Evidencing Channel Mixing effects on the Quantum Coherence of Quantum Hall channels

Charles Boudet[1], Avirup De[1], J. Nath[1], M. Kapfer[1], P. Roulleau[1], D. A. Ritchie[2], Ian Farrer[3] and D. C. Glattli[1]
[1]*Université Paris-Saclay, CEA, CNRS, SPEC, 91191 Gif-sur-Yvette Cedex, France*
[2]*Cavendish Laboratory, University of Cambridge, J.J. Thomson Avenue, Cambridge CB3 0HE, UK*
[3]*Department of Electronic and Electrical Engineering, University of Sheffield, Mappin Street, S1 3JD, UK*

Recent experiments probing the coherence of two-particle interference using electronic Hong Ou Mandel noise correlation[1] have indicated that a finite interference visibility might be observed both in fractional and integer regime might be due channel mixing. By channel mixing we mean quasiparticle tunneling between co-propagating edge channels due to random disorder on the edge. Here we consider a Quantum Hall bar with a Quantum Point Contact (QPC) in its middle at filling $\nu = 2$ or 3, see Fig. 1. The partition shot noise induced by the partitioning of quasiparticle when the QPC partially reflects the inner channel is detected. DC shot noise (DCSN) refers to a DC voltage applied on the source contact, Photo-Assisted Shot Noise (PASN) refers to a microwave sinewave voltage applied on the source and electronic Hong Ou Mandel (HOM) noise when a microwave is applied to both source and drain but with a time delay.

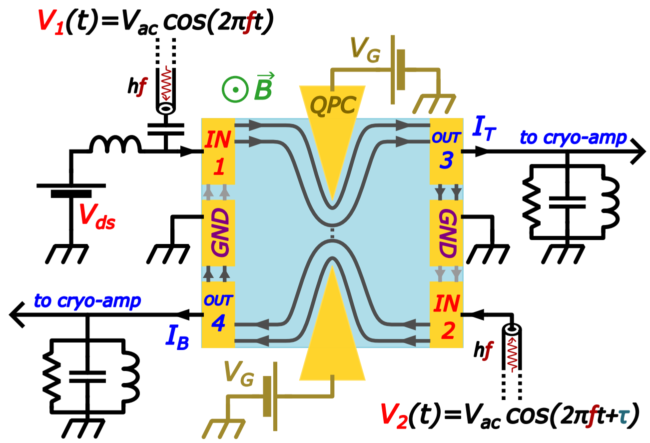

Fig. 1. QPC setup, $\nu = 2$. Charge carriers excited by V_1 and V_2 (of time lag τ) are partitioned; transmitted and backscattered currents I_T and I_B are filtered by a 2.5 ± 0.25 MHz LC circuit, ensuingly amplified by the cryogenic amplifiers. Signal is captured by a DAQ from with cross-correlations are computed. Additional details are found in [1].

It was theoretically shown in[2] that the effect of channel mixing is not observable in DCSN but observable in PASN for GHz excitation when the quasiparticle time-delay between the source and the QPC matters. While the visibility of two-particle HOM interference is expected to be 100% due to fermionic statistics and gauge invariance, channel mixing provide a which-path detection reducing the visibility of HOM interference with non-zero HOM dip.

Here we have performed detailed photo-assisted shot noise (PASN) measurements and electronic Hong Ou Mandel (HOM) shot noise measurements at bulk filling factor $\nu = 2$ and 3 to qualitatively and quantitatively probe the channel mixing predictions when varying the transmission of the inner channel[3], see Fig. 2. We definitely demonstrate channel mixing by observing a finite PASN of the secondary conductance plateaus of the QPC. This work gives important conclusion regarding the possibility to manipulate single particle in time-domain for future electronic flying qubit applications.

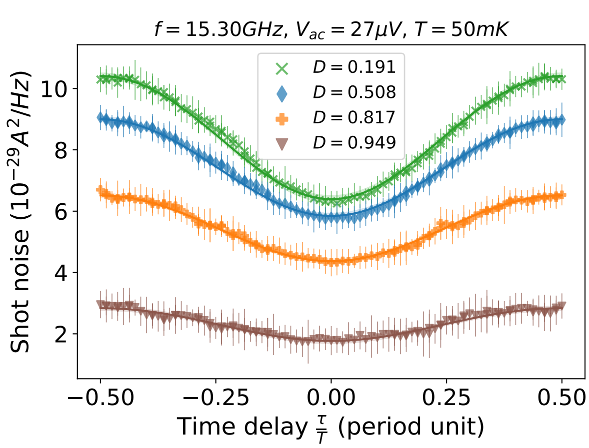

Fig. 2. Fitted data from HOM shot noise experiments at different transmission coefficients D. The noise offset is related to channel mixing[2]. Visibility ≈ 20%.

The authors acknowledge the H2020 FET-OPEN UltraFastNano #862683 grant.

References

[1] I. Taktak, M. Kapfer, J. Nath, P. Roulleau, M. Acciai, J. Splettstoesser, I. Farrer, D. A. Ritchie, D. C. Glattli, Nat. Commun. **13**, 5863 (2022).

[2] M. Acciai, P. Roulleau, I. Taktak, D. C. Glattli, J. Splettstoesser, Phys. Rev. B **105**, 125415 (2022).

[3] C. Boudet, A. De, J. Nath, M. Kapfer, P. Roulleau, D. Ritchie, Ian Farrer, and D.C. Glattli, "Why Electronic Hong Ou Mandel Noise Correlations Look Non-Fermionic in the Integer Quantum Hall regime?", in preparation.