

Probing collision-induced electronic entanglement in ballistic conductors

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Abstract

Entanglement between single flying electrons constitutes a key resource for quantum information processing in ballistic conductors [1]. However, detecting entanglement in electronic platforms remains a major experimental and theoretical challenge.

To address this issue, we adapt entanglement witnesses originally developed in quantum optics [2] to the framework of electron quantum optics, deriving a practical witness for energy entanglement. We show that this witness can be directly related to the two-electron coherence function, which is experimentally accessible through electronic tomography techniques [3].

We then discuss how this witness can be used to probe energy entanglement generated by electron-electron interactions by considering two chiral quantum Hall edge channels capacitively coupled over a finite region exchange energy via Coulomb interactions [4].

We illustrate the mechanism for both ideally energy-resolved electrons and realistic Lorentzian wave packets, and we discuss the robustness of the generated correlations against decoherence in experimentally relevant conditions.

References

1. C. Bäuerle *et al.*, Rep. Prog. Phys., 81 (2018) 056503.
2. S. Wölk *et al.*, Phys. Rev. A, 90 (2014) 022315.
3. R. Bisognin *et al.*, Nat. Comm., 10 (2021) 3379.
4. M. Paulet *et al.*, (in preparation).

Figures

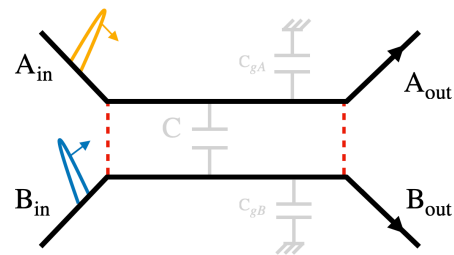


Figure 1: Two chiral edge channels capacitively coupled over a finite region. Coulomb interactions during propagation enable energy exchange, generating correlations and energy entanglement between the outgoing electrons.

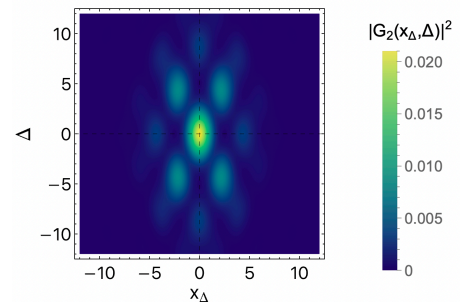


Figure 2: Two-electron coherence in relative coordinate: interaction-induced energy exchange produces four symmetric peaks revealing quantum correlations and entanglement. The central peak corresponds to elastic scattering.