NanoCiencia y Fenómenos Cuánticos

"There is a Plenty of Room at the Bottom"

Richard Feynman 1959, Caltech

Design and engineering at the molecular scale

IFISC

CSIC Universitat de les Illes Balears

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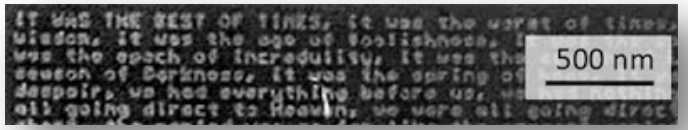
There's Plenty of Room at the Bottom

Richard P. Feynman

THE 1000$ OFFER

FEYNMAN: "In the year 2000, when they look back at this age, they will wonder why it was not until the year 1960 that anybody began seriously to move in this direction. Why cannot we write the entire 24 volumes of the Encyclopedia Britannica on the head of a pin?"

- ✓ Six months after and electrical engineer called Mr. William H. McLellan had actually invented a motor 1/64 of an inch long

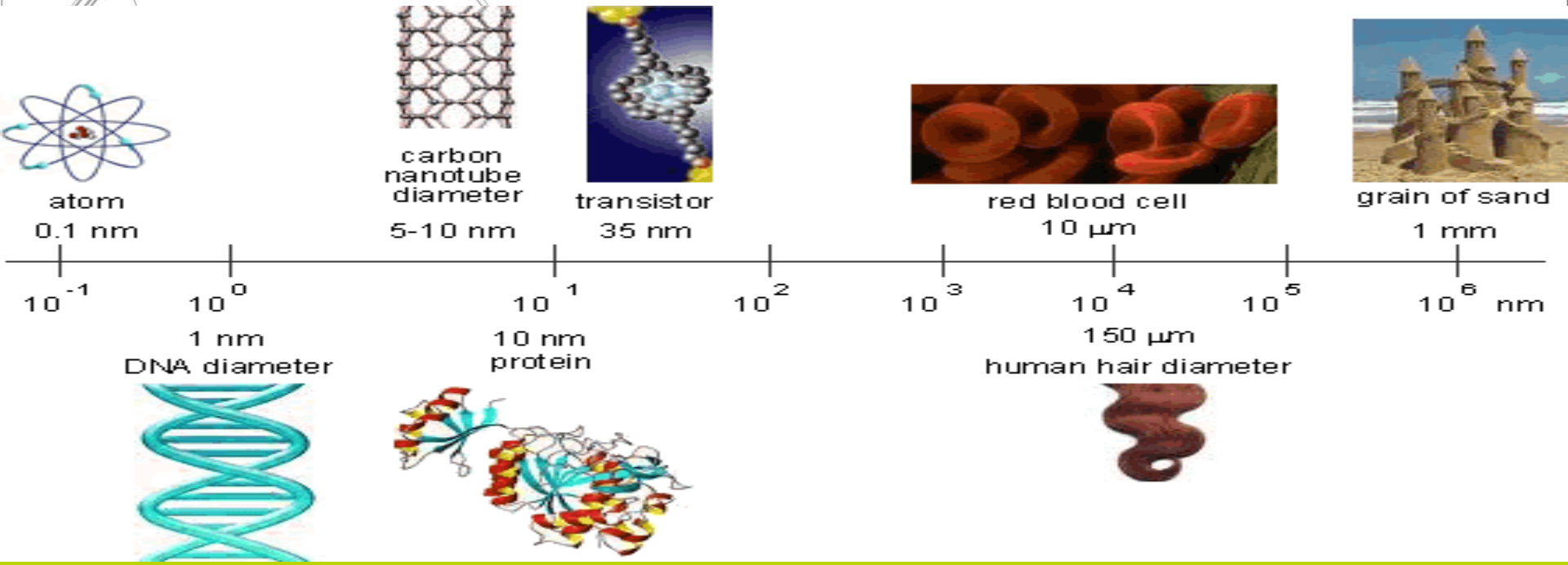


- ✓ 1985 Tom Newman claimed the prize when he wrote the first page of Charles Dickens' A Tale of Two Cities at the required scale, on the head of a pin with a beam of electrons

- How do we write small?
- Information on a small scale
- Better electron microscopes
- The marvellous biological system
- Miniaturizing the computer
- Rearranging the atoms
- Atoms in a small world

