IUPAP Commission 5

Low Temperature Physics

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Commission Conferences

LT (International Conference on Low Temperature Physics)

- LT2, Oxford, UK 1951
- LT22, Helsinki, Finland 1999
- LT23, Hiroshima, Japan 2002
- LT24, Orlando, Florida 2005
- LT25, Leiden, Holland 2008?

QFS (Conference on Quantum Fluids and Solids)

- Konstanz, Germany 2001
- Albuquerque, New Mexico 2003
- Trento, Italy 2004

Titles at LT2, Oxford, England 1952

A. 106 talks

B. 5 talks about physics of thin He films
(t < 1 micron)

C. 5 talks about thin superconducting metallic films
(t < 1 micron)

Talks and papers at LT16, Los Angeles 1981

A. 68 invited talks
   A. 4 talks about thin liquid films and surfaces
   B. 2 talks about thin superconducting films
   C. 1 talk about microrefrigeration
   D. 6 talks about electron localization and tunneling
      A. David Thouless
      B. Phil Anderson

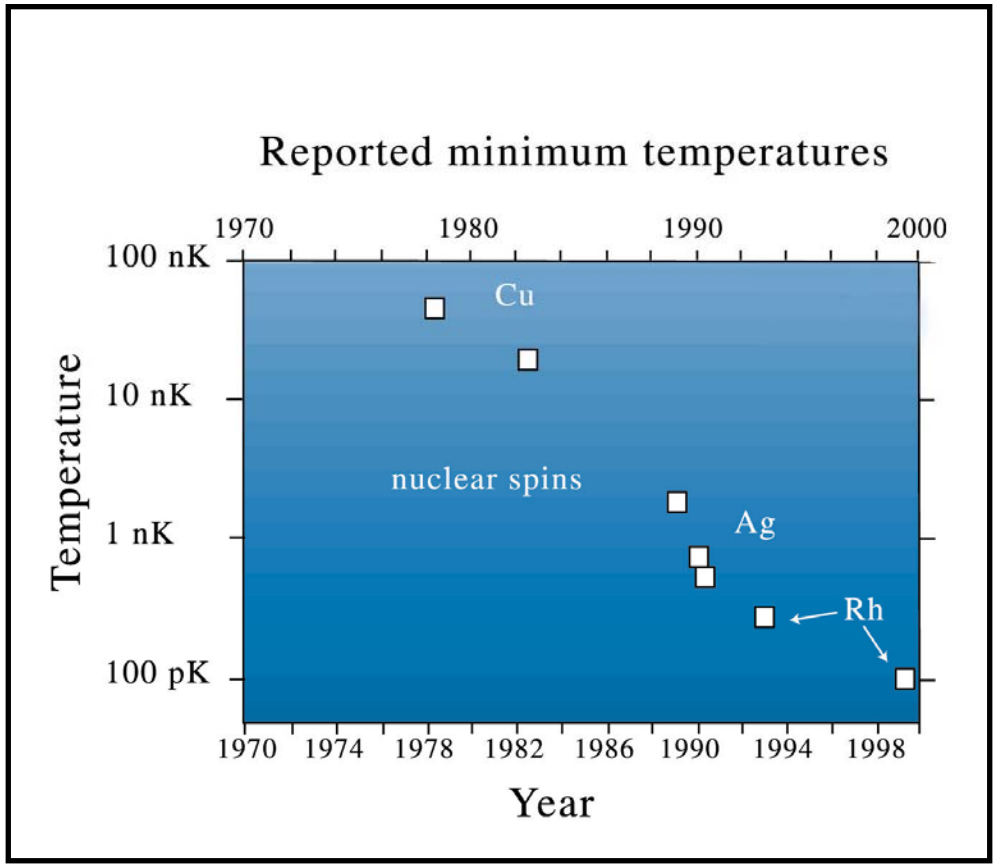
B. 90 sorting categories of contributed papers
   A. Electron localization I, II and III
   B. Point contact tunneling
   C. Microbridges
   D. Quasi-one-dimensional conductors
   E. Low dimensional magnetism
   F. Adsorbed films
   G. Superfluid films
   H. Vortex unbinding in two dimensions
   I. Two dimensional phase transitons I, II
   J. 2D-electrons on He surface

