Adiabatic Cooper Pair Splitter

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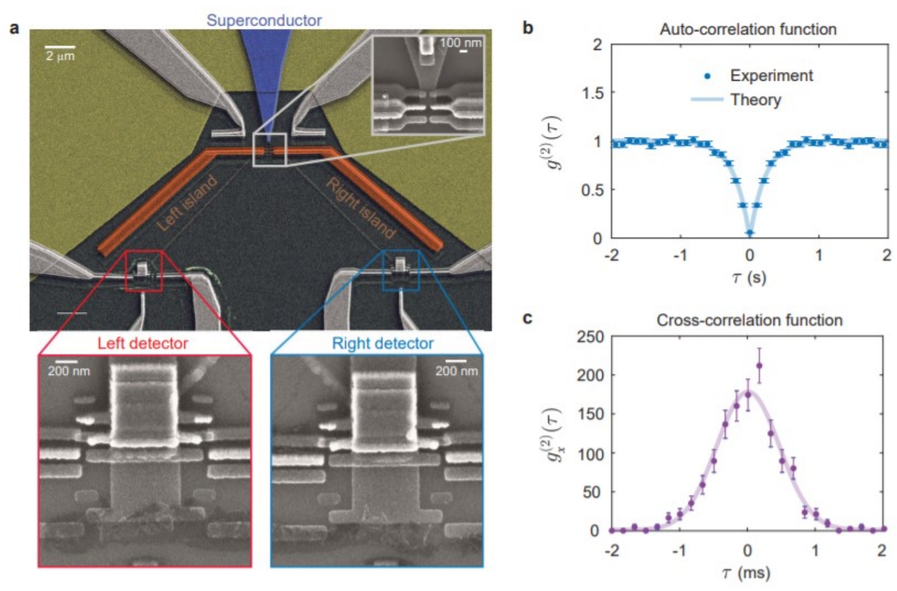
Background and motivation

Main aim

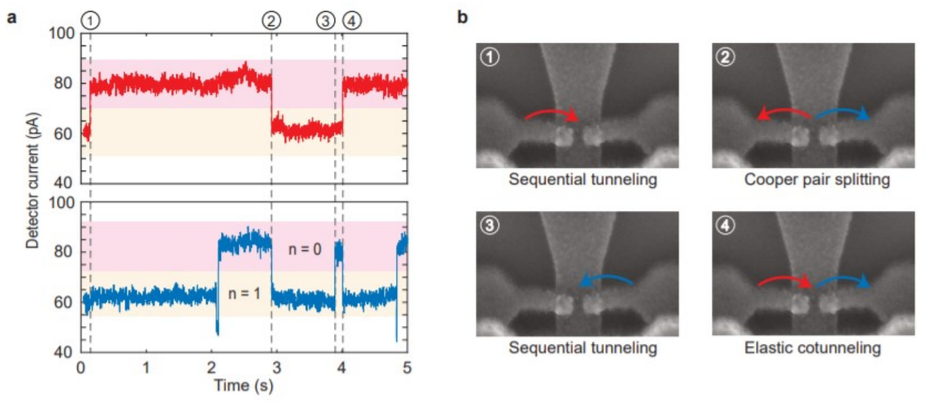
To generate entangled pairs of electrons by extracting and splitting Cooper pairs from a superconductor in a controllable way.

Motivation: Recent experiment on real-time detection of Cooper pairs

A. Ranni, F. Brange, E. T. Mannila, C. Flindt, V. F. Maisi
Nat. Commun. 12, 6358 (2021)

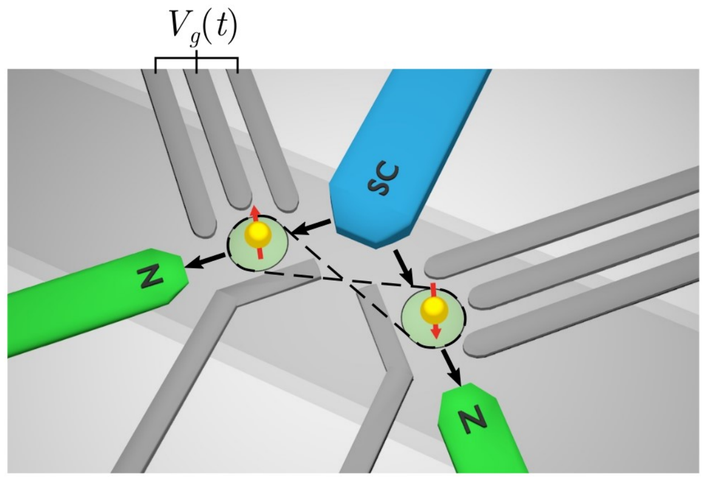


- Real-time detection of Cooper pairs



Idea and model

Cooper pair splitter with quantum dot (QD) levels periodically tuned slowly across a resonance