We are dealing with nanoscale systems

$1nm = 10^{-9}\ m$

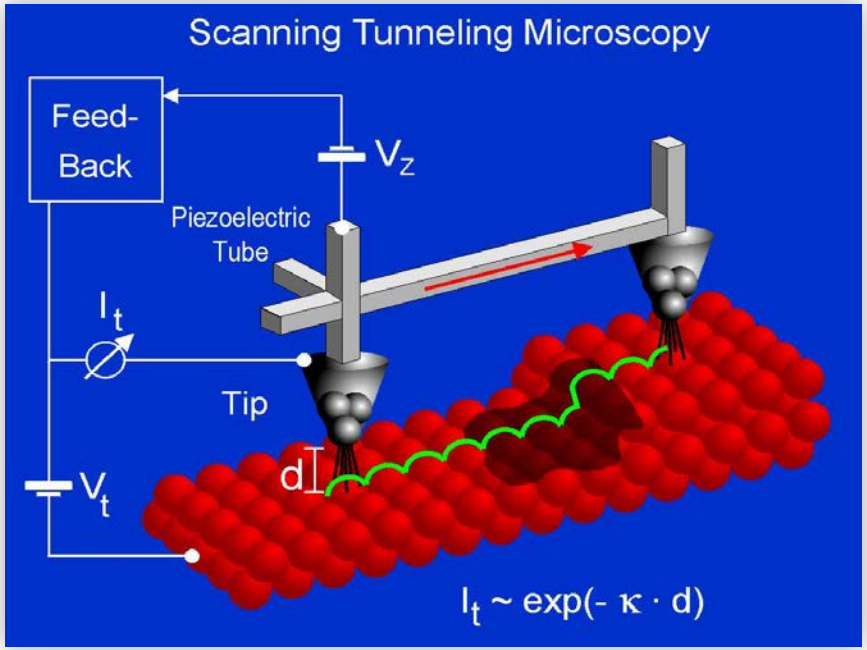


Scanning tunneling microscope,

G.Binning and H. Rohrer, Nobel 1986

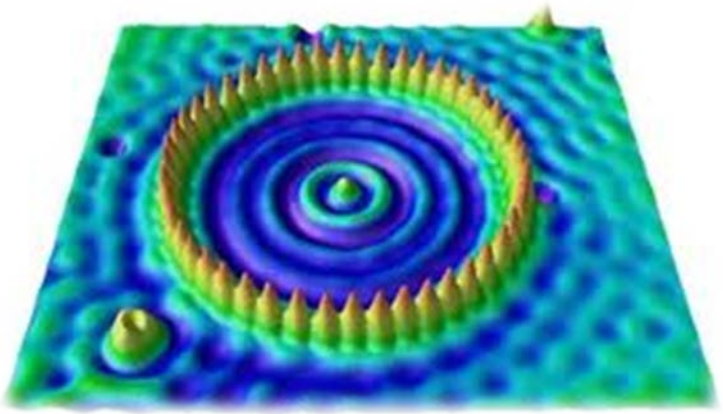
Later Atomic Force Microscope (AFM)

Imaging surfaces at the atomic level

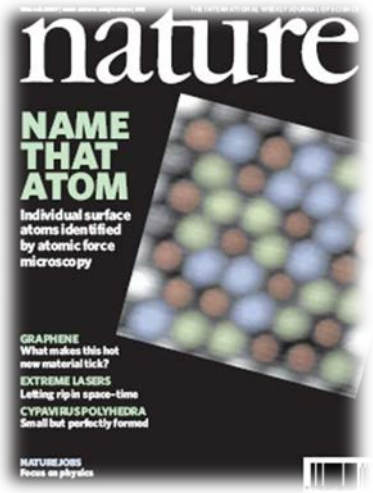


Control over the movement of atoms

Corraling electrons!



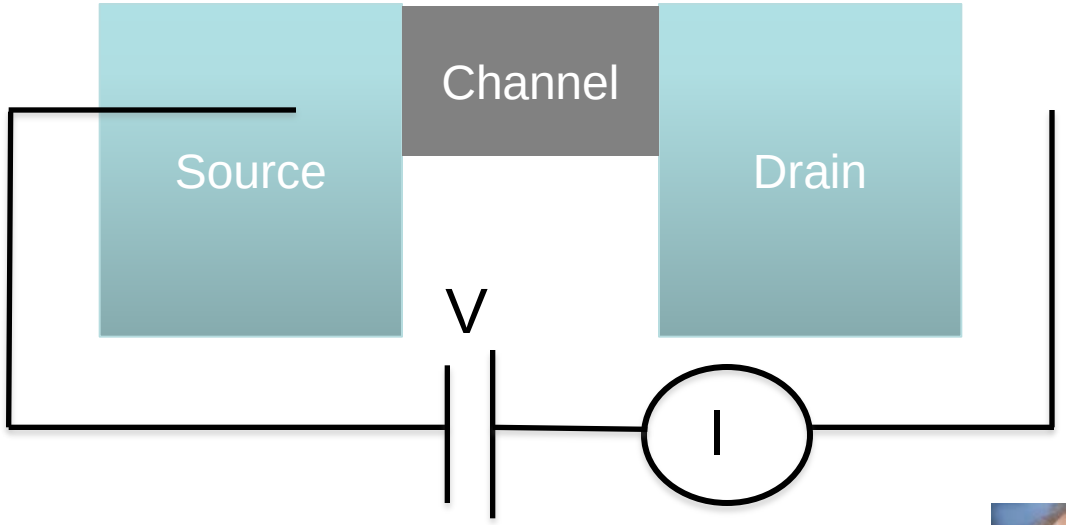
Fe atoms on Cu(111) (r=7.3 nm)