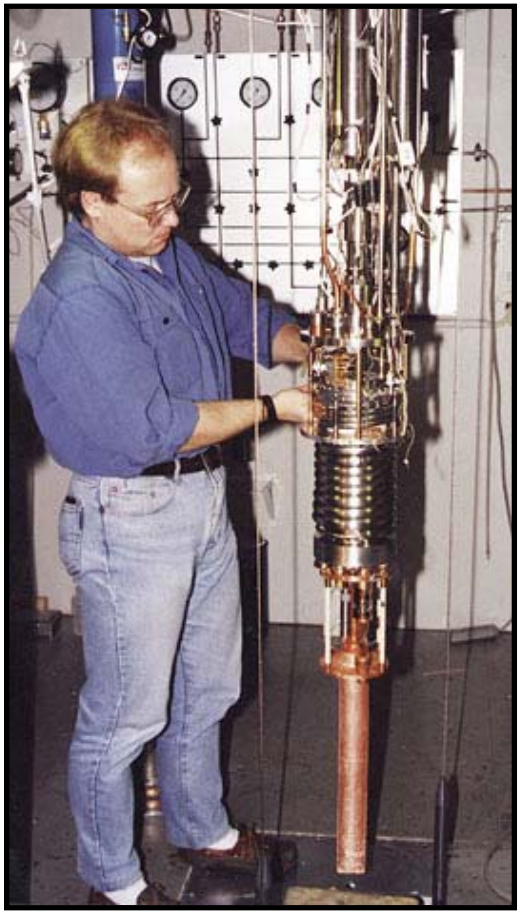
Sessions at LT23, Hiroshima 2002

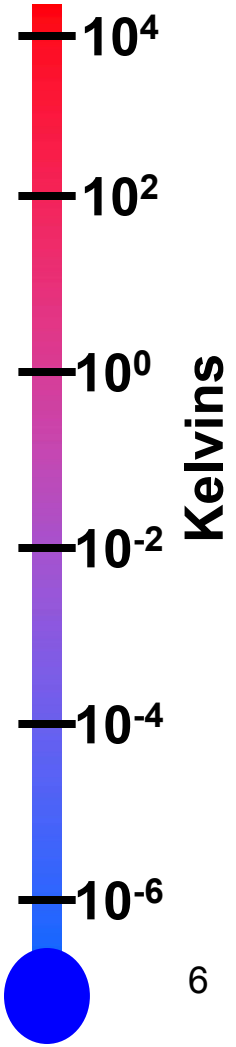
A. Five program lines
   A. Quantum gases. fluids and solids
   B. Superconductivity
   C. Magnetism and properties of solids
   D. Quantum electron transport (15% of the talks)
   E. Applications, materials and techniques

B. Sessions of quantum electron transport
   A. Mesoscopic superconductivity
   B. Transport in nanotubes and nanostructures
   C. Quantum coherence/qubit I, II
   D. Quantum Hall effect
   E. Quantum transport I, II
   F. Metal-insulator transition
   G. Transport in 2DEG
   H. Quantum dot Kondo effect

