Electrons surfing on a sound wave as a platform for quantum optics with flying electrons

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Résumé

Contrary to photons, electrons are propagating particles that interact strongly with each other. Therefore, using flying electrons opens new opportunities to perform large scale quantum manipulations on a chip. Nevertheless isolating and detecting a single flying electron after propagation is nevertheless a challenging task in a metal. Electrons are indeed interacting particle propagating usually in a Fermi sea filled with other electrons. Therefore, even though photon quantum optics experiments were an inspiration for mesoscopic physics, no experiment were so far performed at the single propagating electron level. In this talk, we demonstrate the experimental realisation of high efficiency single electron source and single electron detector for a quantum medium where a single electron is propagating isolated from the other electrons through a one-dimensional (1D) channel. The moving potential is excited by a surface acoustic wave (SAW), which carries the single electron along the 1D-channel at a speed of 3 μm/ns. When such a quantum channel is placed between two quantum dots, a single electron can be transported from one quantum dot to the other, which is several micrometers apart, with a quantum efficiency of emission and detection of 96% and 92%, respectively. Furthermore, the transfer of the electron can be triggered on a timescale shorter than the coherence time T2* of GaAs spin qubits. Our work opens new avenues to study the teleportation of a single electron spin and the distant interaction between spatially separated qubits in a condensed matter system.

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