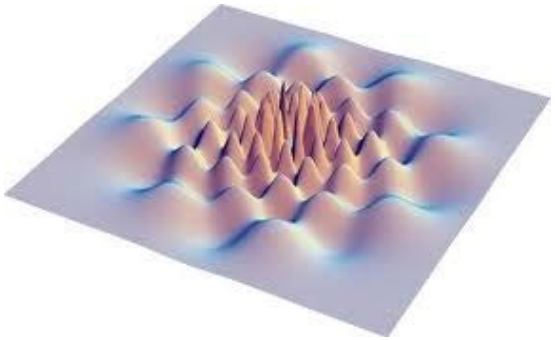


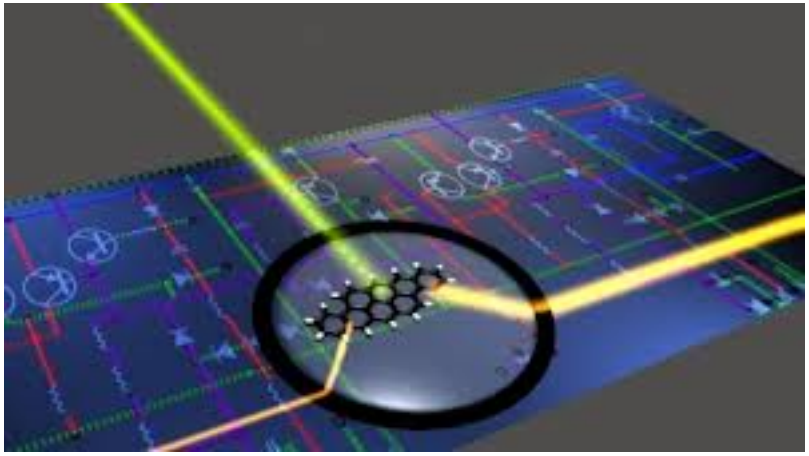
Visualizing atoms

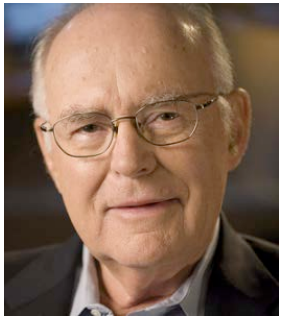
1988 STM images of DNA and biological structures