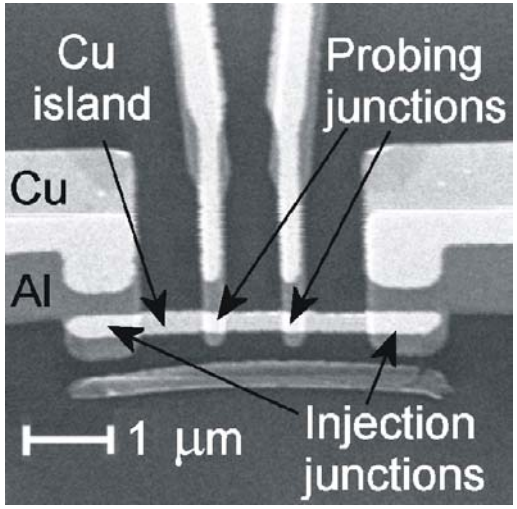
Brute force refrigeration methods

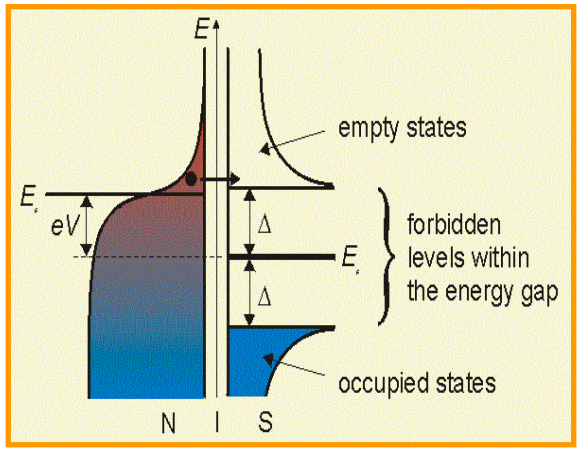


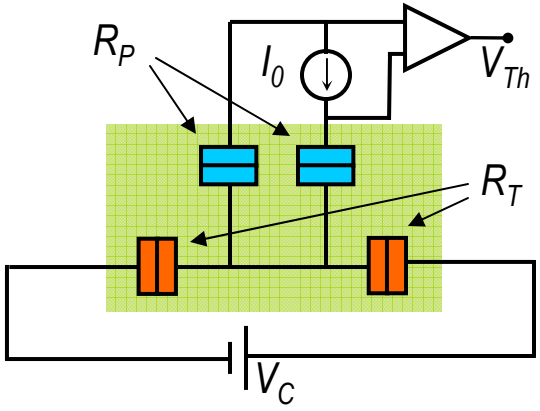


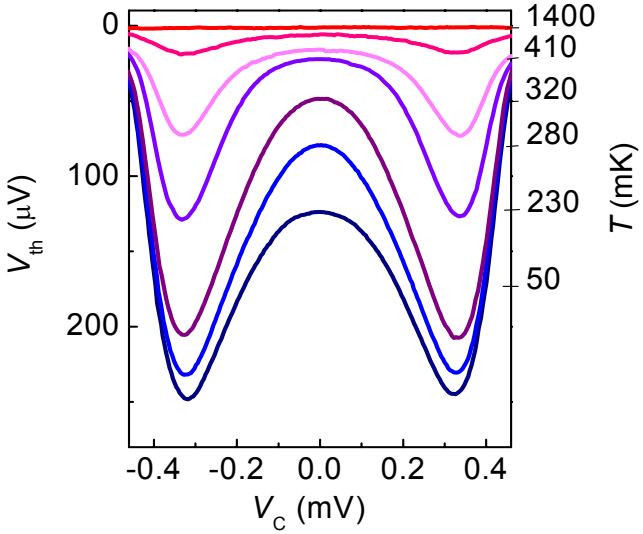


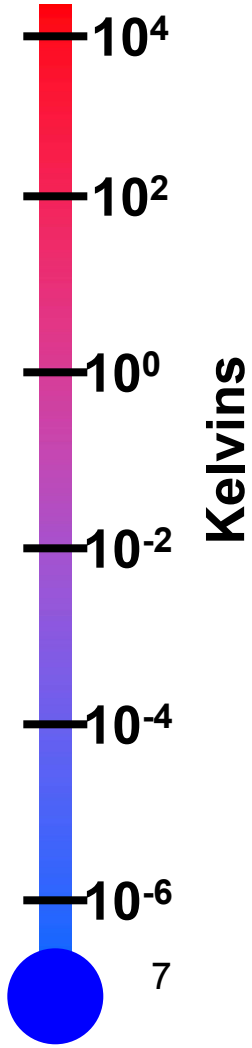
Microrefrigeration on a silicon chip





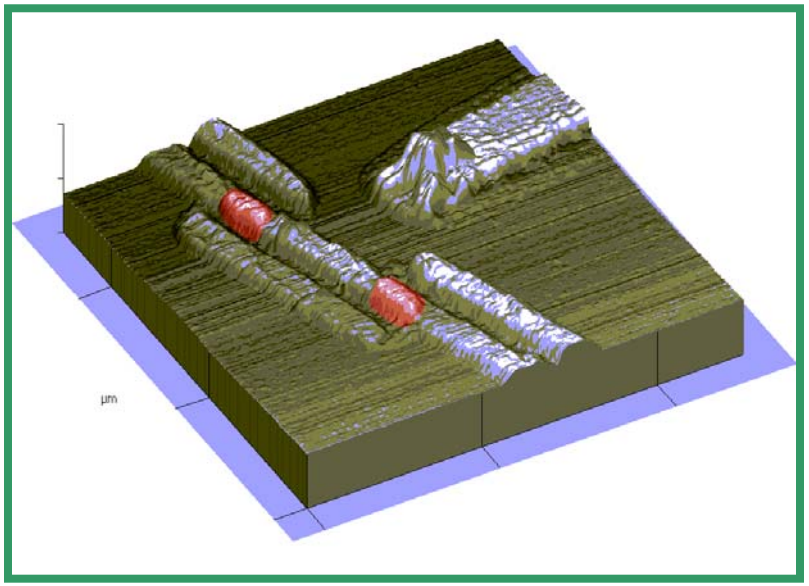






Pekola et al Physics Today, August 2004

SINGLE ELECTRON TRANSISTOR - SET



Invented in 1987

Works only at low temperatures $k_B T < E_C$

Tunnel juntions smaller than 100 x 100 nm^2

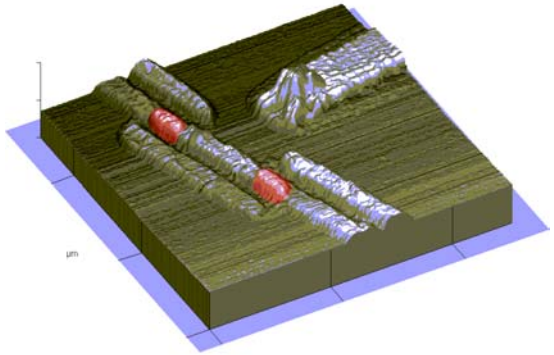
Component for many applications:

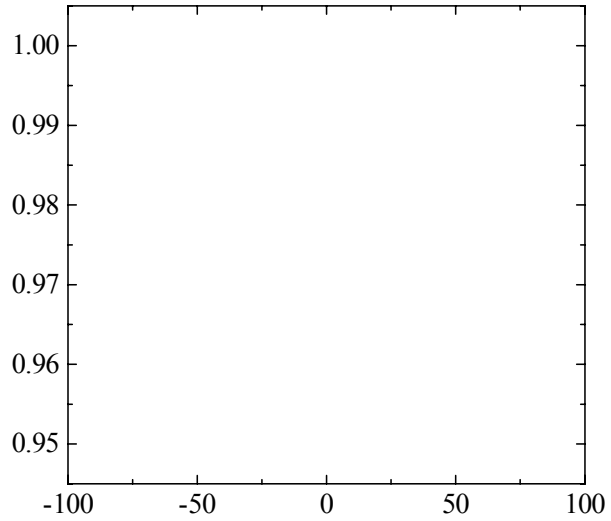
- nanothermometry
- sensitive charge detection
- single electron pumping
- superconducting SET - quantum computing

