Flying interacting electrons and their potential for quantum technologies

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Decades of intensive research have been devoted to the precise control of single electrons, essential for establishing the electrical current standard in the SI unit system. Recently, the concept of flying electron qubits has emerged where the charge or spin degree of freedom of an electron are used as qubits that are manipulated and transported through electronic circuits using simple electromagnetic fields. Challenges remain, including high-fidelity control and scalable quantum circuit design.
In this talk, I will present the latest advances in single electron transport [1]. We will discuss two complementary methods for transporting single charge carriers through quantum electronic circuits. Firstly, electrons are isolated from the Fermi sea and transported using sound waves [2,3], achieving a transport fidelitiy above 99% [4,5] and enabling single particle collision experiments [6]. The partitioning statistics of the two-electron state reveals a clear antibunching effect that could be quantitatively attributed to Coulomb repulsion. This work has been recently extended to the partitioning of a multi-electron state containing up to five electrons.
Secondly, electrons propagate along the surface of the Fermi sea in the form of an ultrashort electron wave packet. We find that the coherence is enhanced compared to the DC case, paving the way for a plethora of new quantum experiments at the single electron level. By elucidating these breakthroughs, we aim to contribute to the ongoing efforts in harnessing single electrons for quantum information processing and advancing our understanding of quantum phenomena at the nanoscale.

References

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