SAWtrain network

SAWtrain Research Highlight 2:
"Non-universal transmission phase behaviour of a large quantum dot"

Here we present an experiment solving a long-standing problem of mesoscopic physics. When an electron is transferred through a quantum dot, its wave function undergoes a phase modification. In this transmission phase one theoretically expects abrupt lapses of π to occur in between consecutive resonances depending on the symmetries of the quantum dot states involved. Pioneering experiments investigating electron transmission of a large quantum dot observed such phase lapses, but surprisingly in between *all* of the investigated resonances. The question then arose if a universal regime was encountered where phase lapses occur generically. In this work we employ a novel electron interferometer to reinvestigate this problem and show that such a universal behaviour is not present.

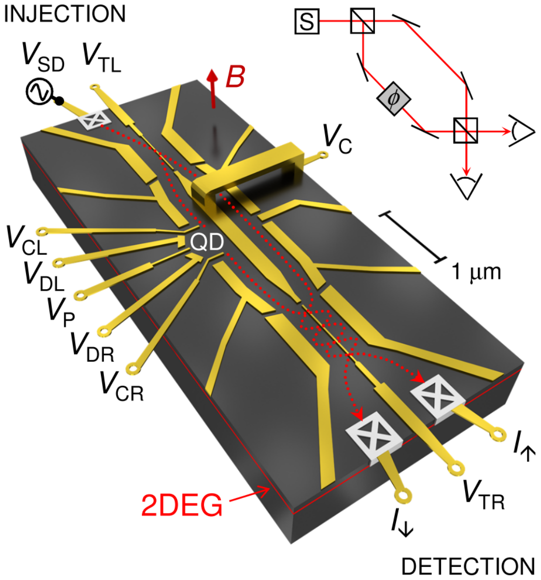

Figure 1: Schematic of our electron interferometer showing surface electrodes defining the conductive channels (red, dotted lines) in the two-dimensional electron gas (2DEG) located below the surface.

The working principle of our device is based on Mach-Zehnder interferometry that is known from optics (see Figure 1). In our nanostructure we implement electron beam splitters with tunnel barriers. The phase shifting medium, which is embedded in one of the interferometer branches, is a 500 nm wide quantum dot (QD) hosting hundreds of electrons.

Scanning the transmission phase along a large set of resonances we made several observations of the absence of a phase lapse. Deforming the quantum dot we additionally demonstrate changes in the sequence of phase-lapses. Our results clearly show a transmission phase behaviour that is non-universal and — as theoretically expected — caused by the internal structure of the quantum dot states.

This interferometry experiment, which is performed in the ballistic transport regime, nicely demonstrates coherent quantum physical phenomena with an ensemble of electrons. In the course of the SAWtrain project, we employ surface acoustic waves (SAW) to bring such electron quantum optics experiments to the single-particle level. For this purpose we develop the elementary building blocks of such a sophisticated setup — such as beam splitters or phase shifters — for SAW-driven single-shot transport of an electron. Establishing highly controlled SAW-assisted single-electron manipulation, we will open up a promising platform for fundamental quantum physics research and quantum computing applications.

Publication:

Hermann Edlbauer, Shintaro Takada, Grégoire Roussely, Michihisa Yamamoto, Seigo Tarucha, Arne Ludwig, Andreas D. Wieck, Tristan Meunier and Christopher Bäuerle, *Nature Communications* **8**, 1710 (2017) — doi:10.1038/s41467-017-01685-z

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