Wigner function of a quantum Hall edge channel excited at GHz frequency

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In the rapidly evolving field of quantum computing, tremendous efforts have been made to realize phase-coherent electronics in the hope to process quantum information encoded on the electronic degrees of freedom. It is now possible to create and propagate quantum states with finite temporal and energy extensions. Although differential conductance or current fluctuations enable to recover energy distribution averaged in time of these states, it does not permit a complete reconstruction of a quantum state. To access, for instance, its Wigner distribution[1] a quasi-probability distribution that encodes both energy and temporal information, one needs a tomography protocol[2]. It has already been implemented but mainly on bosonic or discrete fermionic systems. One experiment successfully reconstructed the Wigner function of a single charge excitation by measuring its overlap with a probe state at a quantum point contact (QPC)[3], enabling a clear reconstruction of the quantum state. However, it was realized in a 2 terminals geometry where the source can not be distinguished from the probe and only for a peculiar class of states.

We will present the implementation of a tomography protocol in a 2 dimensional electron gas in the regime of integer quantum Hall effect where the 4 terminals geometry allows to separate the source from the probe. Although the protocol is fully universal, we tested it on an edge channel excited with a sinusoidal drive. This creates a many excitations state that, for, differs from a simple Fermi sea with a time-varying chemical potential. Indeed, we were able to measure negativities in the Wigner function at a frequency drive f = 9GHz (see figure). This is a manifestation of photo-assisted absorption events [4] which are quantized by nature. We are able to distinguish between a “classical” time varying Fermi potential and a “quantum” many body state.

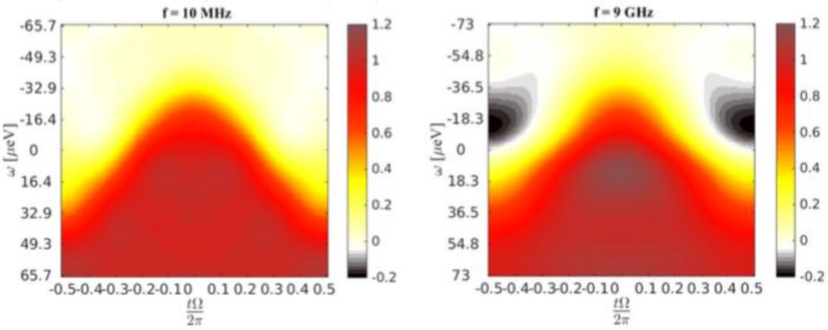

Figure: Wigner function of a Fermi sea driven at f = 10 MHz (left) and f = 9 GHz (right)

References: [1] D. Ferraro *et al*., Phys. Rev. B **88**, 205303 (2013)

[2] Ch. Grenier *et al.*, New Journal of Physics **13**, (2011) 093007

[3] T. Jullien *et al.*, Nature **514**, 603–607 (2014)

[4] M. Vanević *et al.*, Physical Review B **93**, 041416(R) 2016