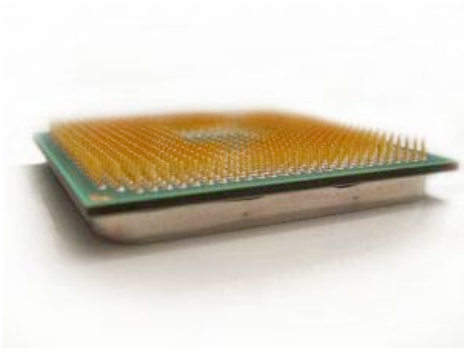
MORE ON THE POWER OF QUANTUM WORD











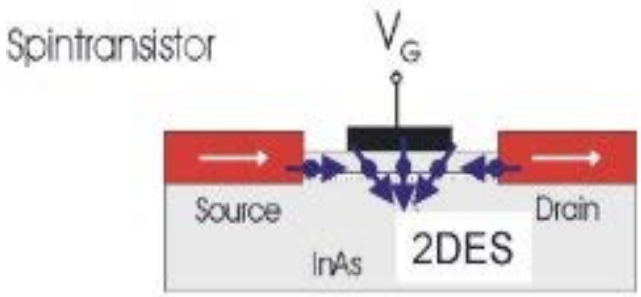
Gordon E. Moore

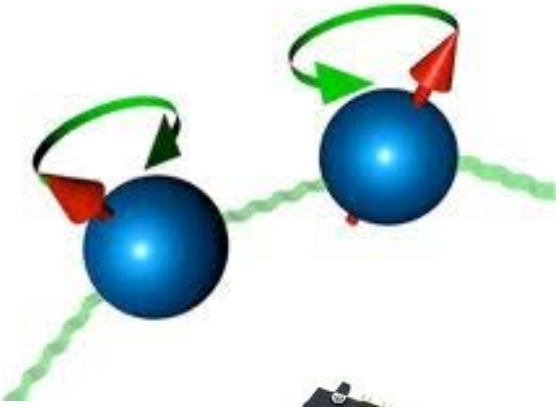
In 2011 → 2×10^9 transistors per square inch on integrated circuits

SPIN-ELECTRONICS

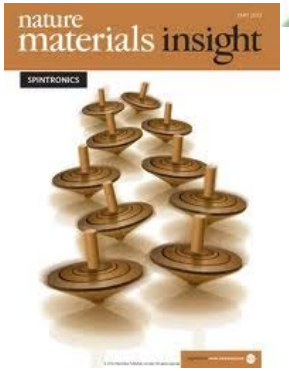
TAKING ADVANTAGDES OF QUANTUM MECHANICS

- SPINTRONICS→Particles have SPIN degree of freedom
- Datta Das transitor, Giant magneto resistance (GMR)





Quantum Spin liquids



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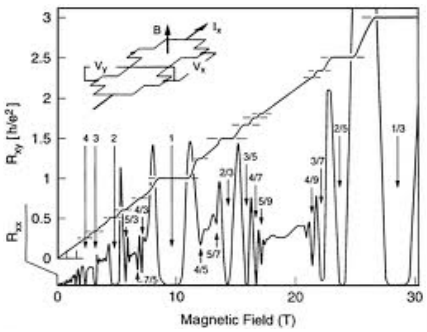
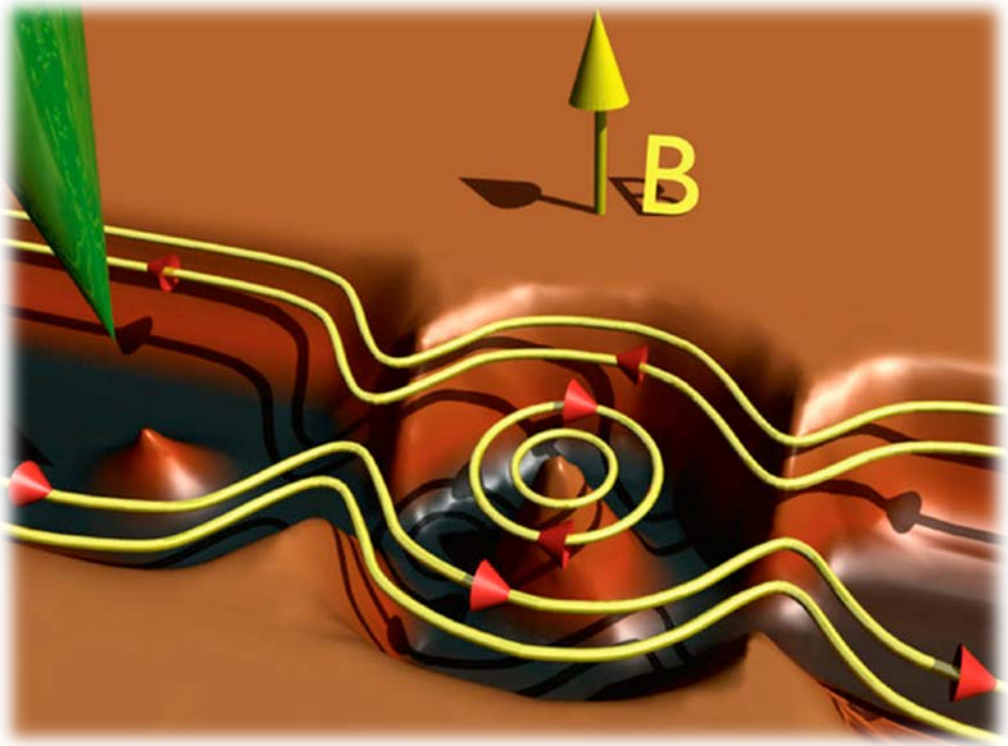
New States of Matter: Topological materials
Quantum Hall Systems, Majorana fermions





Using 2DEG and high magnetic fields. Only at the edges charge and spin is transported. In the bulk the material becomes insulator!

