Surface acoustic waves as testbed for electron flying qubits

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A surface acoustic wave (SAW) is surprisingly efficient to transport a single electron between distant quantum dots [1,2] while preserving in flight its quantum coherent properties [3,4]. The acousto-electric shuttling technique provides thus a perfect testbed to investigate the feasibility of electron-flying-qubit implementations [5]. Here we present our latest results on SAW-driven single-electron transport in a circuit of coupled quantum rails. Mastering picosecond triggering of the transfer process [6] verified via time-of-flight measurements [7], we are capable of synchronising transport along parallel quantum rails. Sending two electrons simultaneously through the coupling region, we observe distinct Coulomb-dominated repulsion – the central ingredient to realise a controlled phase gate for electron flying qubits. Discussing partitioning data of a single electron in the coupling region [5], we further point out the importance of SAW confinement for coherent in-flight manipulation. To address this critical aspect, we finally demonstrate SAW engineering via chirp synthesis enabling single-electron transport with a solitary electro-acoustic pulse. Our results lay the ground for quantum logic circuits with electron flying qubits surfing on sound.

References

[1] Hermelin *et al.*, Nature **477**, 435–438 (2011)
[2] McNeil *et al.*, Nature **477**, 439–442 (2011)
[3] Hermelin *et al.*, Nature **477**, 435–438 (2011)
[4] Jadot *et al.*, Nat. Nanotechnol. **16**, 570–575 (2021)
[5] Ito *et al.*, Phys. Rev. Lett. **126**, 070501 (2021)
[6] Bäuerle *et al.*, Rep. Prog. Phys. **81**, 056503 (2018)
[7] Takada *et al.*, Nat. Commun. **10**, 4557 (2019)
[8] Edlbauer *et al.*, Appl. Phys. Lett. **119**, 114004 (2021)

Figures

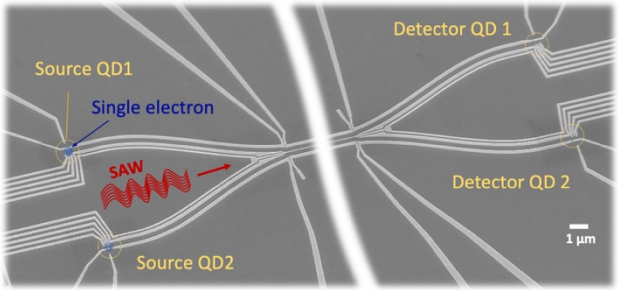

Figure 1: 2-particle collider with single electrons propelled by a surface acoustic wave (SAW). The device is composed of 2 source quantum dots (QD) and 2 detector quantum dots. In the centre region the electrons can interact through a 40-micrometre long tunnel barrier.