Electronic interferometry with ultrashort plasmonic pulses

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Flying qubits –usually associated with photons–are originally intended to serve as a communication link within a quantum computer and represent a vital part of the global road-maps towards secure data transmission. An alternative approach for flying qubits is single electrons propagating in a semiconductor quantum device [1,2,3].
An essential prerequisite for realizing a fully functional flying electron qubit is achieving the non-adiabatic regime. In this regime, it becomes possible to manipulate the coherent quantum state as it propagates, within a timescale shorter than its characteristic time.
Here we present the development of a flying qubit architecture, based on an electronic Mach-Zehnder interferometer (MZI) using ultrashort electronic wavepackets. Injecting such ultrashort wavepackets in a MZI allows manipulation of the quantum state of the qubit in flight [4], while it is being transferred coherently by means of electrostatic gates. Using a pump and probe technique, we demonstrate time-resolved measurement of ultrashort electron wavepackets with a temporal width down to 25 ps [5]. Furthermore, we observe quantum interference when injecting such charge pulses into a quantum interferometer of a length of 14µm [6]. We unveil its origin to quantum rectification due to the nonlinearity of the beam-splitter and demonstrate coherent oscillations *beyond the adiabatic regime*. Our findings lay the groundwork for the realization of a fully functional electron flying qubit and its dynamical control.

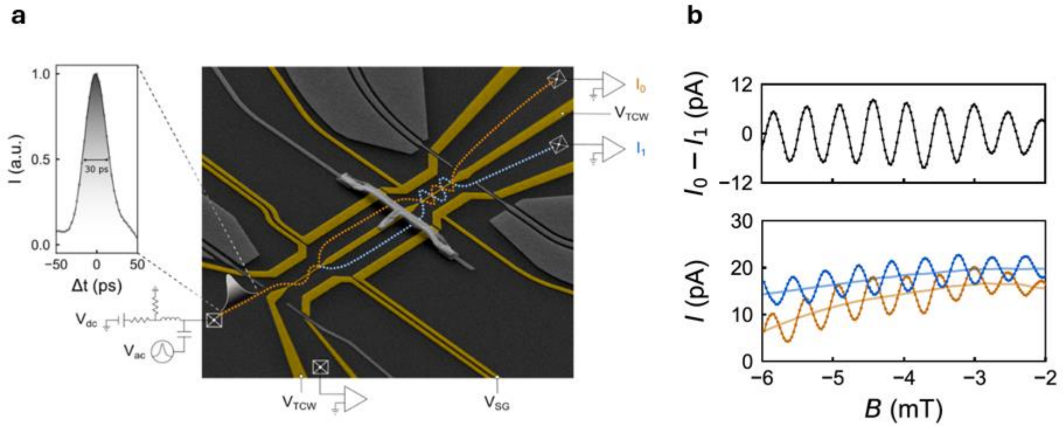

Fig. 1. Electronic Mach-Zehnder interferometer with ultrashort wavepackets. (a) Scanning electron micrograph of the electronic MZI. Inset: time-resolved measurement of a 30 ps width wavepacket. (b) Aharonov–Bohm oscillations with a 30 ps wavepacket: the lower panel shows raw data, while the upper panel displays the current difference.

References

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