Lecture 2:

Quasiparticle current in N/I/S junctions

(cooling, charge imbalance, Coulomb blockade)

Tunneling DOS

VOLUME 5, NUMBER 4 PHYSICAL REVIEW LETTERS AUGUST 15, 1960

ENERGY GAP IN SUPERCONDUCTORS MEASURED BY ELECTRON TUNNELING

Ivar Giaever
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(Received July 5, 1960)

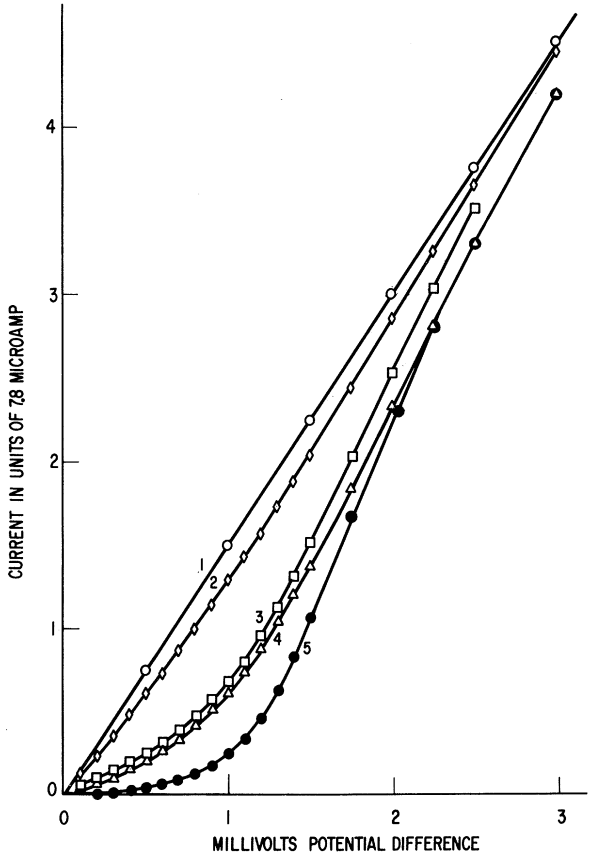


FIG. 1. Tunnel current between Al and Pb through Al_2O_3 film as a function of voltage. (1) $T = 4.2°K$ and $1.6°K$, $H = 2.7$ koe (Pb normal). (2) $T = 4.2°K$, $H = 0.8$ koe. (3) $T = 1.6°K$, $H = 0.8$ koe. (4) $T = 4.2°K$, $H = 0$ (Pb superconducting). (5) $T = 1.6°K$, $H = 0$ (Pb superconducting).

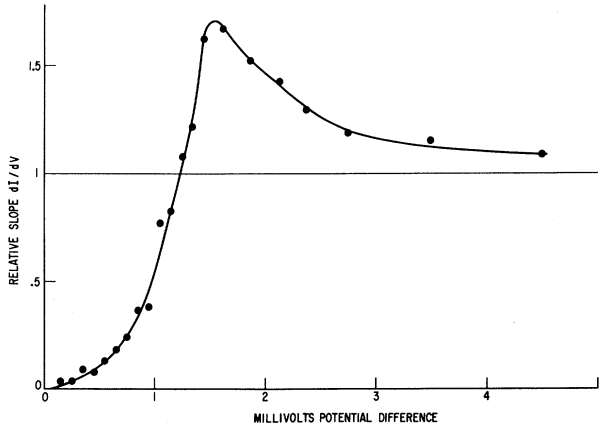


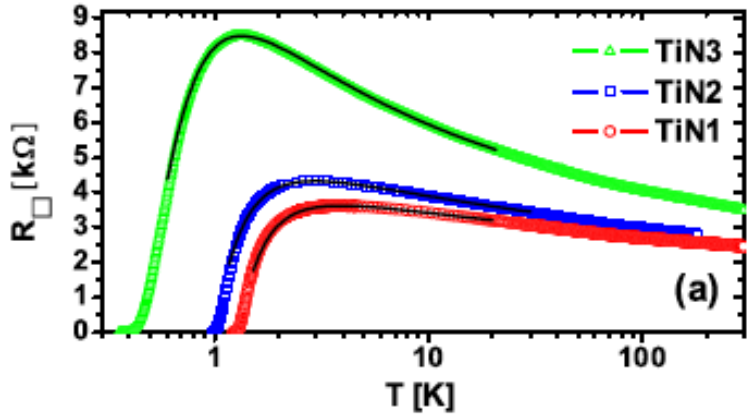
FIG. 2. From Fig. 1, slope dI/dV of curve 5 relative to slope of curve 1.

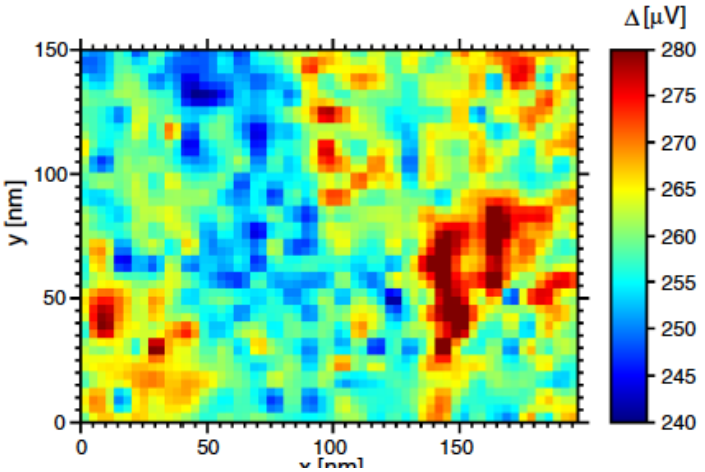
Tunneling DOS and fluctuations

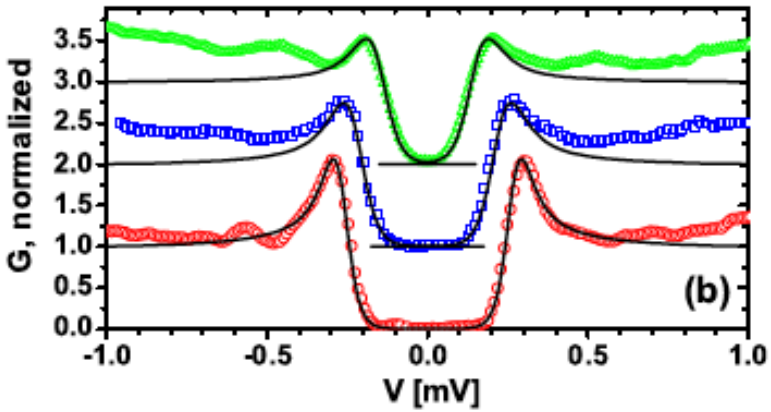
PRL 101, 157006 (2008) PHYSICAL REVIEW LETTERS week ending 10 OCTOBER 2008

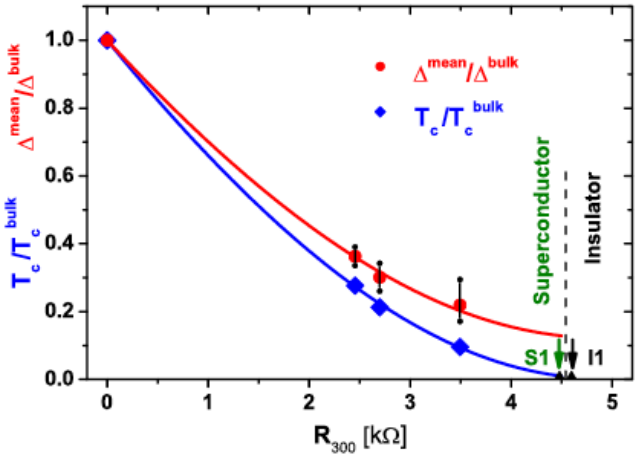
Disorder-Induced Inhomogeneities of the Superconducting State Close to the Superconductor-Insulator Transition

B. Sacépé,[1] C. Chapelier,[1] T. I. Baturina,[2] V. M. Vinokur,[3] M. R. Baklanov,[4] and M. Sanquer[1]









Tunneling DOS and fluctuations

VOLUME 82, NUMBER 21 PHYSICAL REVIEW LETTERS 24 MAY 1999

Exchange Fields and the Finite Bias Tunneling Anomaly in Paramagnetically Limited Superconducting Al Films

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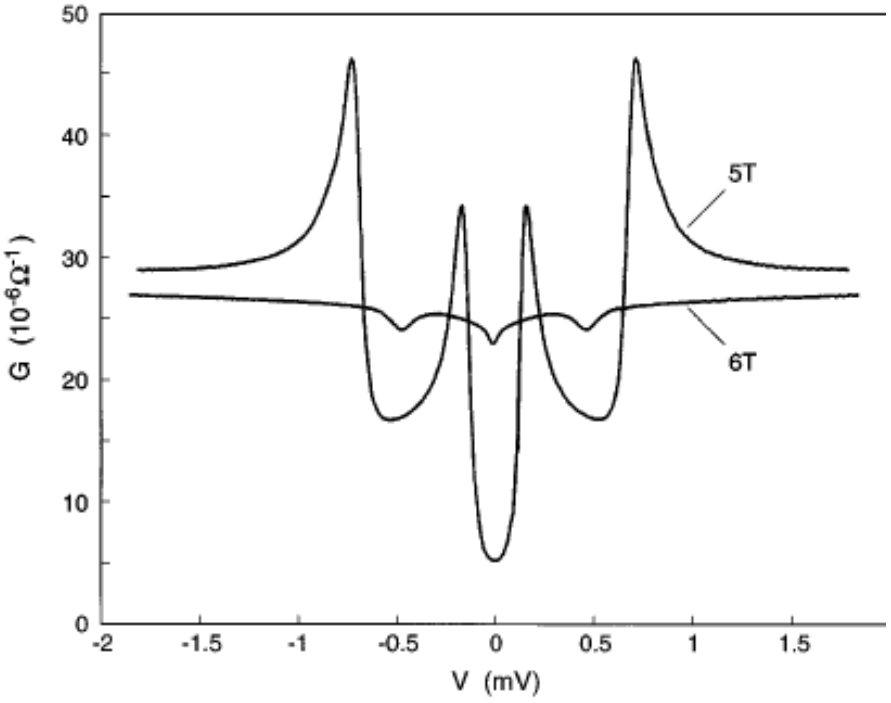
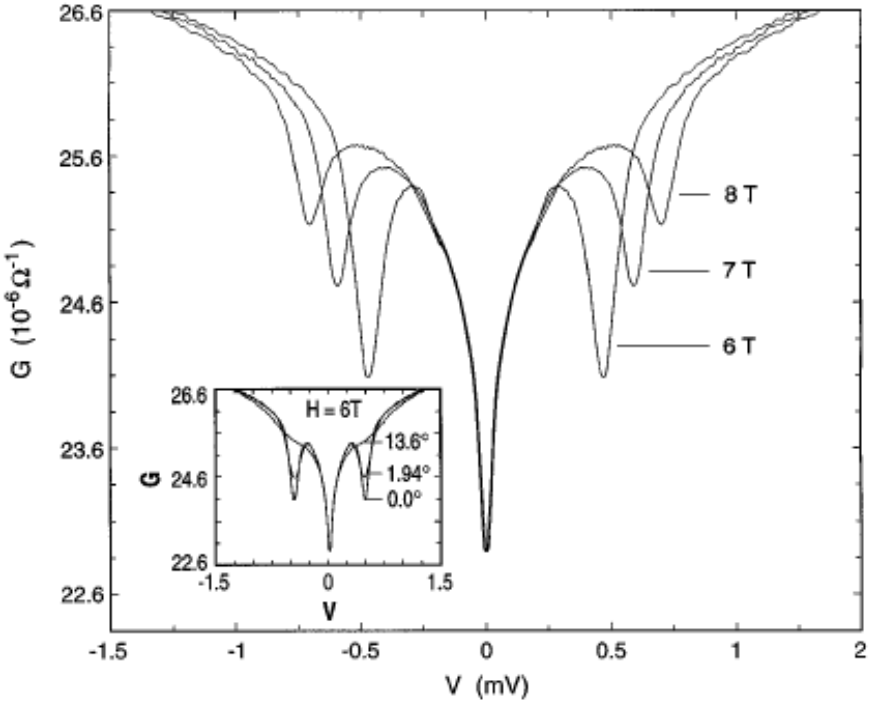


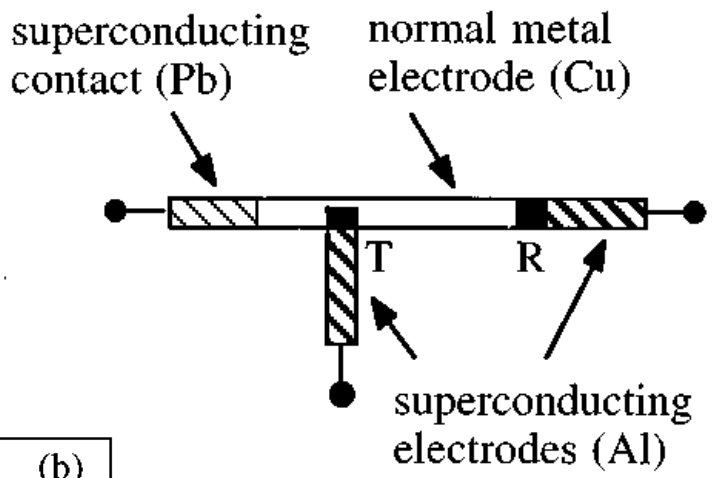


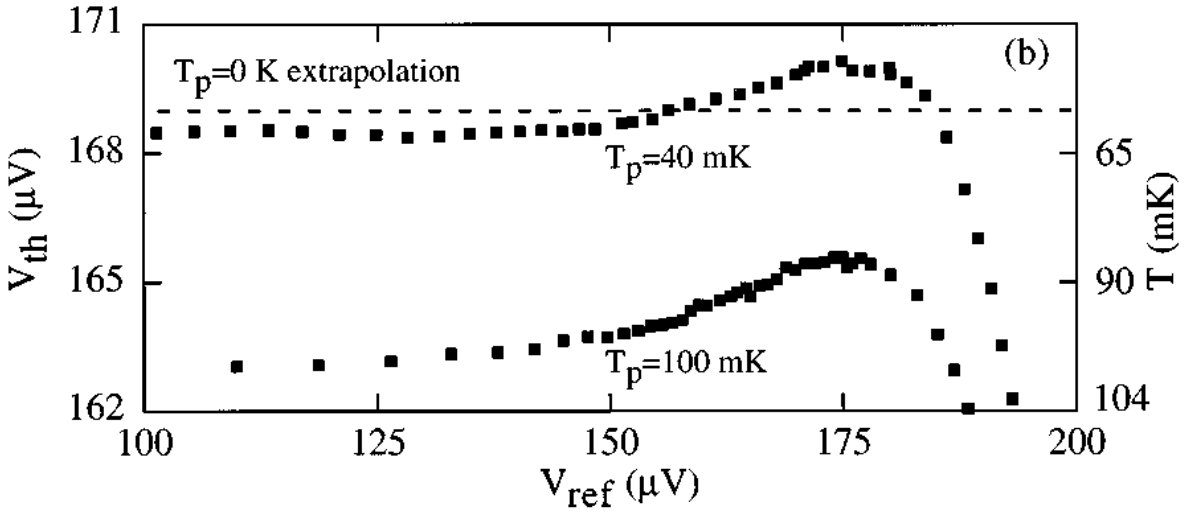
Cooling

Electronic microrefrigerator based on a normal-insulator-superconductor tunnel junction

M. Nahum,[a] T. M. Eiles,[b] and John M. Martinis
National Institute of Standards and Technology, Boulder, Colorado 80303

Applied physics letters, 1994





charge imbalance

Experimental Observation of Pair-Quasiparticle Potential Difference in Nonequilibrium Superconductors*

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(Received 20 March 1972)

It is shown experimentally that when a quasiparticle current is converted into a pair current in a superconductor, the quasiparticle potential in the nonequilibrium region differs from the pair chemical potential.

PRL **28**, 1363 (1972)

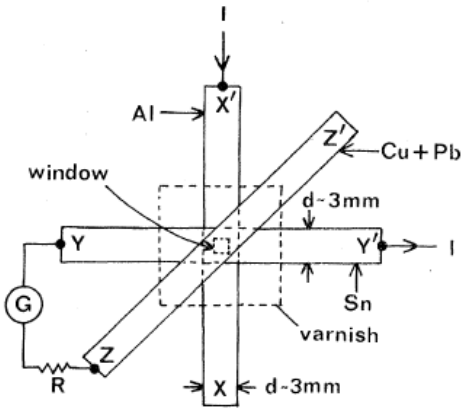


FIG. 1. Sample configuration. In order of deposi the films are Al (XX'), Sn (YY'), varnish, Cu (ZZ' and Pb (ZZ'). Galvanometer G and resistor R mea the potential difference V between Y and Z.

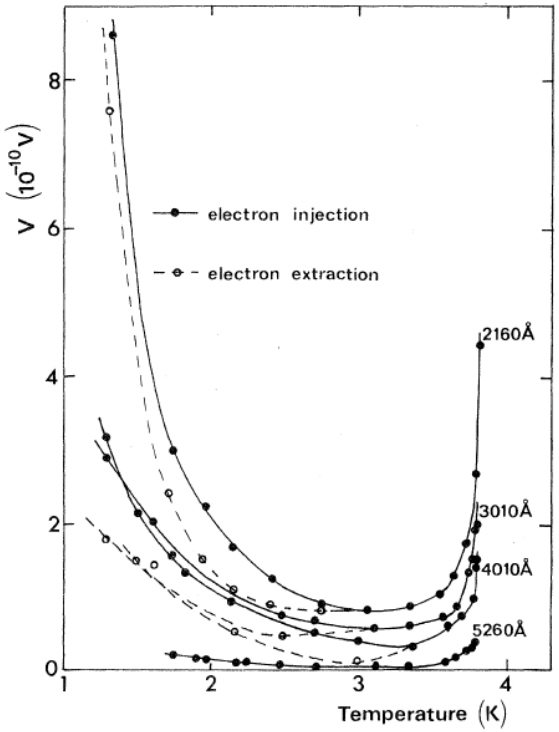


FIG. 2. Potential difference V between Y and Z for four thicknesses of Sn versus temperature. V is normalized to the injection current (I) of 1 mA. Sample area, 0.1 cm^2.

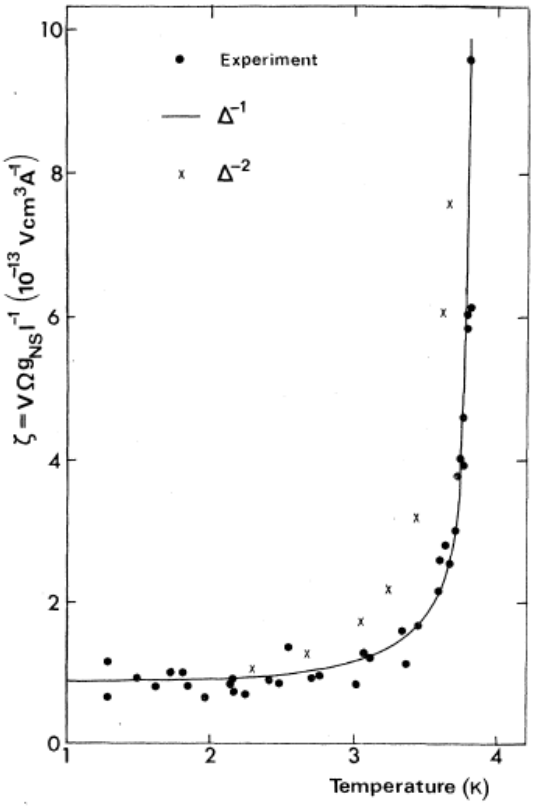


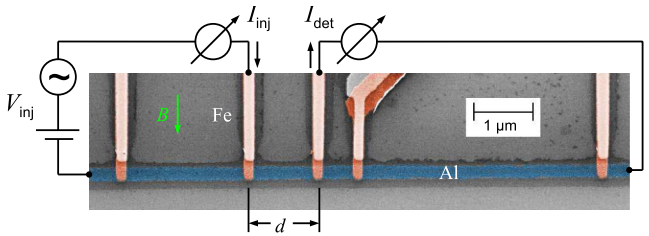
FIG. 3. Plot of $\zeta = V\Omega g_{NS} I^{-1}$ versus temperature for the three thinnest samples.

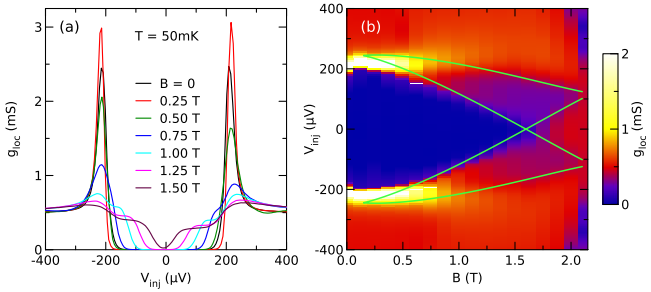
spin imbalance

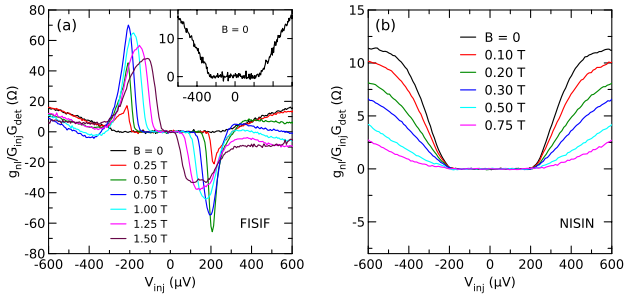
PRL **109,** 207001 (2012) PHYSICAL REVIEW LETTERS week ending 16 NOVEMBER 2012

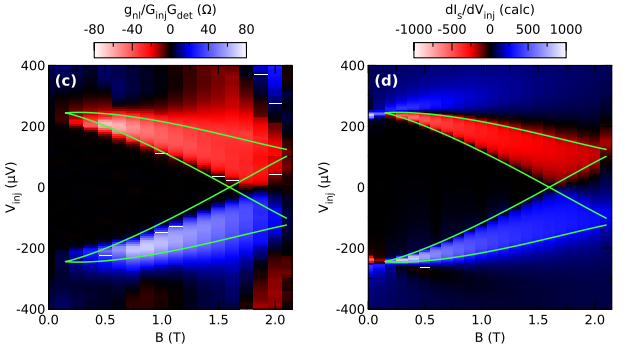
Long-Range Spin-Polarized Quasiparticle Transport in Mesoscopic Al Superconductors with a Zeeman Splitting