Coulomb Blockade Thermometry

$V_{1/2} = 5.439 N k_B T/e$ **primary thermometer**

$\Delta G/G_T = \varepsilon_c/6k_BT$ **secondary thermometer**

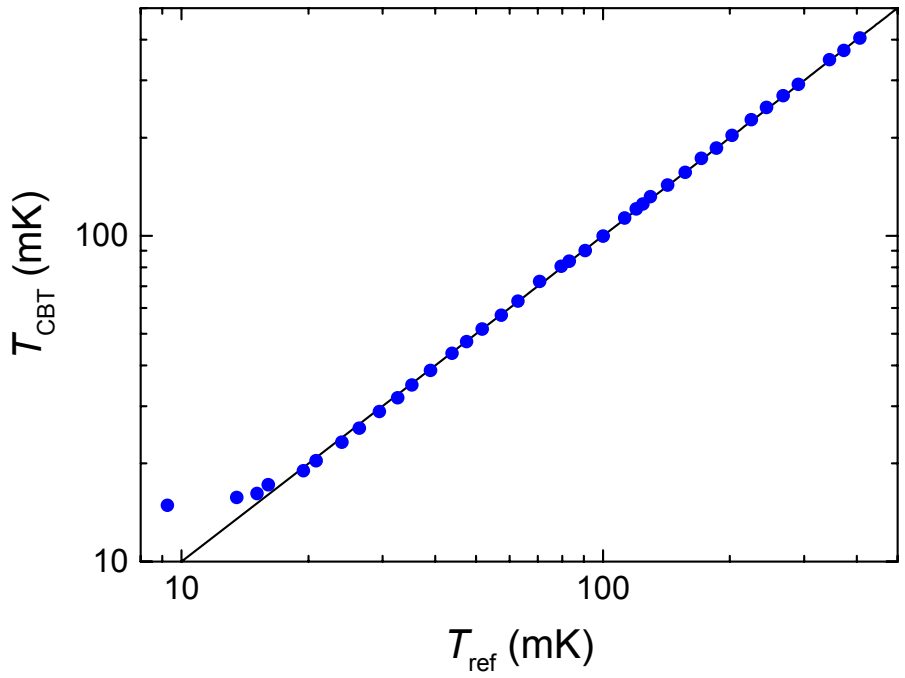




Normalised conductance, G/G_T, of a CBT sensor vs. voltage V. The theoretical curve is shown as a black line.

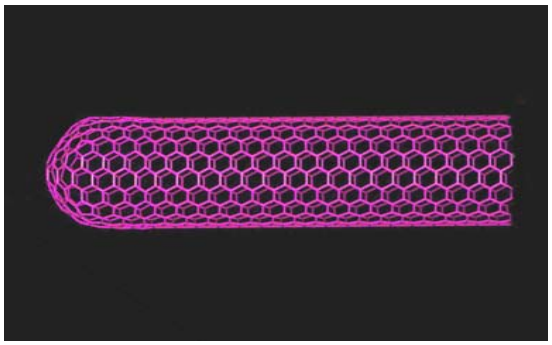
J. Pekola, K. Hirvi, J. Kauppinen, M. Paalanen, PRL**73**, 2903 (1994).

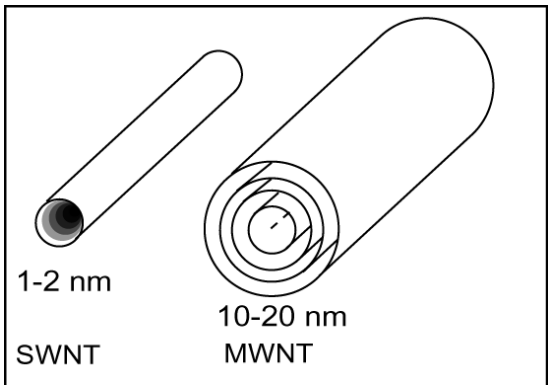
NANOTHERMOMETRY

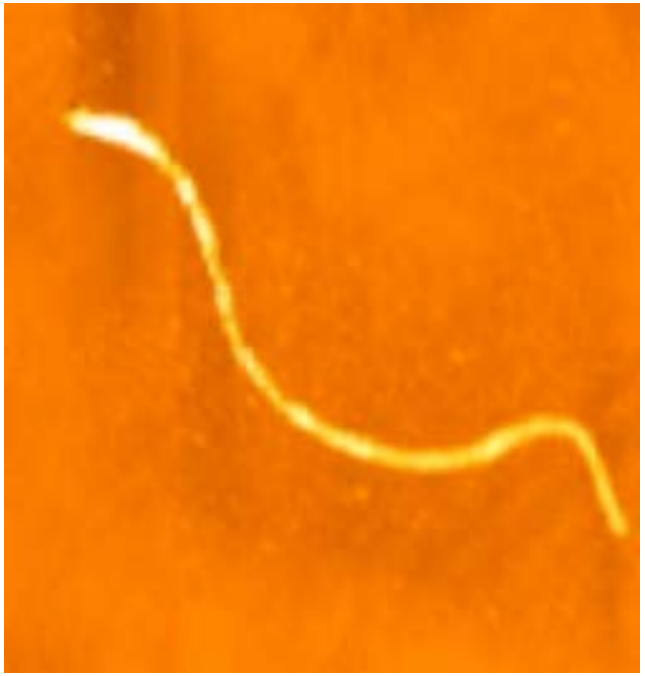


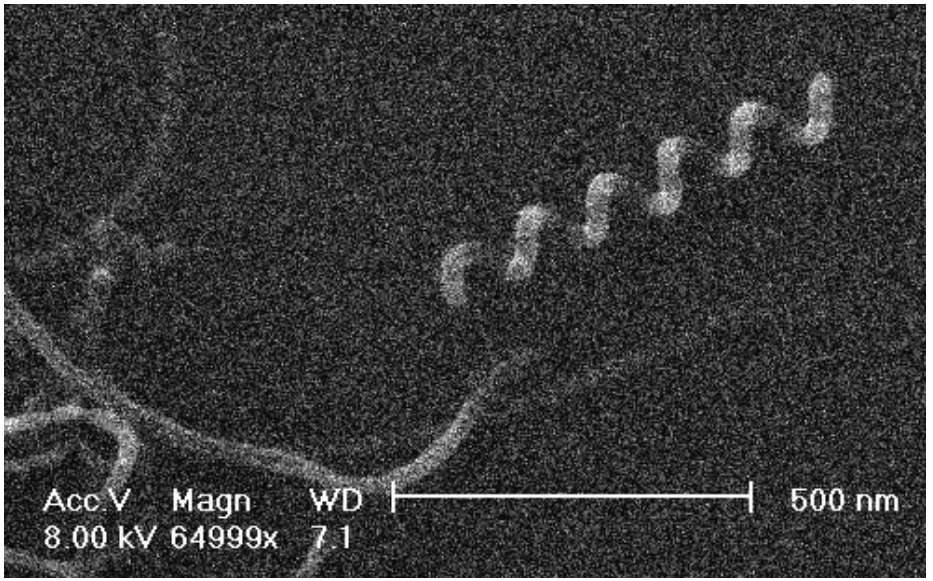
Measurements by *M. Meschke, H. Godfrin, R. E. Rapp, J. P. Pekola* at CNRS, CRTBT, Grenoble (2002).

