiment demonstrates the possibility to generate on-demand coherent and indistinguishable single-electron wavepackets for quantum information processing in quantum conductors.

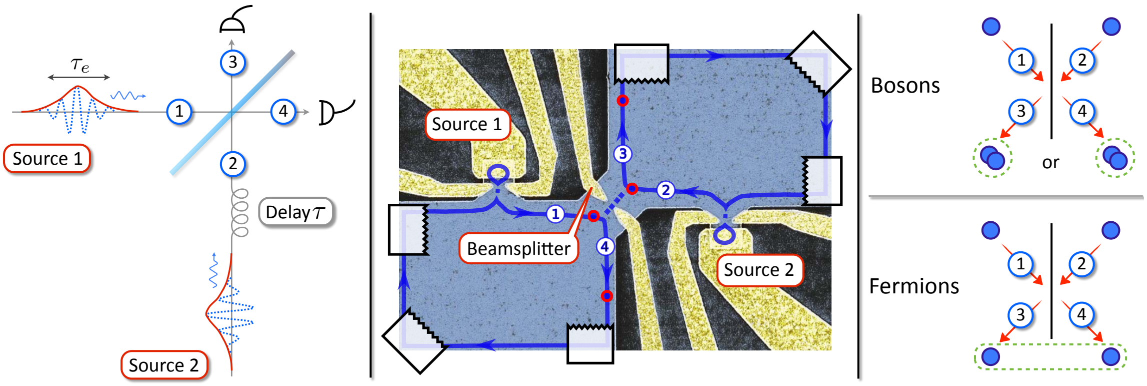

Figure 1: Two single particle wavepackets of width τ_e are emitted at inputs 1 and 2 and interfere on the splitter. Whereas photons bunch and exit in the same output, we observe antibunching of indistinguishable electrons due to Fermi statistics

[1] Henny et al., Science **284**, 296 (1999).
[2] Ji et al., Nature **422**, 415 (2003).
[3] Bocquillon et al., Physical Review Letters **108**, 196803 (2012).
[4] Bocquillon et al., Science DOI: 10.1126/science.1232572 (2013).
[5] Ol'khovskaya et al., Physical Review Letters **101**, 166802 (2008).
[6] Jonckheere et al., Physical Review B **86**, 125425 (2012).
[7] Hong et al., Physical Review Letters **59**, 2044 (1987).