

# Tunable Andreev-Conversion of Single-Electron Charge Pulses

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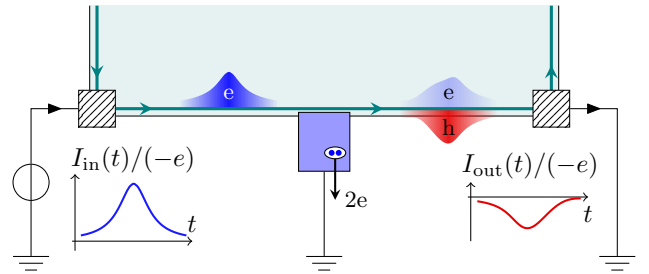
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Electron quantum optics explores the coherent propagation and interference of single-electron charge pulses in electronic nano-scale circuits that are similar to tabletop setups with photons [1]. So far, experiments with dynamic single-electron emitters have focused on normal-state conductors. However, the inclusion of superconducting elements [2,3] would pave the way for a wide range of applications that exploit the electron-hole degree of freedom, for example, for quantum information processing or quantum sensing. Here, we propose and analyze a tunable mechanism for the on-demand conversion of single-electron pulses into holes through Andreev processes on a superconductor [4]. To this end, we develop a Floquet-Nambu scattering formalism that allows us to describe the conversion of charge pulses on a superconductor, and we show that it is possible to generate arbitrary superpositions of electrons and holes with the degree of mixing controlled by the magnetic flux in an interferometric setup. We provide a detailed discussion of the optimal operating conditions in realistic situations and demonstrate that our proposal is feasible based on current technology.

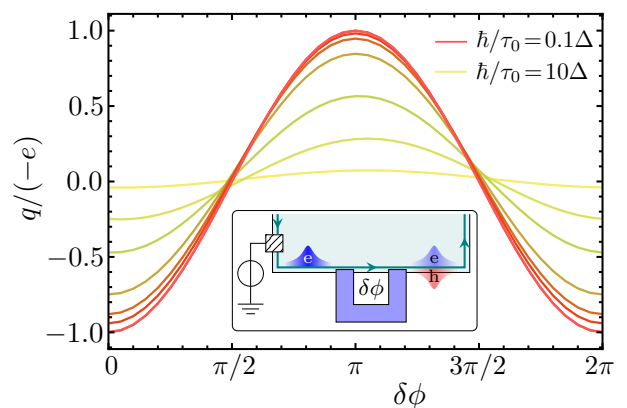
## References

- [1] E. Bocquillon *et al.*, *Ann. Phys.* **526**, 1 (2014).
- [2] F. Amet *et al.*, *Science* **352**, 966 (2016).
- [3] G.-H. Lee *et al.*, *Nat. Phys.* **13**, 693 (2017).
- [4] P. Burset, B. Roussel, M. Moskalets, and C. Flindt, *in preparation*.

## Figures



**Figure 1:** Andreev conversion of a charge pulse. Clean single-electron states are injected into a chiral edge state by applying Lorentzian-shaped voltage pulses to the input contact. Through partial Andreev reflections on a superconductor, the charge-pulses are converted into coherent superpositions of an electron (e) and a hole (h).



**Figure 2:** Tunable electron-hole conversion. The degree of conversion can be controlled by the phase difference  $\delta\phi$  between two superconductors.