ELECTRON TRANSPORT IN CARBON NANOTUBES



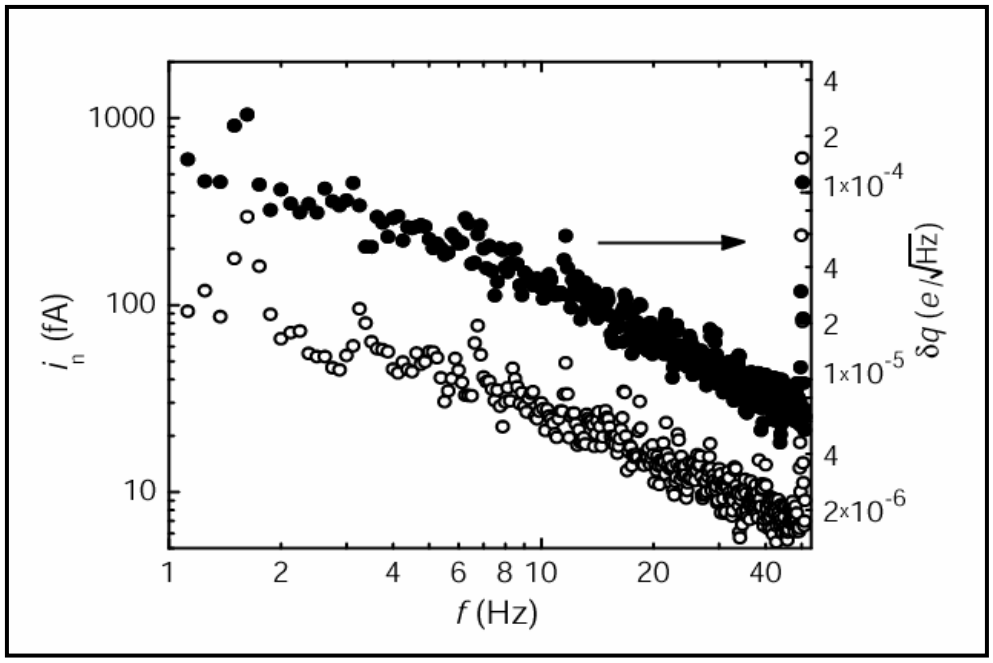


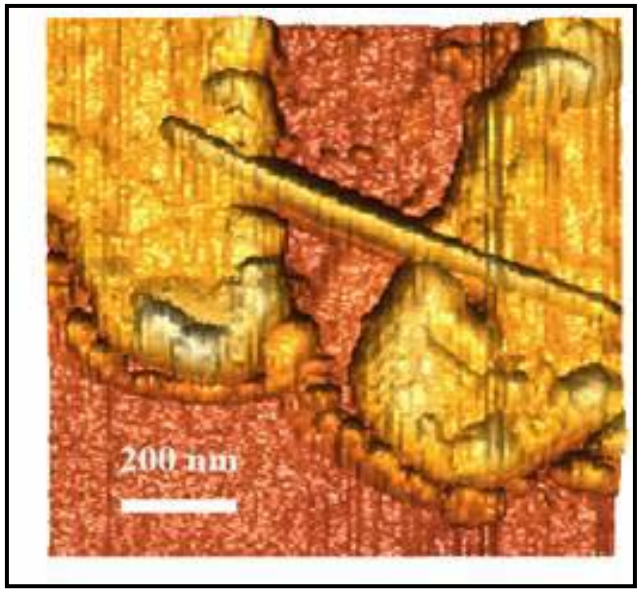


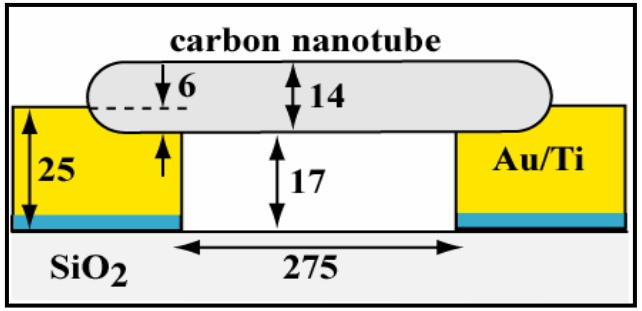


MOST SENSITIVE SINGLE ELECTRON TRANSISTOR MADE OF MWCNTs

Sensitivity $6 \cdot 10^{-6} e/\sqrt{Hz}$

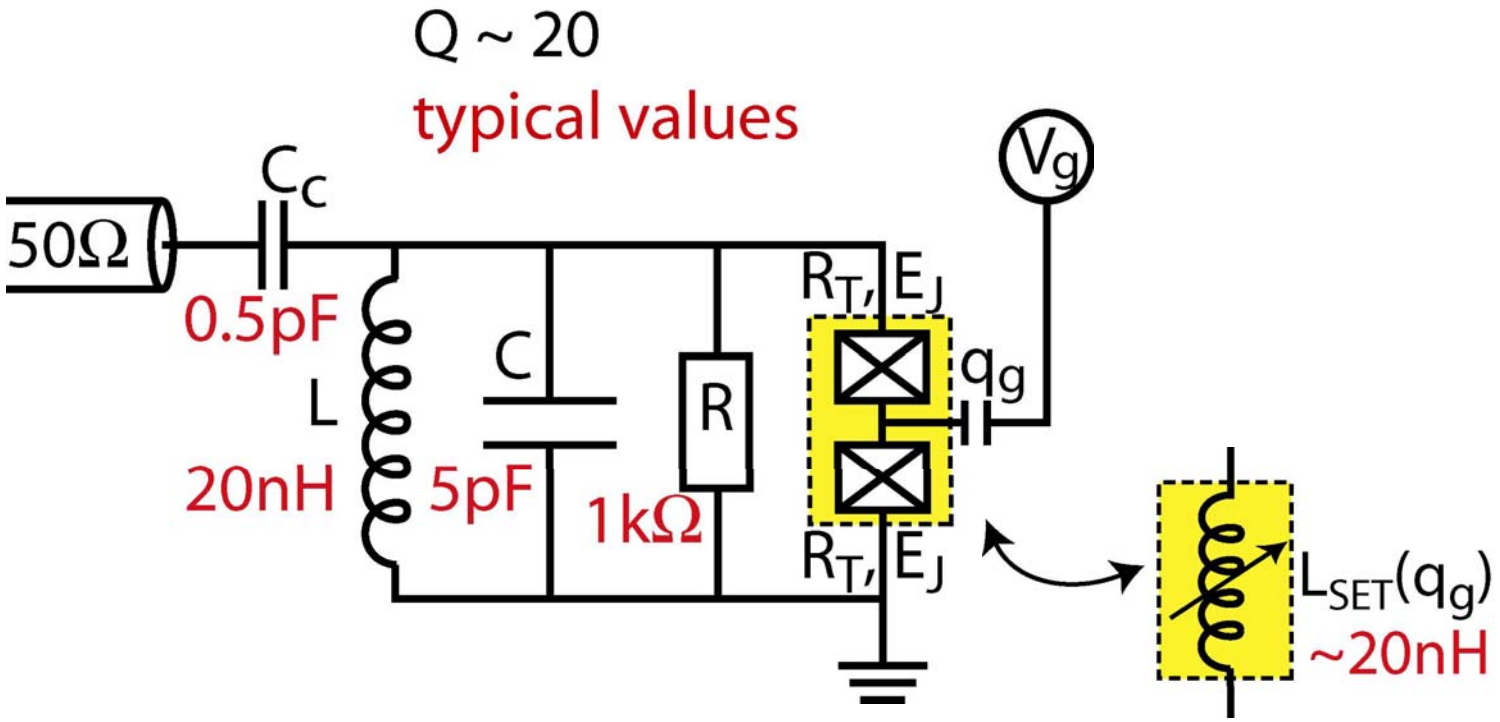






L. Roschier et al , Appl. Phys. Lett. ***75****, 728 (1999).*

INDUCTIVELY COUPLED SUPERCONDUCTING SET
- a fast electrometer

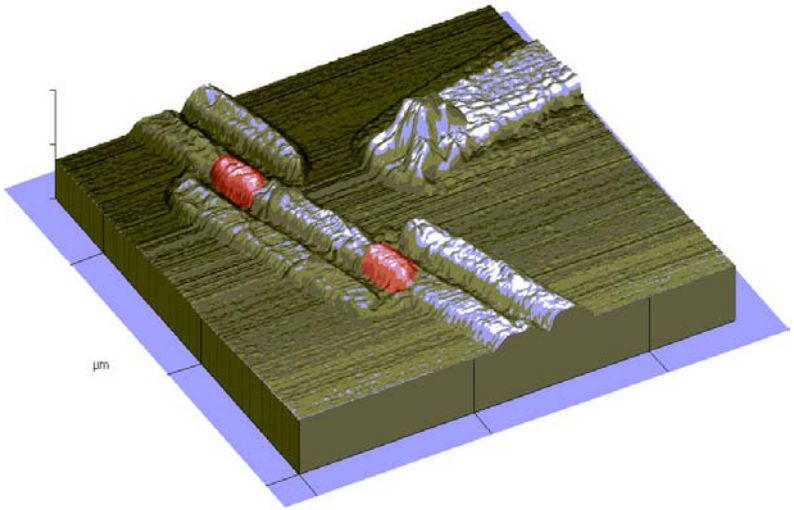


Gate modulation of resonant frequency f_0

