Generation and visualization of few electron states in a quantum conductor

Bisognin Remi, Kumar Manohar, Roussel Benjamin, Cabart Clement, Bocquillon Erwann, Berroir Jean-Marc, Plaais Bernard, Cavanna Antonella, Gennser Ulf, Jin Young, Chapdelaine Camille, Mohammad-Djafari Ali, Degiovanni Pascal and **Feve Gwendal**
CNRS - Pierre Aigrain Laboratory, France

Thanks to the recent development in nanoelectronics, we can now study the quantum properties of electrical currents at the elementary excitation level. This naturally leads to the following question: can we experimentally extract from an electrical current its elementary excitations and fully characterize their coherence properties? In this work by driving locally a 1D conductor with a Lorentzian drive, we generate current pulses carrying one or two elementary excitations. Using two-particle interferometry, we fully reconstruct the wavefunction of the excitations propagating in the conductor. By shaping the width of the current pulses, we can engineer single electron wavefunctions of controlled energy and time distributions related by the Heisenberg uncertainty principle. To implement these electron quantum optics experiments, we use a model conductor which consists in a 2D electron gas in the integer quantum Hall effect at very low temperature. In this regime charges propagate along 1D ballistic edge channels which are used to characterize elementary excitations in electronic interferometers. The wavefunction measurement is based on a general quantum tomography protocol. The protocol relies on repeated overlap measurements between the generated current pulses and a set of reference probes in a Hong Ou-Mandel electronic interferometer. The reduction of the low frequency shot noise at the interferometer output is a direct measurement of this overlap. The wavefunction is extracted in two steps. First, we reconstruct the time-energy Wigner representation of the electronic current using all overlaps. Secondly a signal-processing algorithm decomposes the Wigner distribution in its elementary building blocks: the single electron wavefunctions. By demonstrating the controlled generation and the visualization of few electron states in a quantum conductor, this work opens new perspectives in quantum nanoelectronics.

Speaker Biography

Bisognin Remi currently a PhD student in the Quantum Electron Optics group of the Pierre Aigrain Laboratory. He is doing his PhD under the supervision of Gwendal Feve. His research interest are Quantum Optics, Optical Networks and Quantum Electron.

e: remi.bisognin@lpa.ens.fr

Notes: