

Quantum Information with Solid-State Devices

VO 141.246

Dr. Johannes Majer

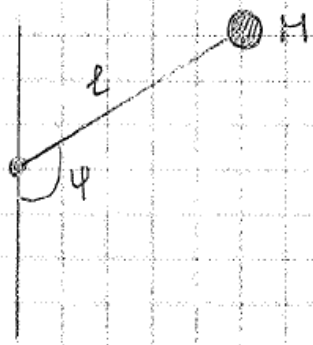
Lecture 7



Exam

- I assign a paper related to the class
- fix a date
- you present the paper/we discuss, questions with special focus on what we learned during the lecture

pendulum with friction



$$\text{torque: } \vec{T} = \vec{r} \wedge m\vec{g}$$

$$T = -\sin(\varphi) l m g$$

$$\text{angular momentum: } \vec{L} = \vec{r} \wedge \vec{v}$$

$$L = m l^2 \omega = m l^2 \dot{\varphi}$$

$$T = \frac{d}{dt} L$$

$$-m g l \sin(\varphi) = m l^2 \ddot{\varphi}$$

$$\ddot{\varphi} l + g \sin(\varphi) = 0$$

$$\ddot{\varphi} + \omega_0^2 \sin(\varphi) = 0$$

$$\omega_0 = \sqrt{\frac{g}{l}}$$

assuming an external torque T_{ext}
and an angular friction $T_{\text{fr}} = -f_{\text{fr}} \cdot \dot{\varphi}$

$$T + T_{\text{ext}} + T_{\text{fr}} = \frac{d}{dt} L$$

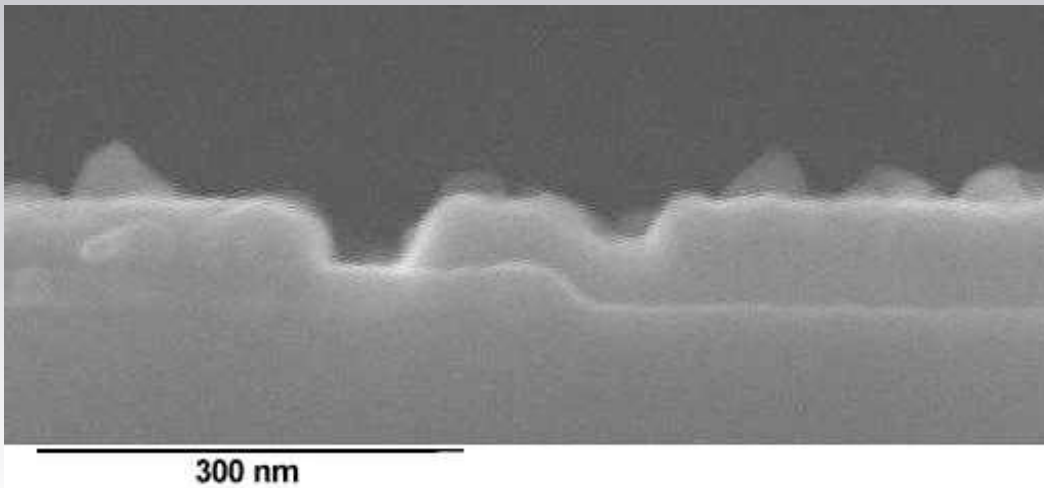
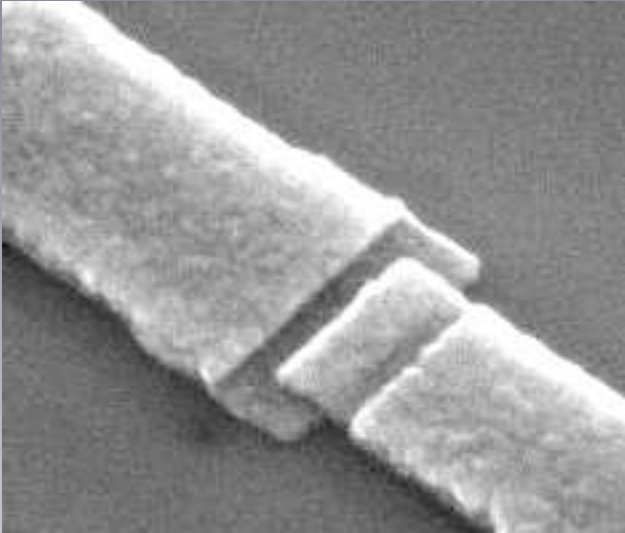
$$T_{\text{ext}} = m l^2 \ddot{\varphi} + f_{\text{fr}} \dot{\varphi} + m l g \sin(\varphi)$$

comparison with RCSJ model

bias current capacitance Josephson current
current resistance

$$I = I_0 \sin(\delta) + \frac{\phi_0}{2\pi R} \dot{\delta} + \frac{C \phi_0}{2\pi} \ddot{\delta}$$

tunnel junction

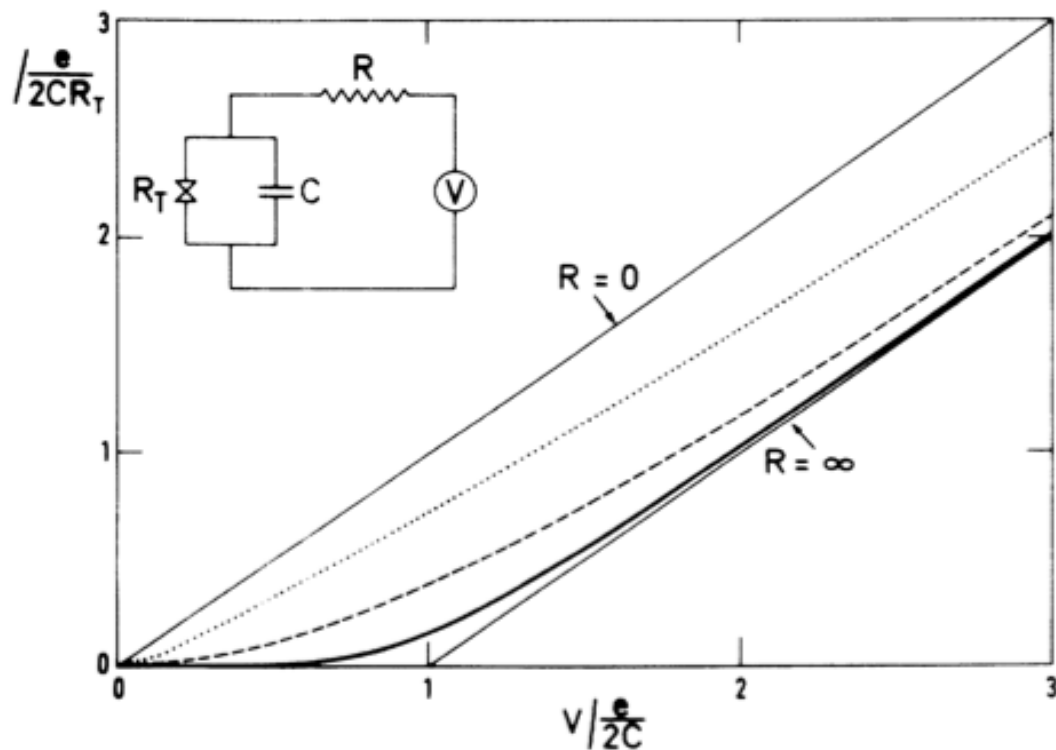


Effect of the Electromagnetic Environment on the Coulomb Blockade in Ultrasmall Tunnel Junctions

M. H. Devoret,⁽¹⁾ D. Esteve,⁽¹⁾ H. Grabert,⁽²⁾ G.-L. Ingold,⁽²⁾ H. Pothier,⁽¹⁾ and C. Urbina⁽¹⁾

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(Received 4 December 1989)



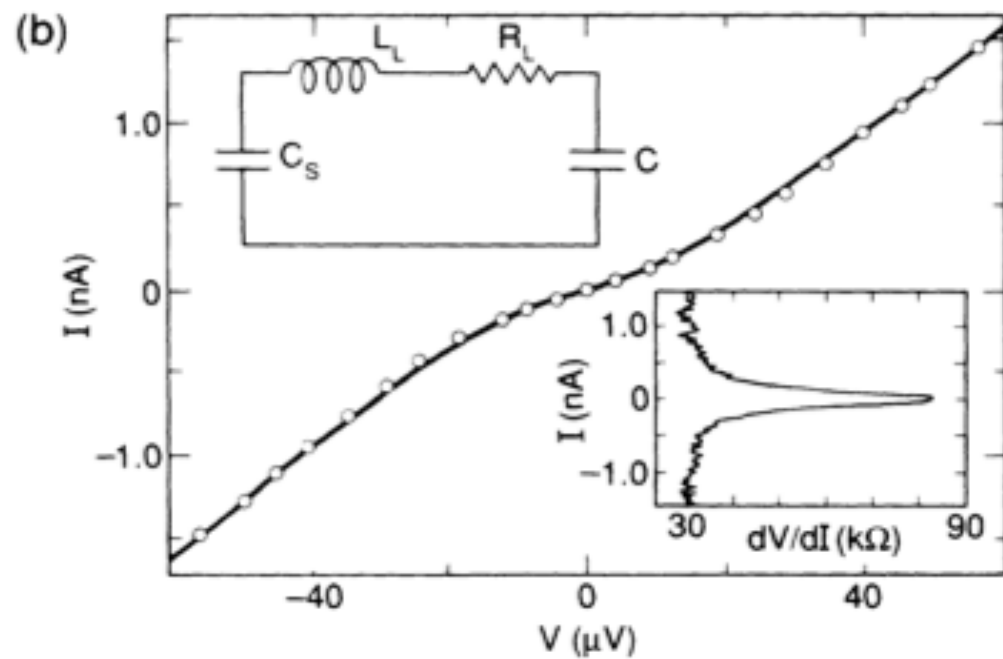
Charge Fluctuations in Small-Capacitance Junctions

A. N. Cleland, J. M. Schmidt, and John Clarke

Department of Physics, University of California, Berkeley, California 94720

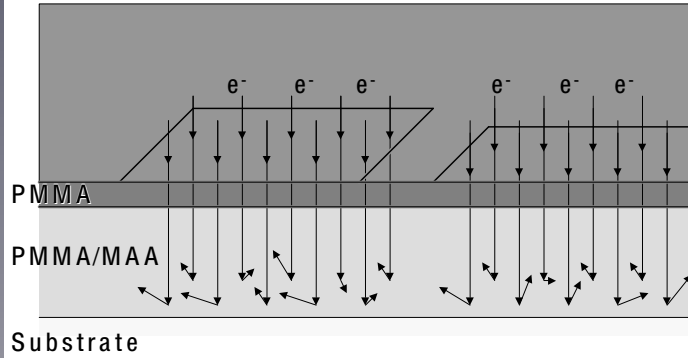
and Materials and Chemical Sciences Division, Lawrence Berkeley Laboratories, Berkeley, California 94720

(Received 18 December 1989)

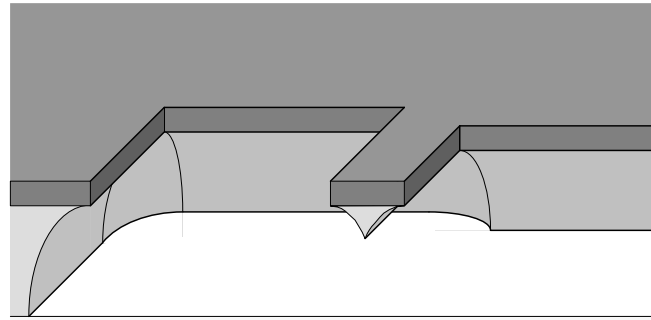


Shadow Evaporation

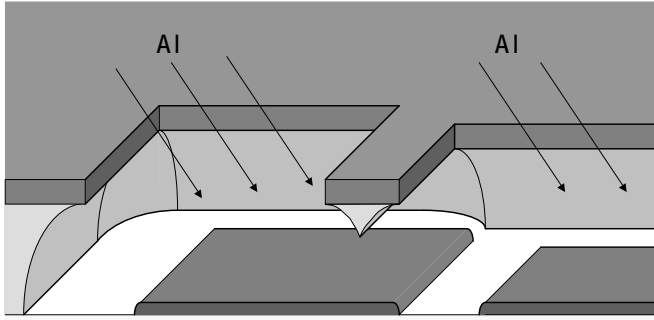
1. electron beam writing



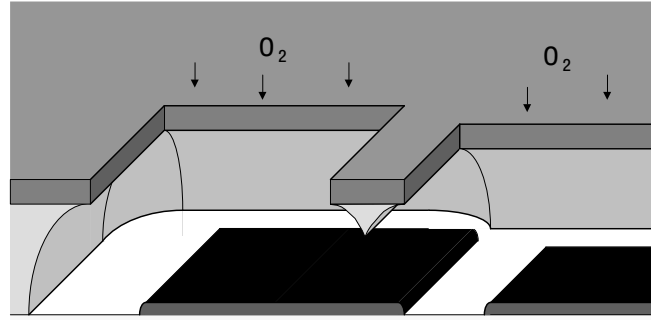
2. development



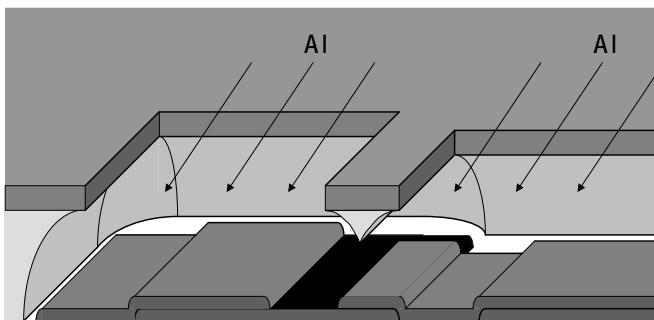
3. first aluminum evaporation



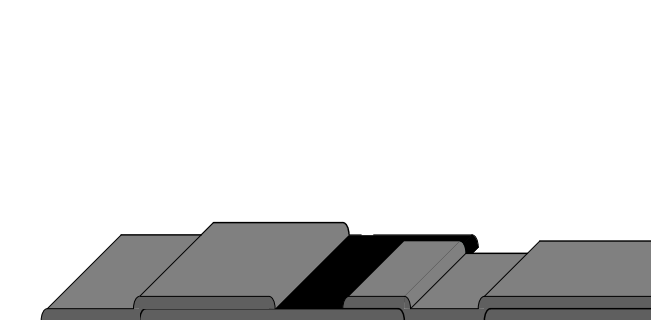
4. oxidation



5. second aluminum evaporation



6. lift-off



T. A. Fulton and G. J. Dolan.

Observation of single-electron charging effects in small tunnel junctions.

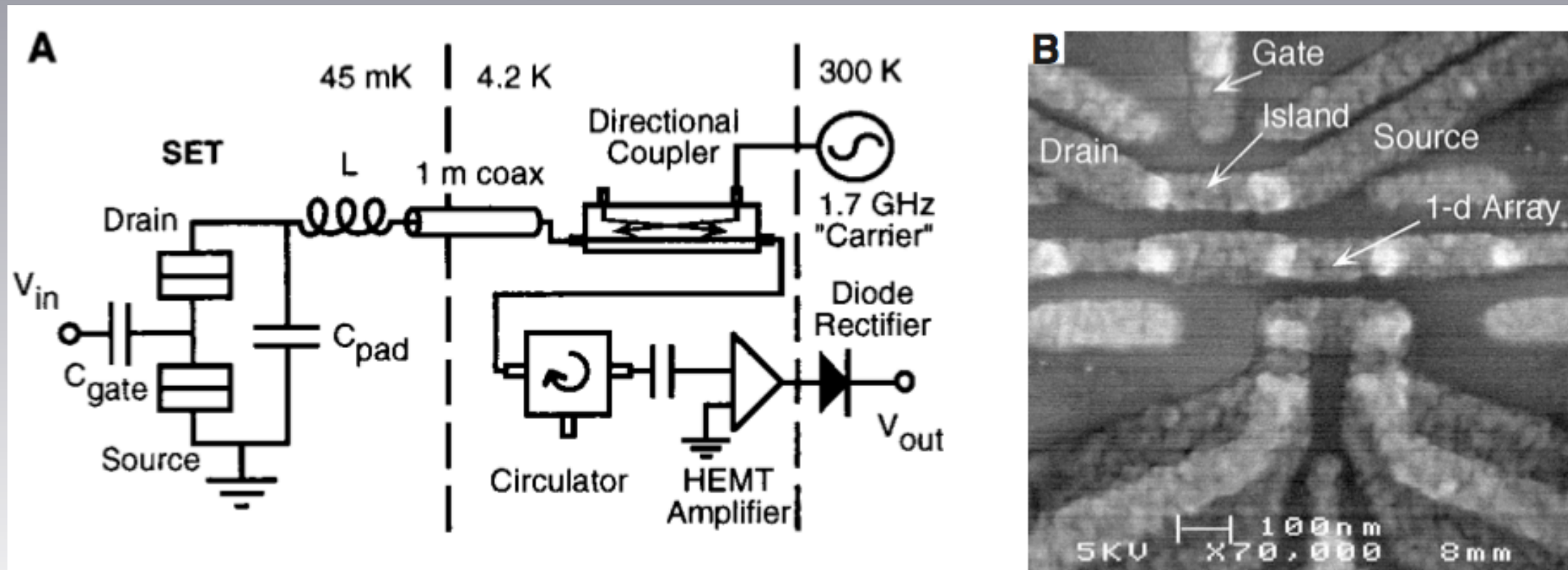
Physical Review Letters, 59(1):109-112, July 1987.

RF SET

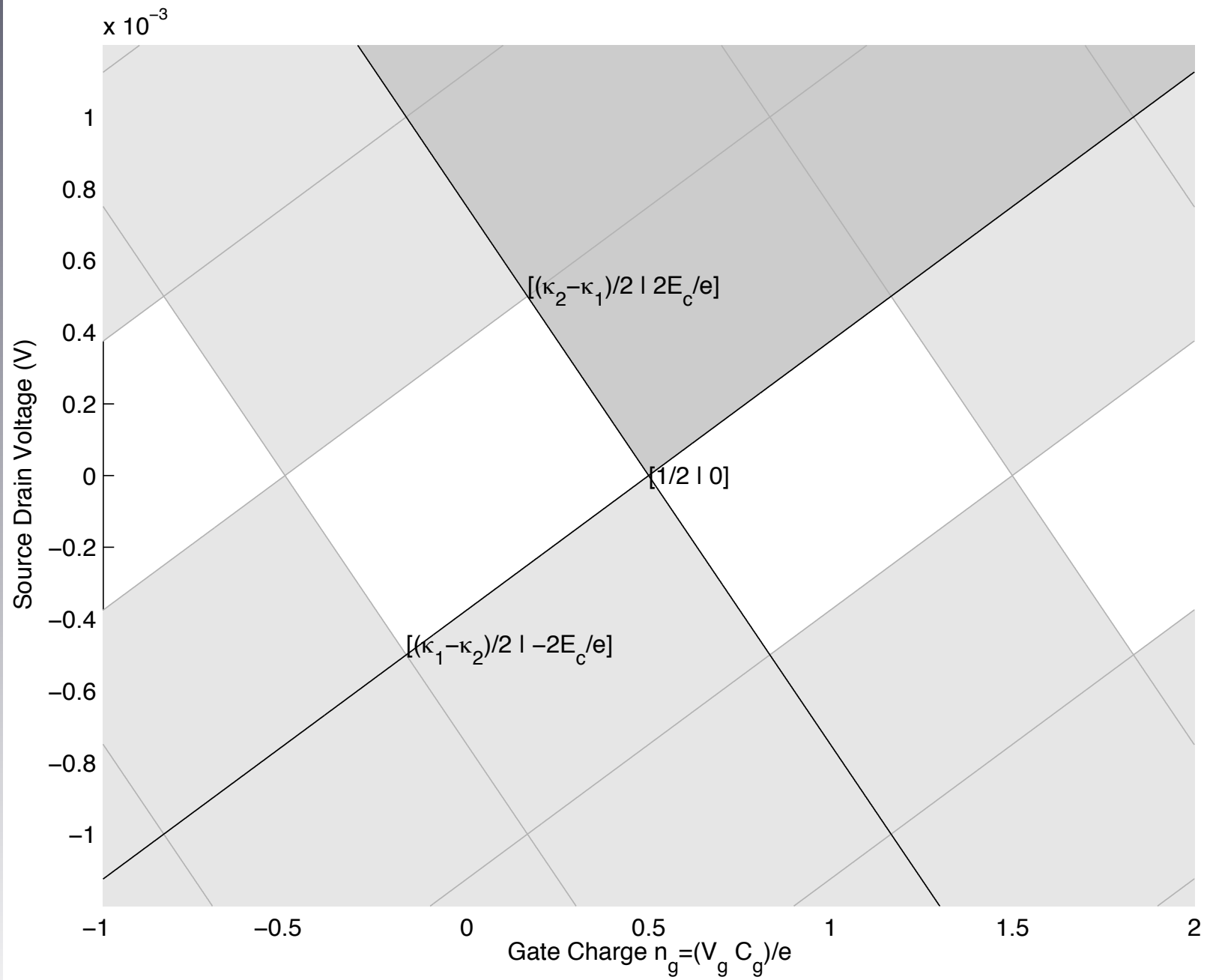
The Radio-Frequency Single-Electron Transistor (RF-SET): A Fast and Ultrasensitive Electrometer

R. J. Schoelkopf,* P. Wahlgren, A. A. Kozhevnikov,
P. Delsing, D. E. Prober

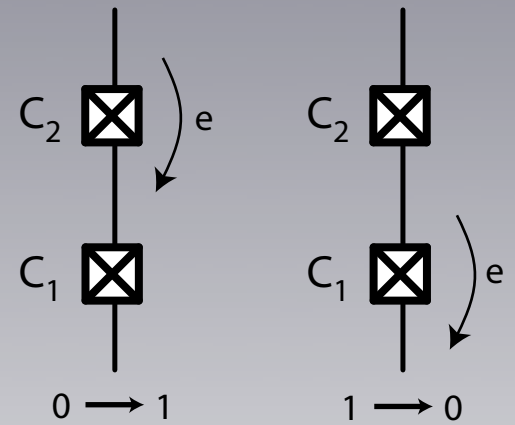
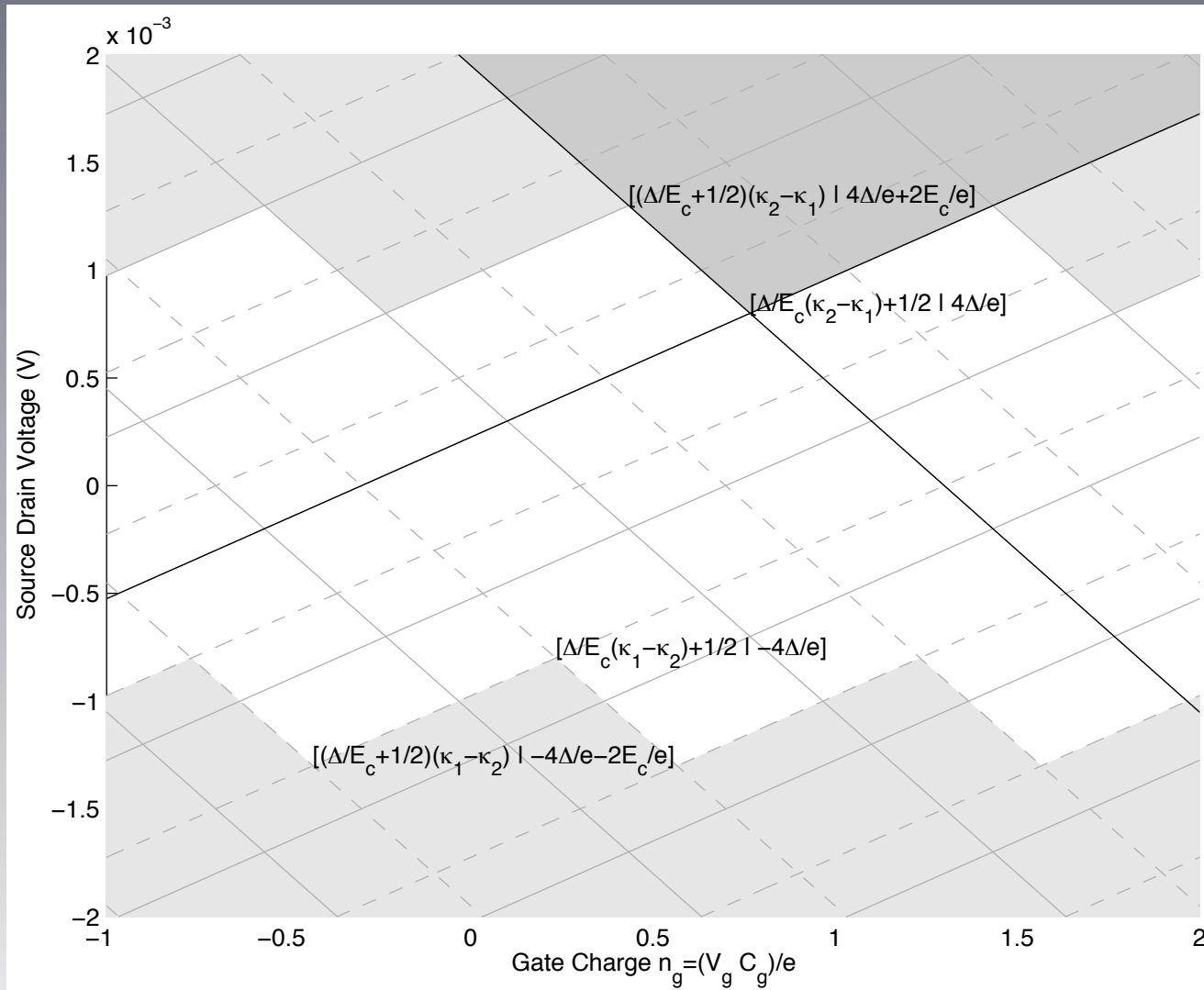
SCIENCE • VOL. 280 • 22 MAY 1998 • www.sciencemag.org



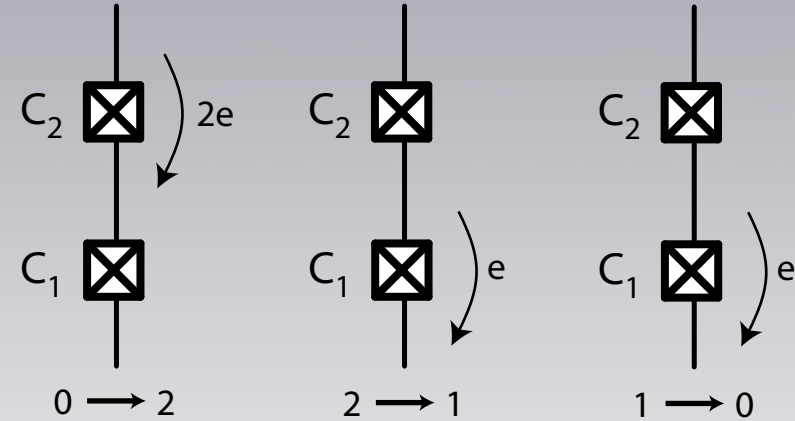
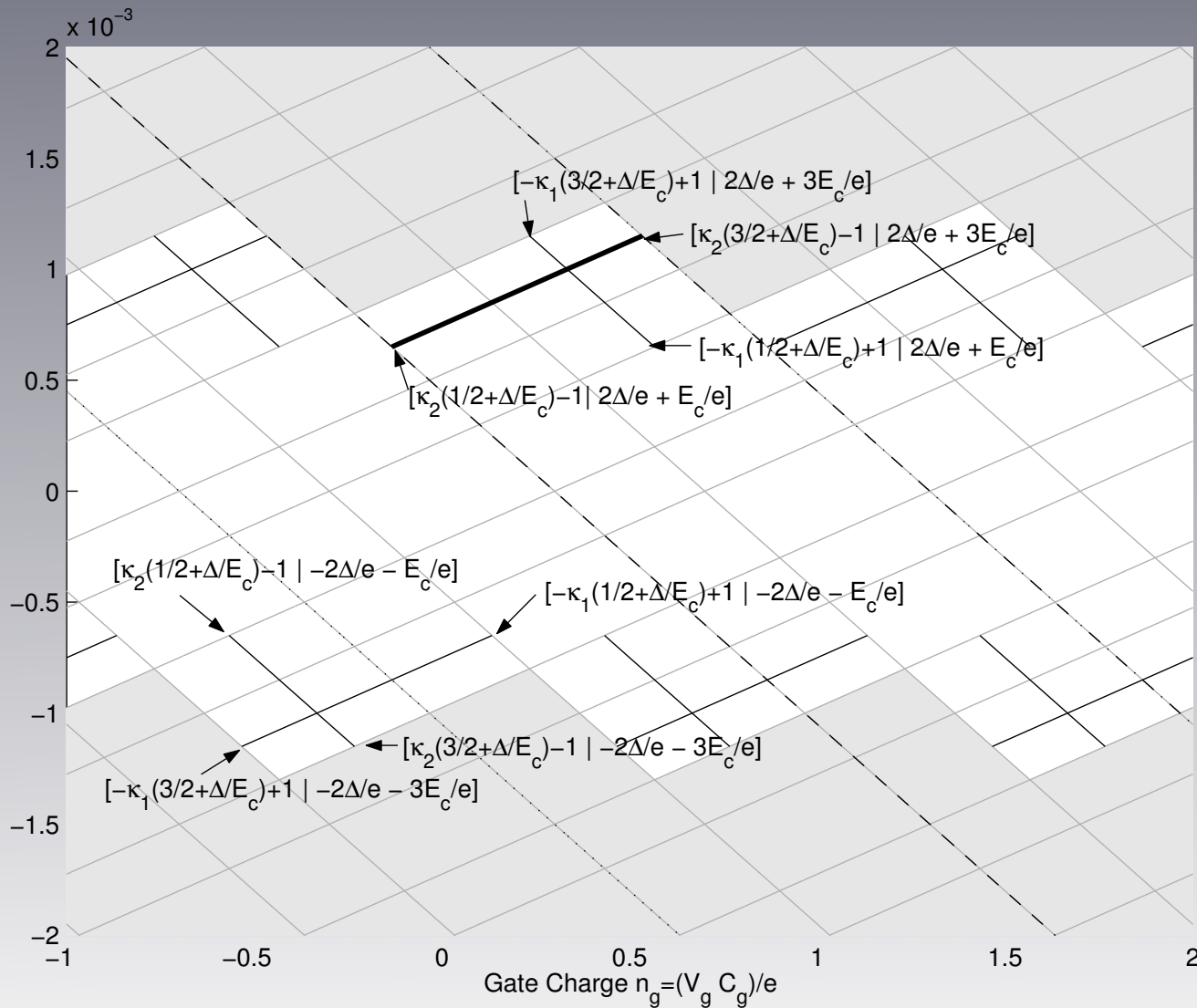
LC tank circuit, impedance transformer