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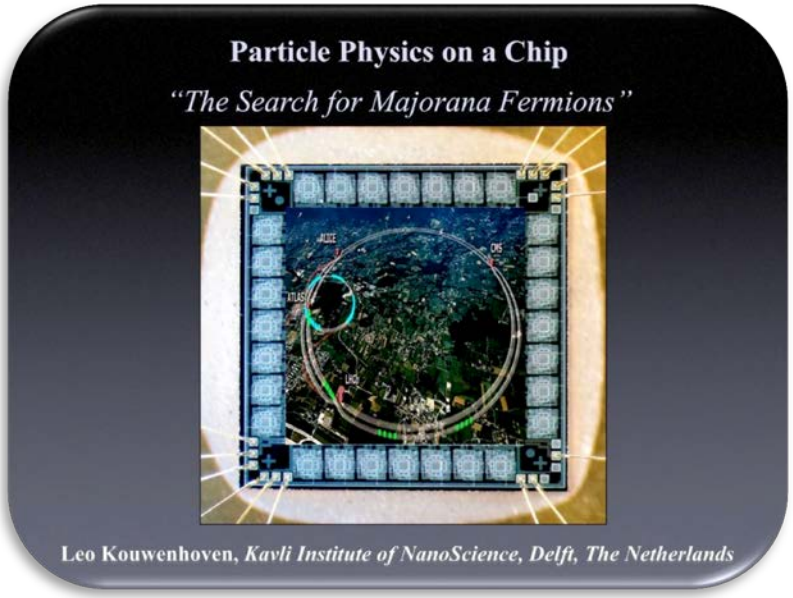
New Routes of Matter: Topological materials
The elusive particles→Majorana fermions



Spin Orbit interactions creates, in nanowires, a new state of matter: particles that are their own antiparticles→ Majorana Fermions

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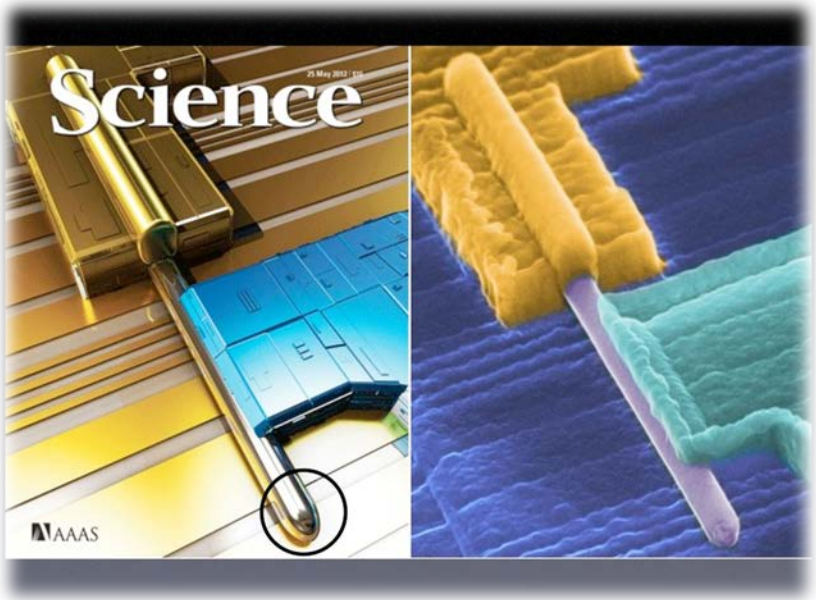
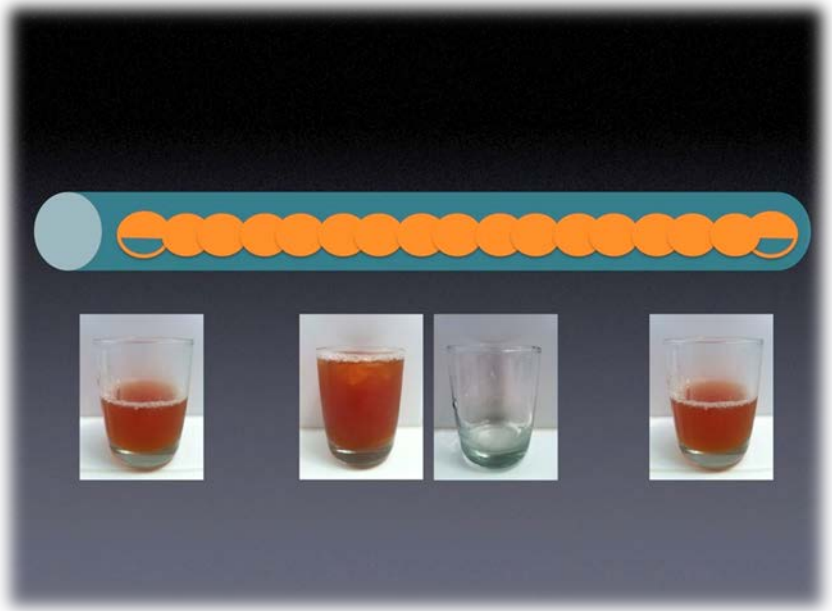
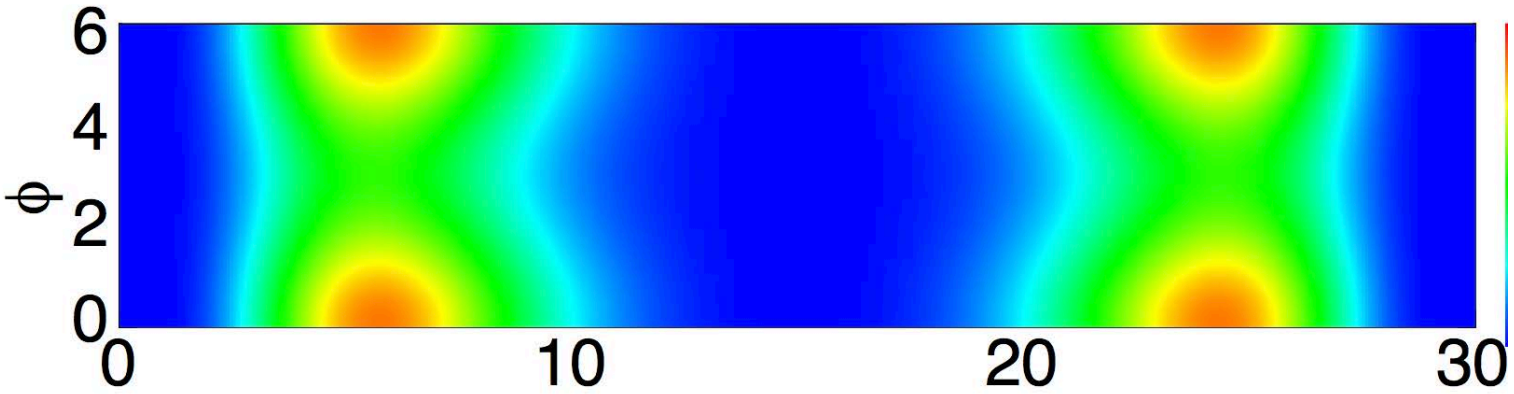
Majorana Nanowires







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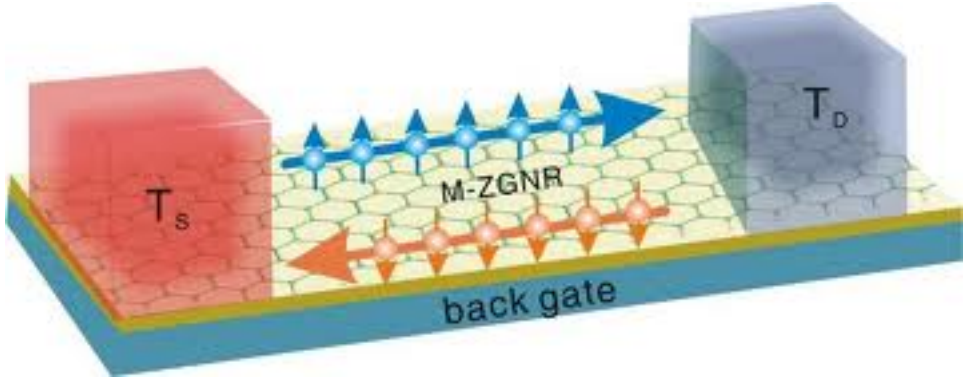
HOW EFFICIENT ARE QUANTUM SYSTEMS IN

- ✓ Energy store, Converting Waste Energy,
- ✓ Fabricating “much better” Coolers and Power Suppliers



We are developing a Nonlinear Thermo-Electrical Theory for Quantum Systems

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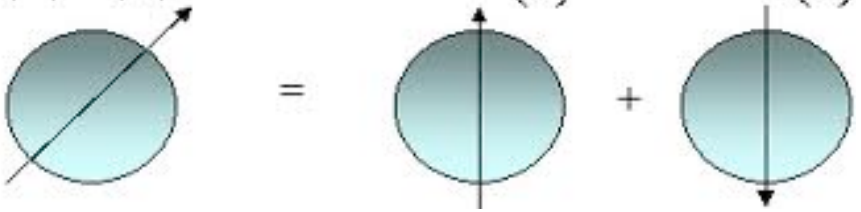
QUANTUM COMPUTERS AND QUANTUM INFORMATION