F. Hübler,[1,2,3] M. J. Wolf,[1] D. Beckmann,[1,2,*] and H. v. Löhneysen[2,3,4]

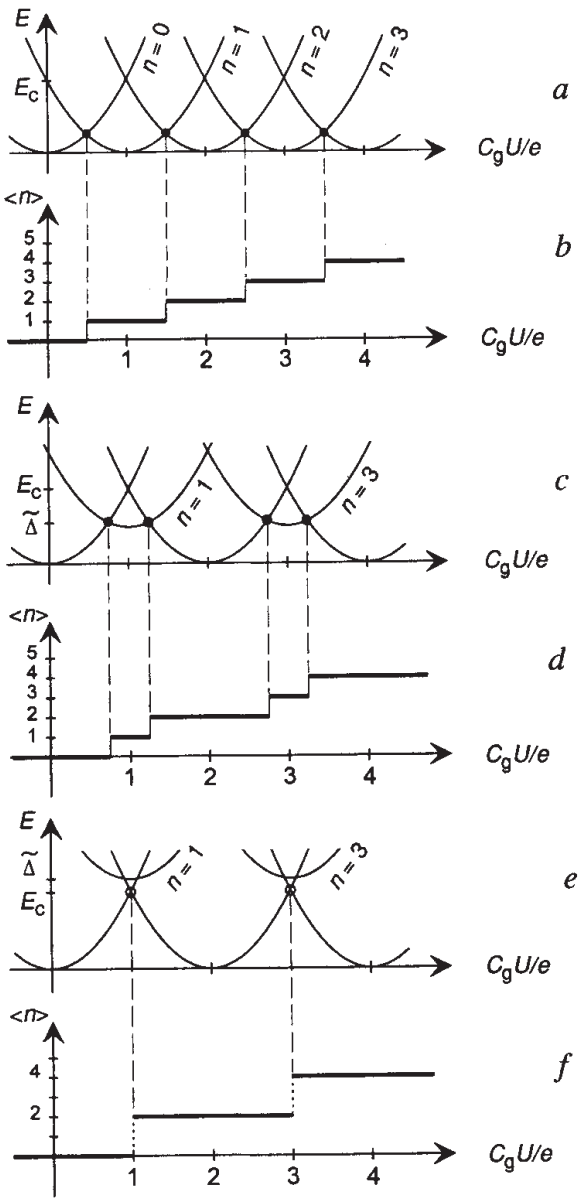








Parity effect



Two-electron quantization of the charge on a superconductor

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NATURE · VOL 365 · 30 SEPTEMBER 1993

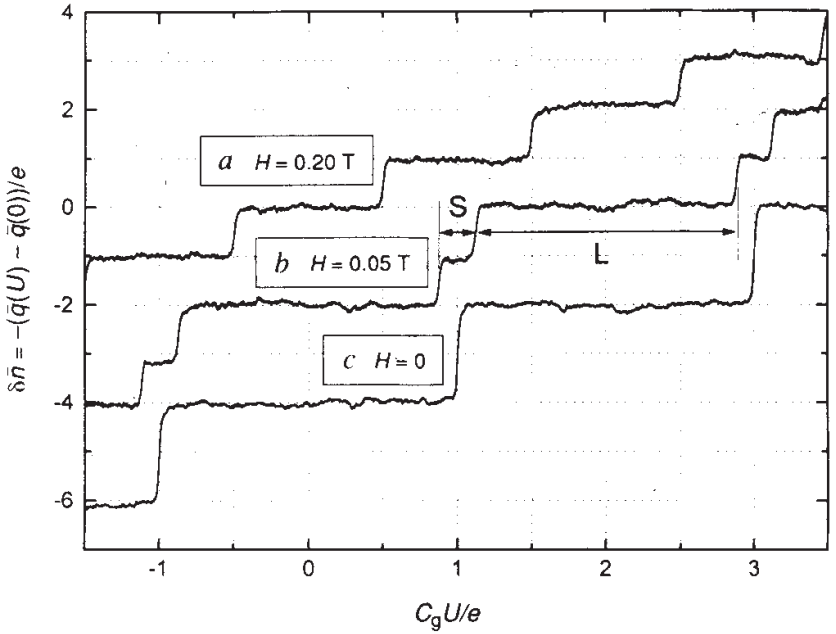

FIG. 2 Variations of the average value $\bar{q}$, in units of e, with the polarization C_gU/e, at $T = 28$ mK, for three values of the magnetic field H applied to the sample. *a*, Non-superconducting island. *b* and *c*, Superconducting island. For clarity, *b* and *c* have been offset vertically by 2 and 4 units, respectively. The letters L and S refer to the long and short steps, respectively.