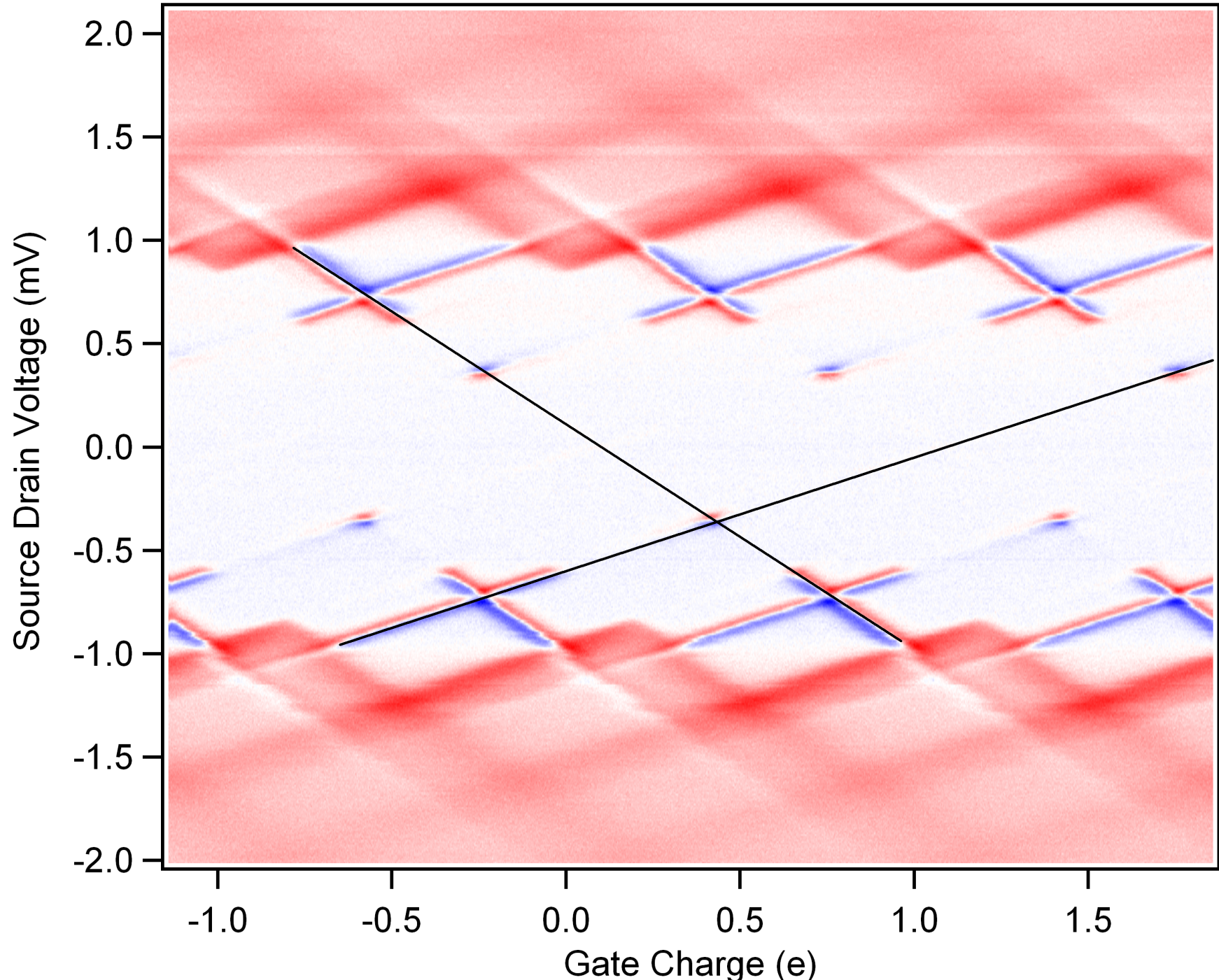
Superconducting SET



Josephson quasi particle cycle



Superconducting RF-SET



Coherent control of macroscopic quantum states in a single-Cooper-pair box

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