Much, much faster than their classical versions

Quantum BIT→ QUBITS Superposition of states

$$|\psi\rangle = \alpha|0\rangle + \beta|1\rangle \qquad |\alpha|^2 + |\beta|^2 = 1$$

$$\alpha|0\rangle = \begin{pmatrix} 1 \\ 0 \end{pmatrix} \qquad \beta|1\rangle = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$$



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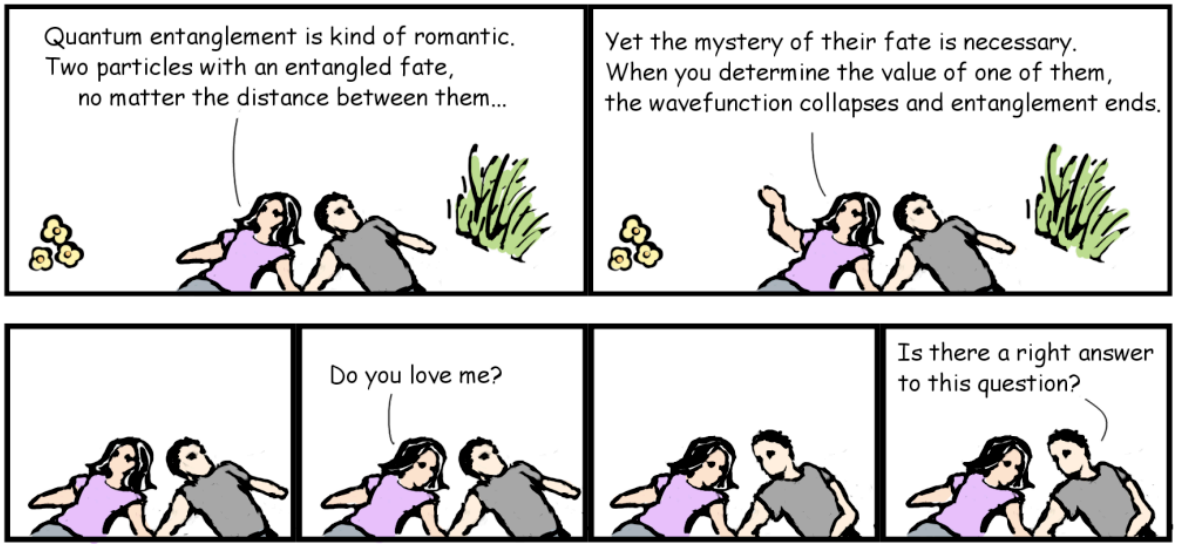
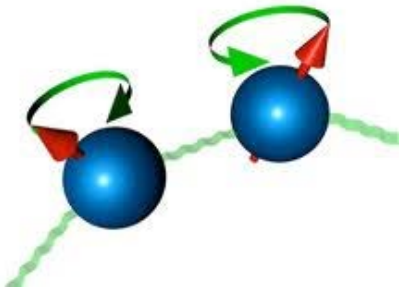
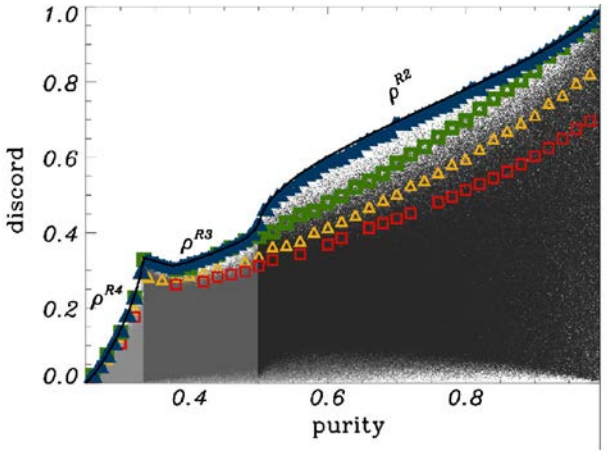
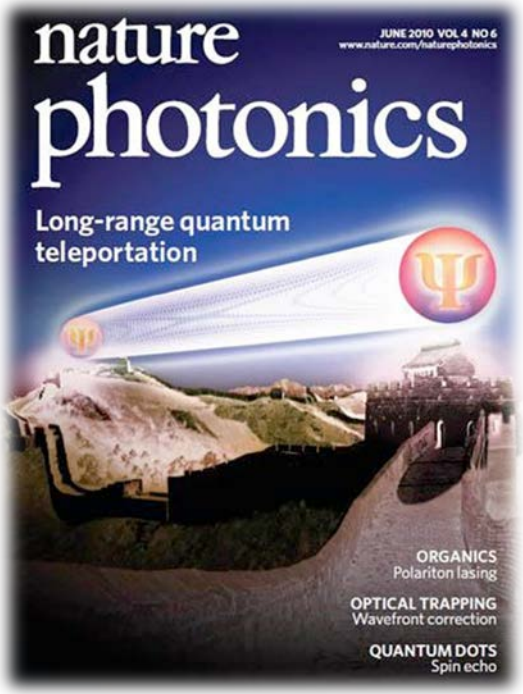
TELEPORTATION: ENTANGLEMENT