Measurement of the Even-Odd Free-Energy Difference of an Isolated Superconductor

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(Received 16 November 1992)

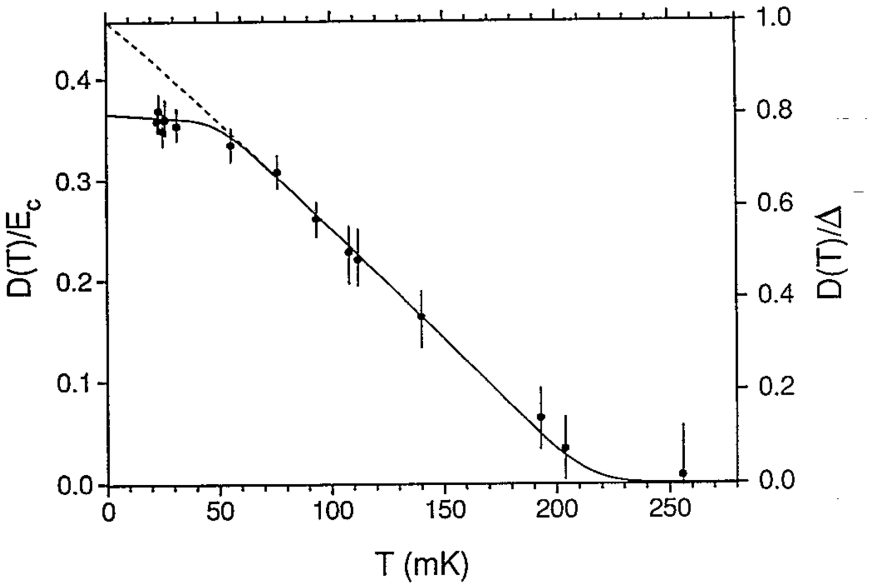

FIG. 5. Difference D between the free energies of the island with an odd and an even number of electrons as a function of temperature. Experimental values (dots) are directly measured in units of E_c. Dashed line is a theoretical expression of $D(T)/\Delta$ (scale on the right-hand side), assuming a continuous BCS density of states, $\rho_A = 0.572\ \mathrm{eV}^{-1}$, $N_A = 38\times10^7$, and $\Delta^{\mathrm{fit}}/e = 195\ \mu\mathrm{V}$ (see text). Full line is a modified expression corresponding to a single, twofold degenerate state added at 0.8Δ. The vertical scale factors of theory and experiment coincide for $C_\Sigma^{\mathrm{fit}} = 0.19$ fF.

$$D(T) = \frac{L - S}{L + S}$$

Anderson criterion

ARTICLE

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Superconducting parity effect across the Anderson limit

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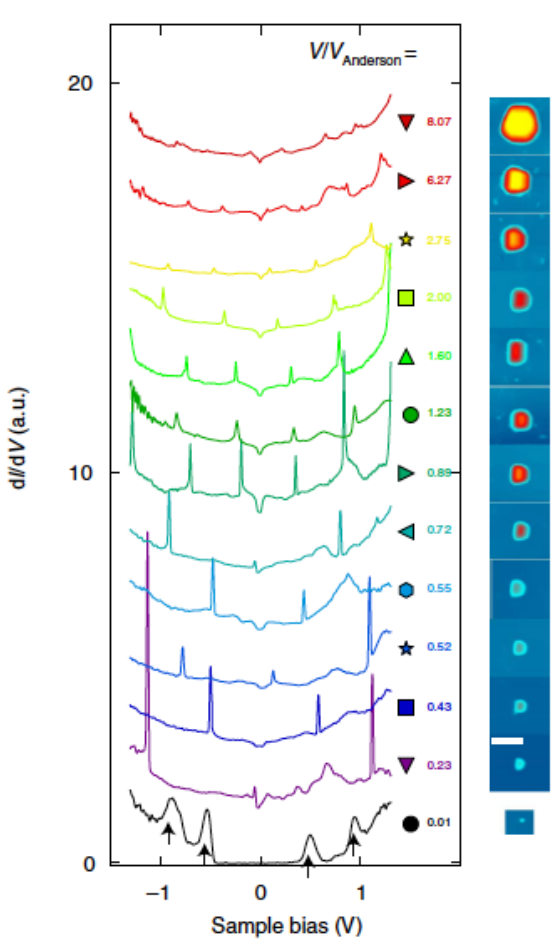