- Effective Hamiltonian

$$\hat{H}(t) = \sum_{\ell\sigma} \epsilon_\ell(t)\hat{d}^\dagger_{\ell\sigma}\hat{d}_{\ell\sigma} - \left(\gamma\hat{d}^\dagger_S + \sum_\sigma \kappa \hat{d}^\dagger_{L\sigma}\hat{d}_{R\sigma} + \text{H.c.}\right) \qquad \sigma = \uparrow,\downarrow \quad \ell = L,R$$

QD dot levels CPS Elastic cotunneling

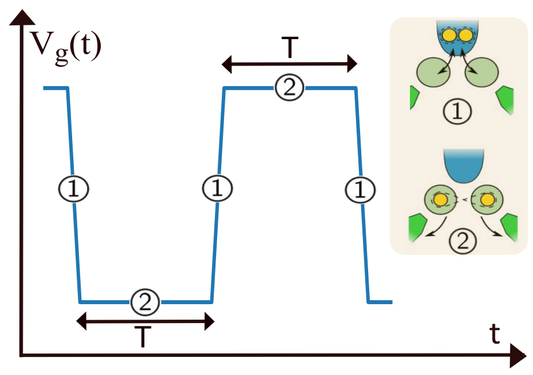
Coupling to leads modelled by a Lindblad equation (high-bias limit)

Driving protocol

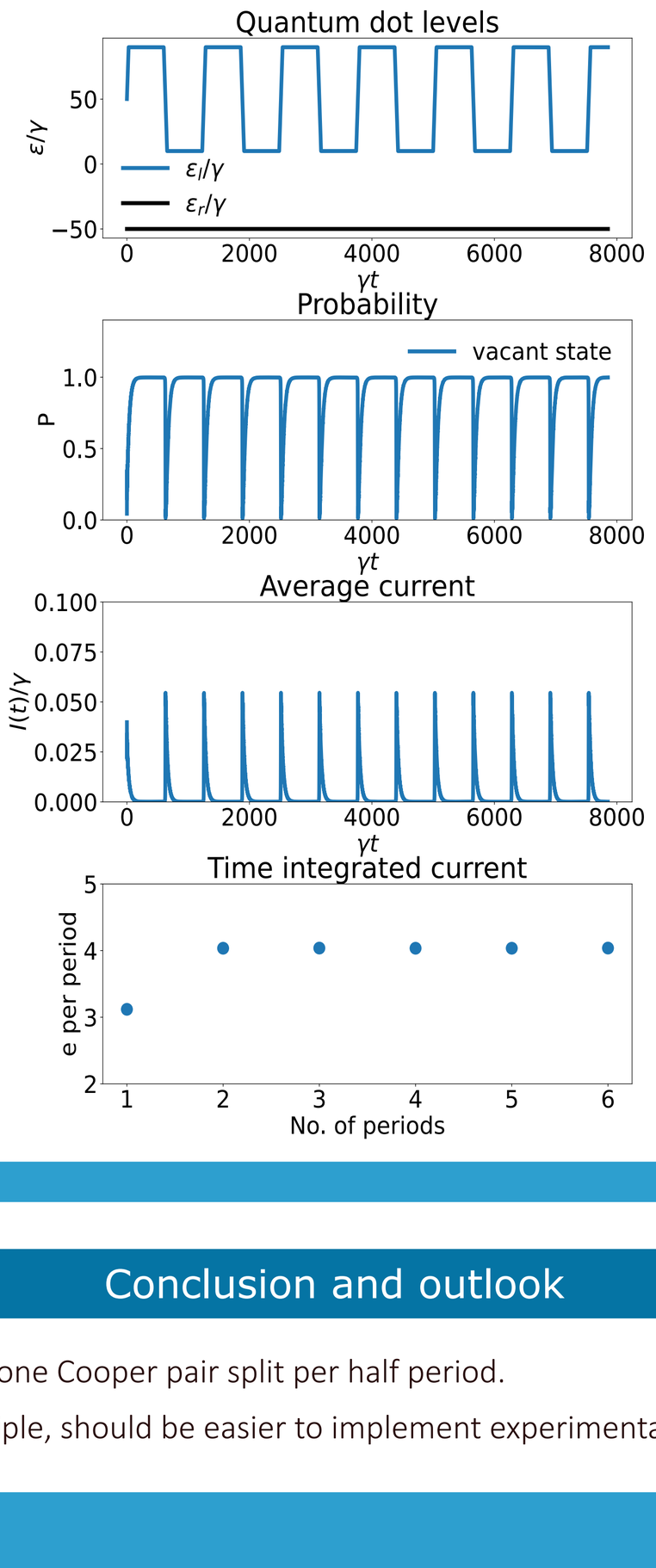
One of the QD levels is driven slowly enough that it is adiabatic.

1. Loading phase:
   CPS is moving **through resonance**.
   One Cooper pair moves into the QDs through adiabatic loading.

2. Unloading phase:
   CPS is **off resonance** for a time T.
   The Cooper pair tunnels out from the dots to the leads.



Results



Conclusion and outlook

- Exactly one Cooper pair split per half period.
- In principle, should be easier to implement experimentally.