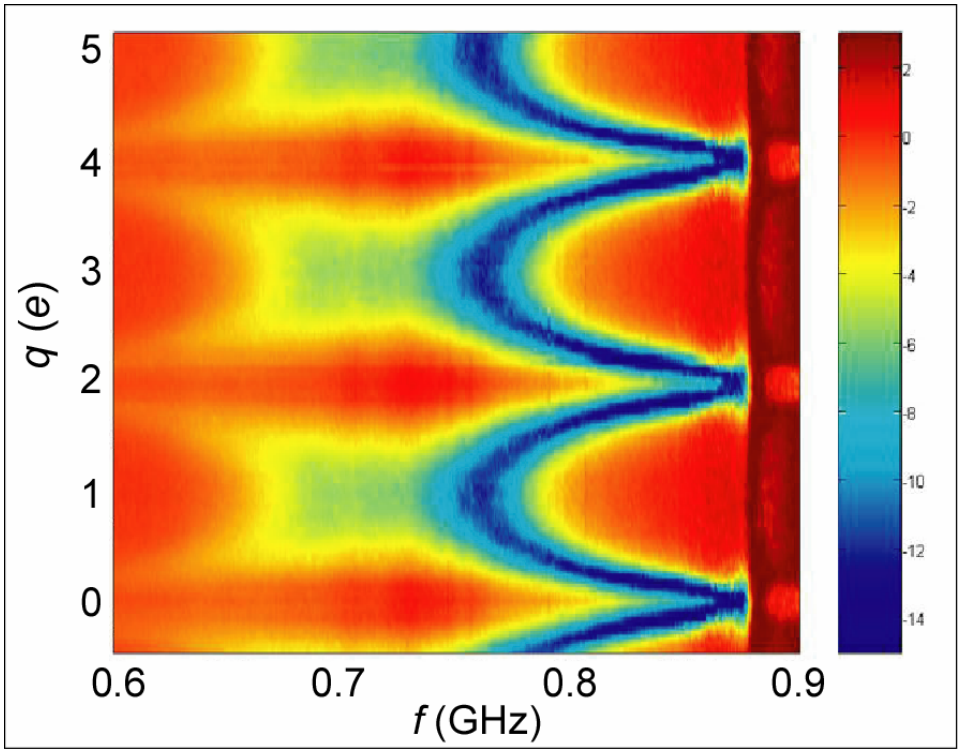
$$f_0(q_g) = \frac{1}{2\pi}\sqrt{\frac{1}{\left(L \,||\, L_{SET}(q_g)\right)C}}$$

INDUCTIVE SINGLE ELECTRON TRANSISTOR

- Nearly quantum limited operation
- Charge sensitivity $3 \cdot 10^{-5} e/\sqrt{Hz}$
- Energy sensitivity ~ □
- Small back action, large band width

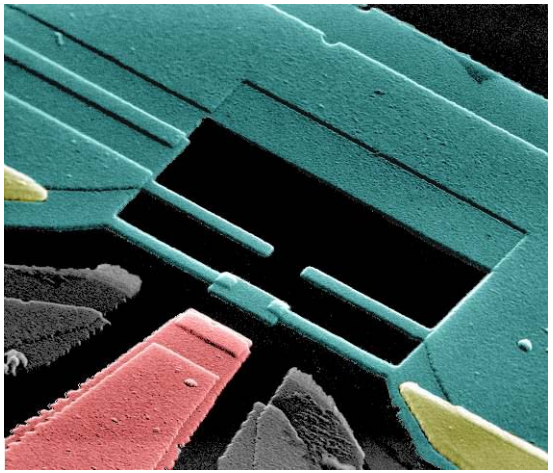


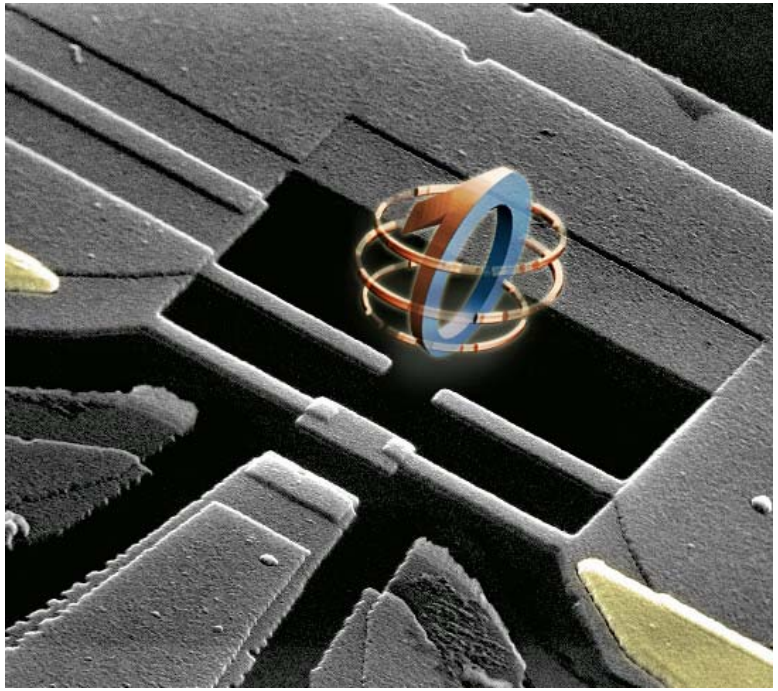
*M. Sillanpää. L. Roschier, and P. Hakonen, PRL **93**, 066805 (2004).*



QUANTUM COMPUTING WITH JOSEPHSON JUNCTIONS

Quantronium (Saclay)