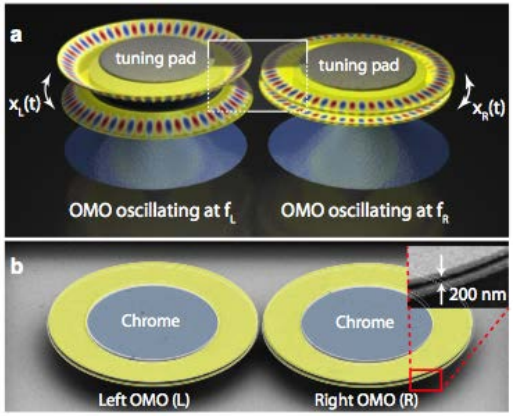




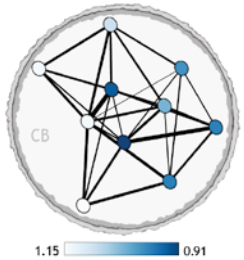


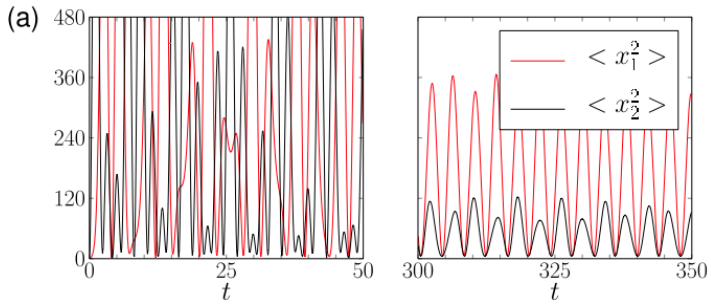
QUANTUM SYNCHRONIZATION COMPLEXITY&NANOSCIENCE

Recent Experiment:
Two quantum oscillators coupled with light



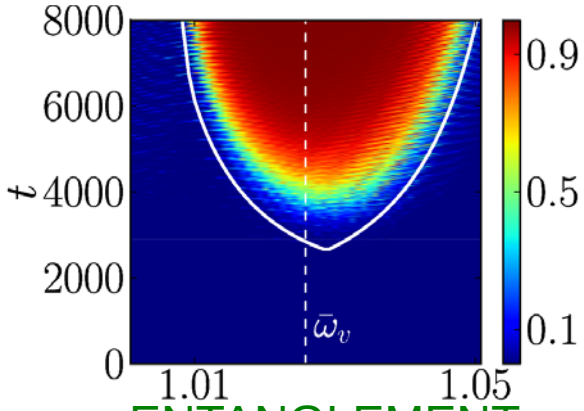
Recent theoretical progress
Quantum Network synchronization



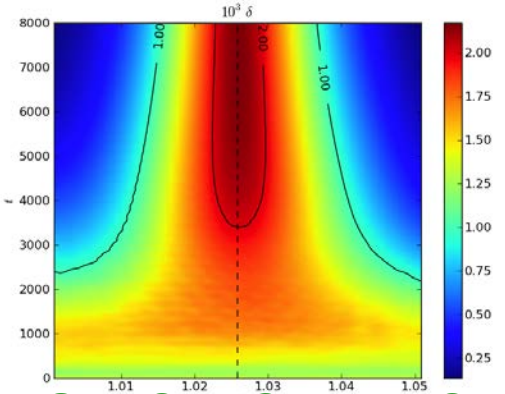


Different units with different frequency become synchronized

Fundamental questions→ Entanglement and Synchronization



ENTANGLEMENT



SYNCHRONIZATION

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Who are we?