

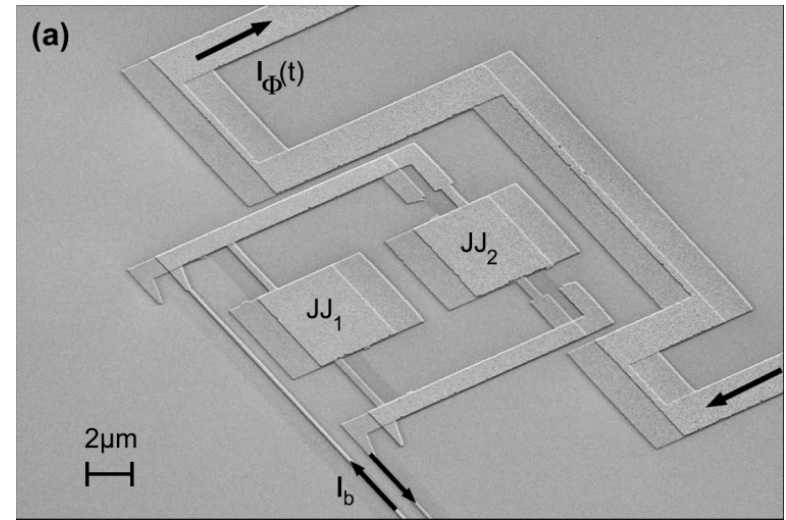


F. Lecocq

J3N 2012

Superconducting quantum electronic:

Using a dcSQUID as a 2D artificial atom



Florent LECOCQ

Directed by

Olivier Buisson

2004-2007
ENSPG (now PHELMA)

2007-2011
PhD Université de Grenoble

2011-present
Research Assistant @ NIST Boulder

(see LinkedIn / Viadeo)



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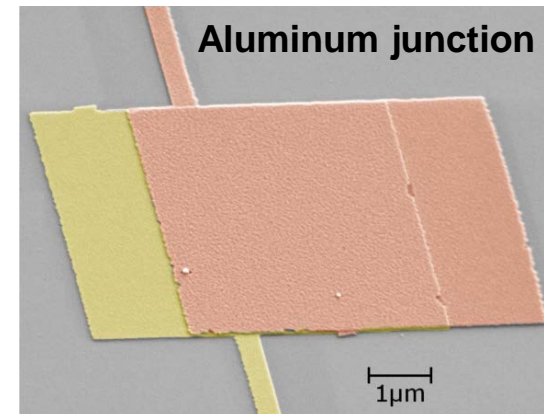
1. Introduction & Motivation

2. A dcSQUID as a 2D artificial atom

3. Bridge-Free Nanofab technique

What you need :

- Ultra-low noise: low temperature
- Ultra-low dissipation: superconductivity
- Non-linear, non-dissipative element: **Josephson junction**



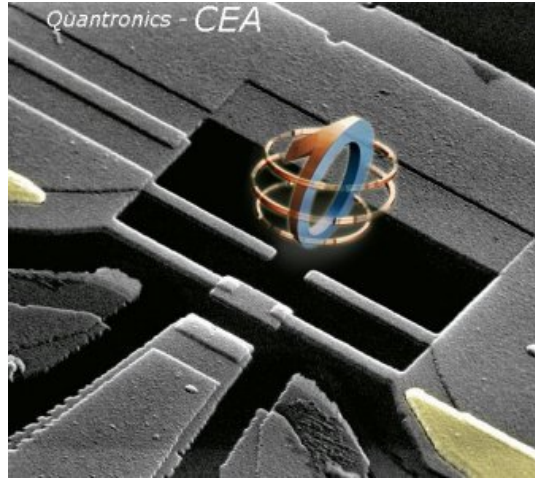
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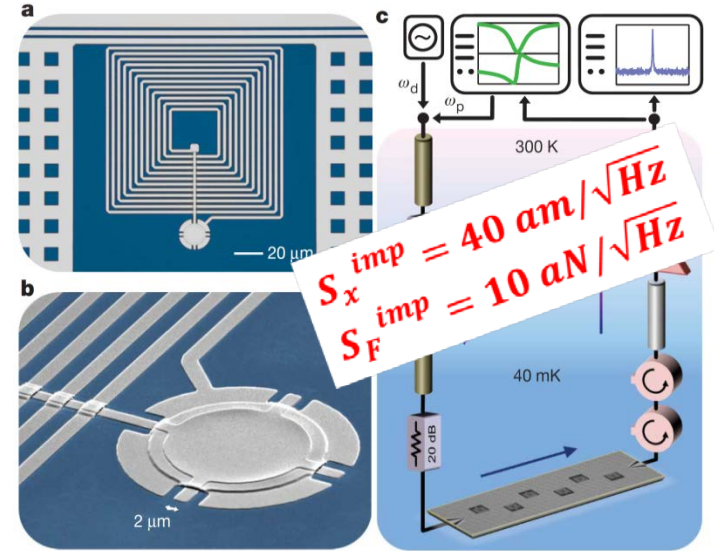
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Vion, et al, *Science* (2002)