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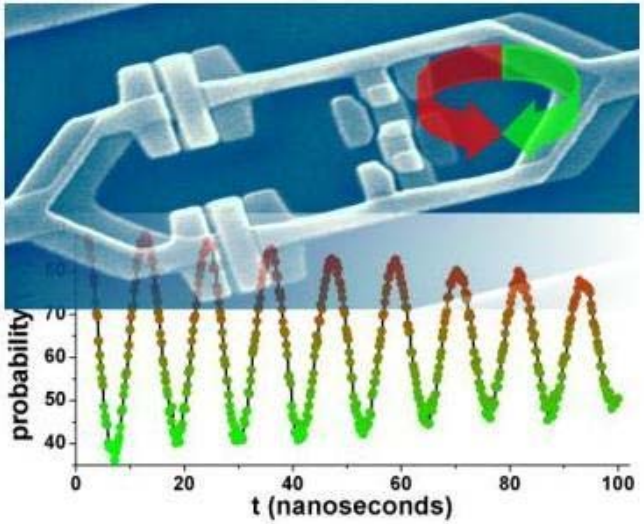
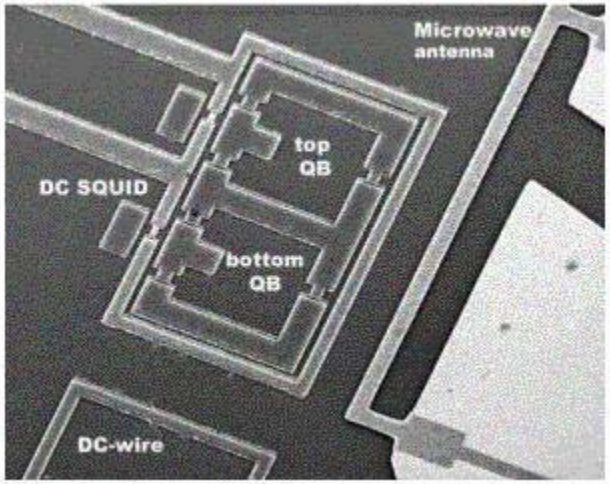
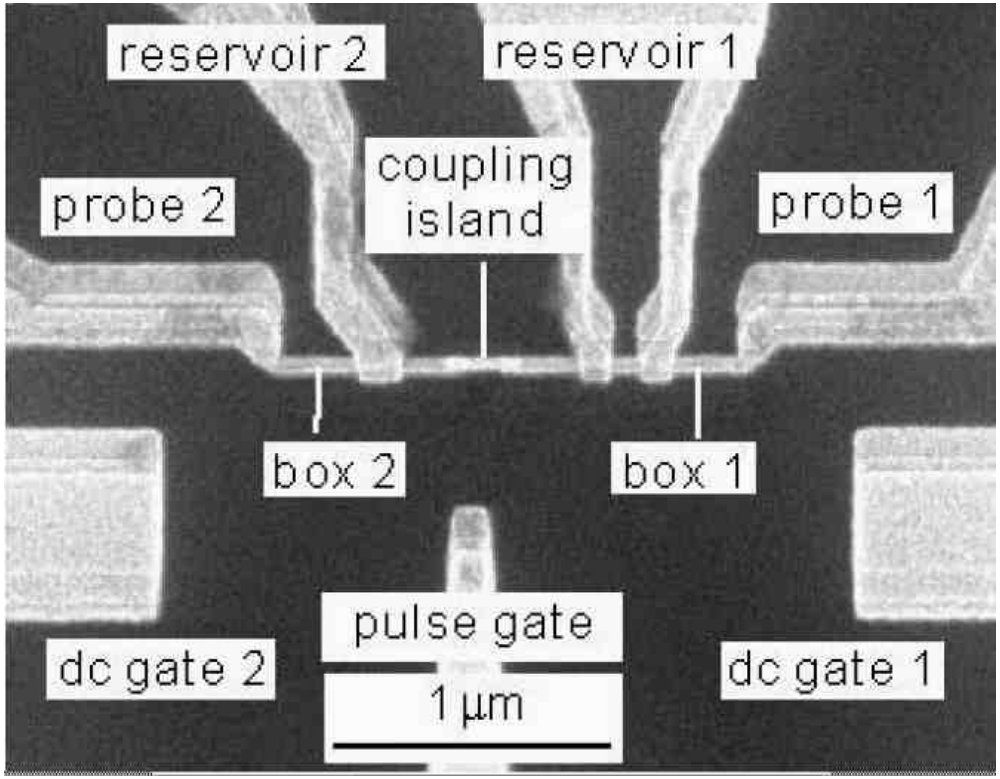


Delft: a flux qubit + Rabi oscillations



Delft: 2 coupled flux qubit

NEC (Tsukuba): entanglement in 2 coupled charge qubits



Conclusions

- Studies of nano-size samples have a long history in low temperature physics
  - Quantum electron transport in 2D, 1D and 0D (quantum dot) samples
  - Magnetism in nanoparticles

- Recent exciting developments in low temperature nanophysics:
  - Quantum computing with superconducting nanodevices
  - Quantum measurement problem and QND-experiments
  - Superconductivity in carbon nanotubes
  - Kondo effect in quantum dots and nanotubes
  - Imaging of single electron spins
  - Nanothermometry and microrefrigeration
  - Electron pumps and metrology

- Quantum computing and telecommunication would benefit from the coordinated efforts of C5 with C15 and C17.

- Quantum electron transport is common to C5 and C8