Probing quantum electromagnetic magnetic fields with subnanosecond time resolution: the single electron radar

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In this talk we discuss how an electronic interferometer can be used to measure a time dependent electric field on a sub-nanosecond time scale based on alteration of the wave function of a single electronic excitation[1,3] propagating across a Mach-Zenhder interferometer (figure 1) when the fast varying potential is applied to one of the two branches, thereby realizing the electronic analogue of a radar.

Our key result is the electron radar equation that connects the experimental signal — the Aharonov-Bohm dependent part of the finite frequency average outgoing current — to the electronic wave function used as a probe and to the electromagnetic field to be probed. It is valid in the presence of Coulomb interactions[2] within the interferometer and quantum electromagnetic field and incorporates the back-action effects of the quantum electromagnetic field to be probed onto the electron fluid. The detection of a squeezed vacuum which exhibits time dependent quantum fluctuations will be used as an illustration of this general framework.

References

[1] B. Roussel, *et al*, PRX Quantum **2** (2021), [020314]

[2] C. Cabart, *et al*, Phys. Rev. B **98** **(2018)**, [155302]

[3] R. Bisognin, *et al*, Nature communications **10** (2019) 1-12, [3379]

Figure

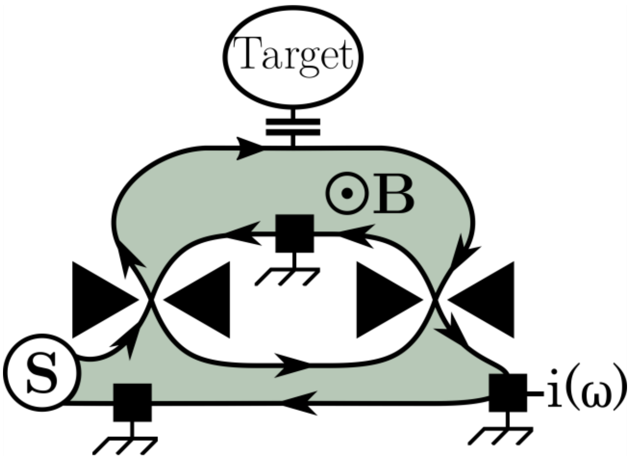

Figure 1: Draft of the electronic Mach-Zenhder interferometer in a 2D electron gas (in grey) under a strong perpendicular magnetic field. A single electron is emitted from the source (bottom left) and propagates in the edge channels of the Quantum Hall Effect (black lines) following the direction of the arrows. The Quantum point contacts (pairs of black triangles) act as beam splitters for single electrons. The upper branch is capacitively coupled to the Target to probe. The measurement is made on the output electrical current at fixed frequency (bottom right).