Teufel et al, *Nature* (2011)

What you get :

- Non Classical states
- High Resolution and High Frequency
- Quantum limited sensitivity

SQUID

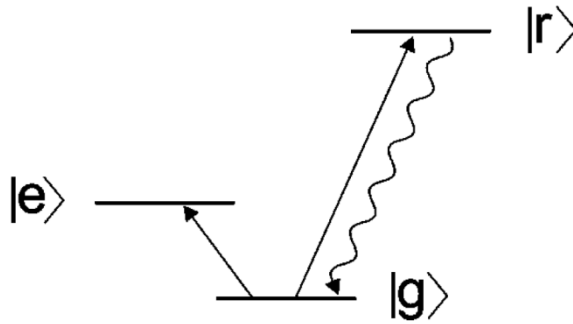
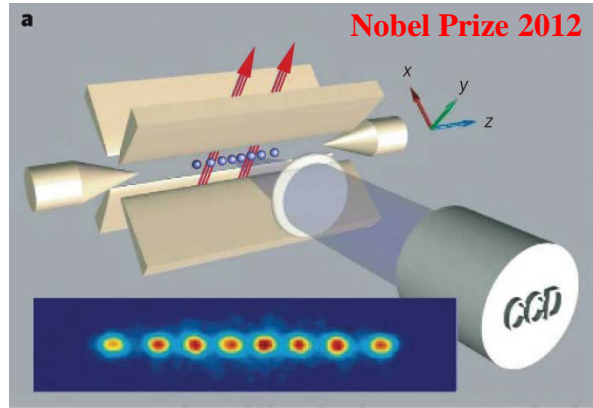
Voltage Quantum Standard

Hybrid : GaAs Qdot or atoms coupled to superconducting electronic

RSFQ

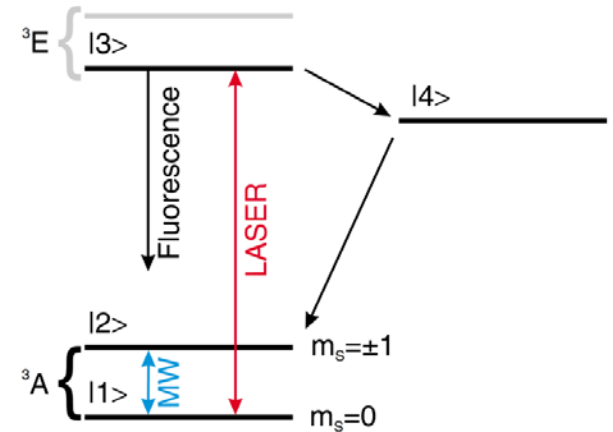
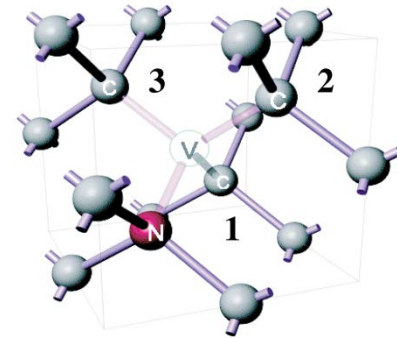
Finally you access to all sort of quantities via TRANSDUCTION

Trapped ion



Leibfried, *Rev.Mod.Phys* (2003)
Blatt and Wineland, *Nature* (2008)