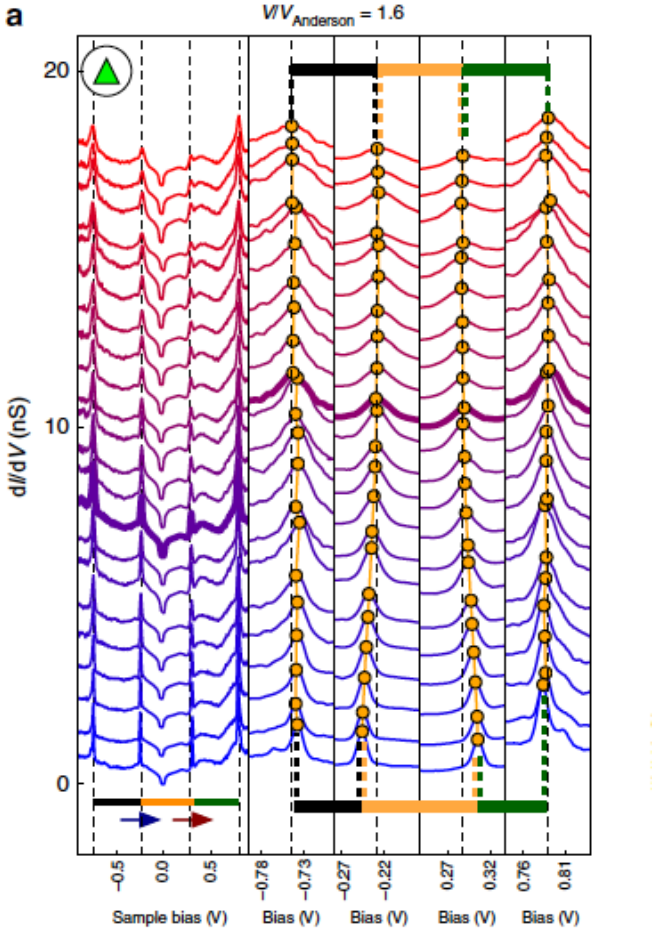

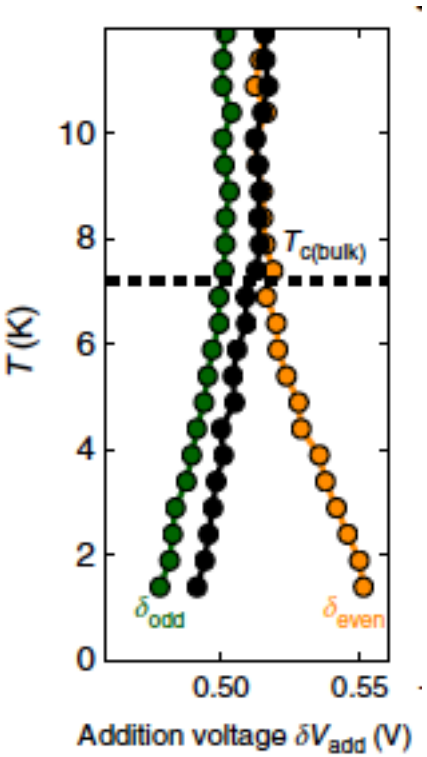

Coulomb blockade in NISIN junction

PRL **111,** 147001 (2013) PHYSICAL REVIEW LETTERS week ending 4 OCTOBER 2013

Excitation of Single Quasiparticles in a Small Superconducting Al Island Connected to Normal-Metal Leads by Tunnel Junctions

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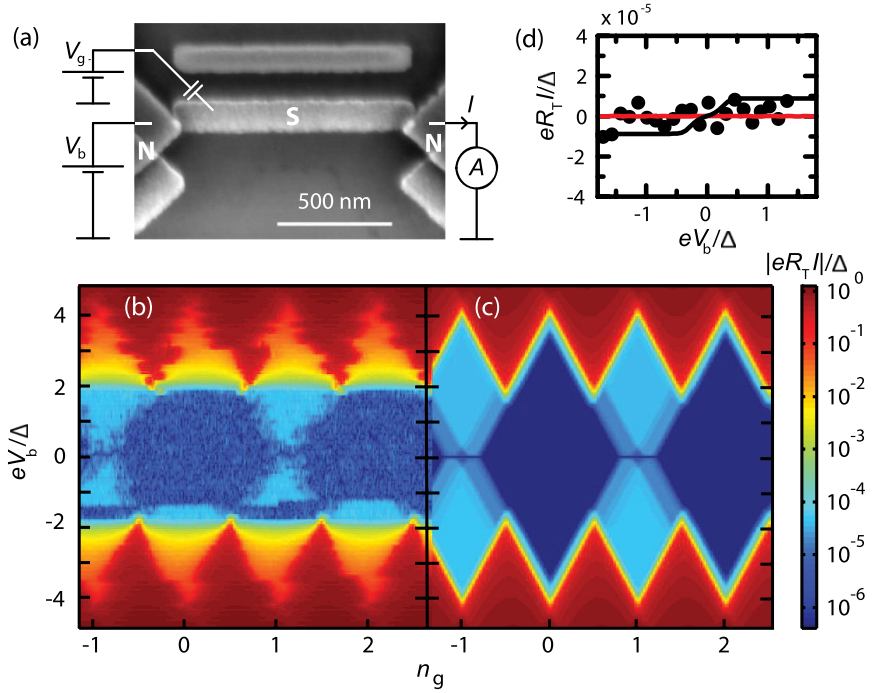

NISIN turnstile

Hybrid single-electron transistor as a source of quantized electric current

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Nature Physics 2008