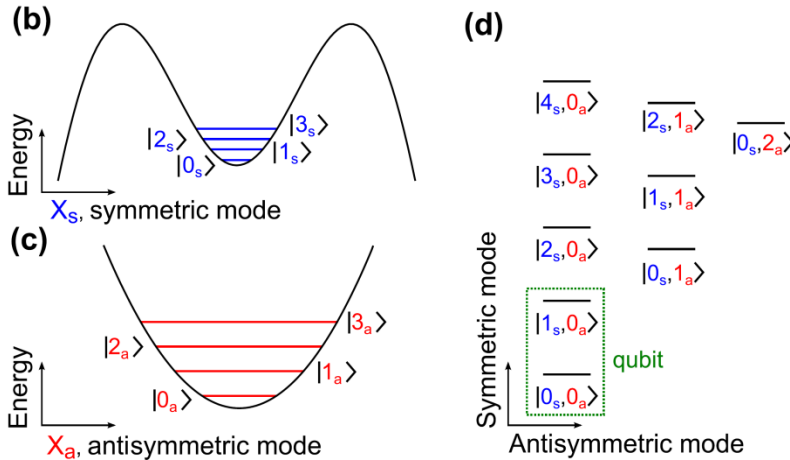
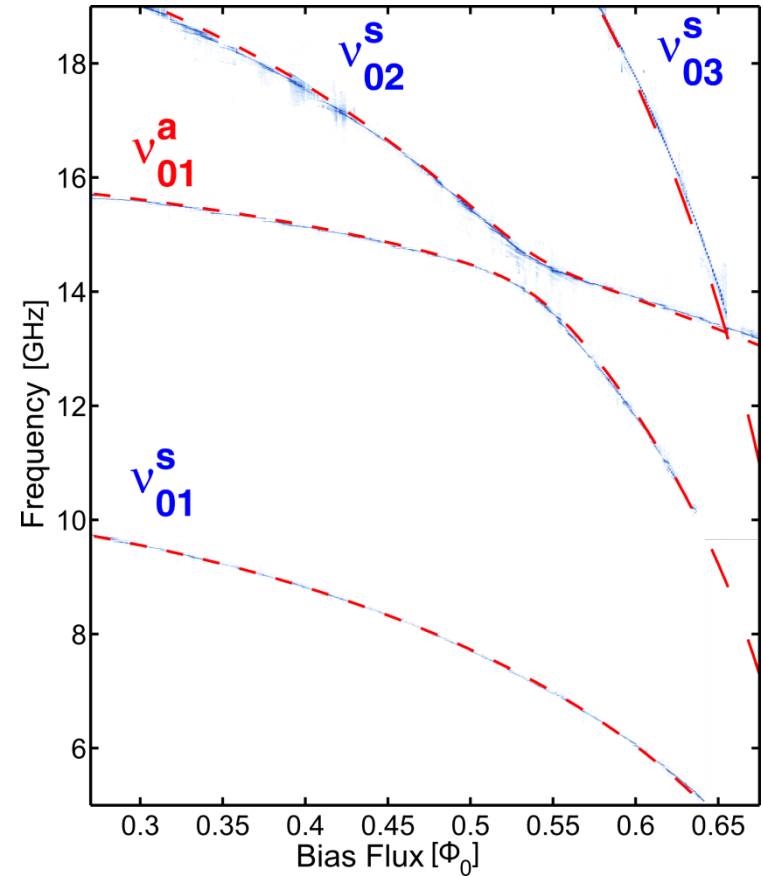
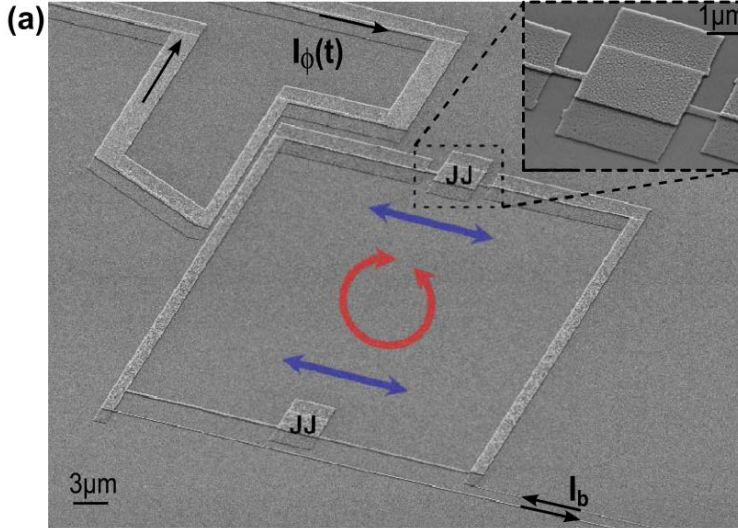
NV centers in diamond



Jelezko et al, *Phys. Rev. Lett.* (2004)

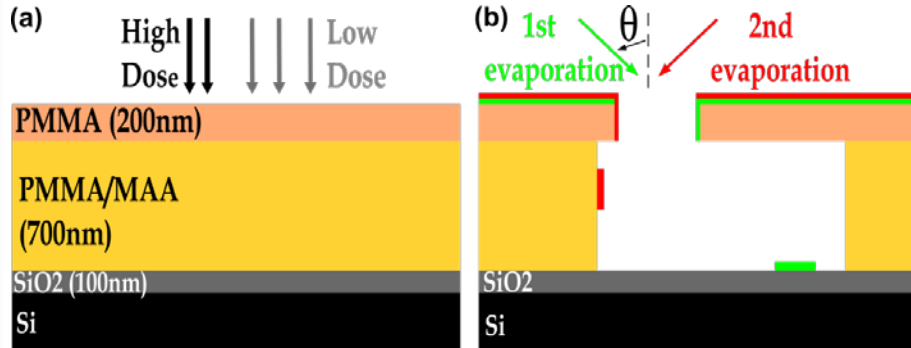
High fidelity readout, mode coupling physics at the quantum level, etc...

**Superconducting artificial atom
with multiple degrees of freedom ?**

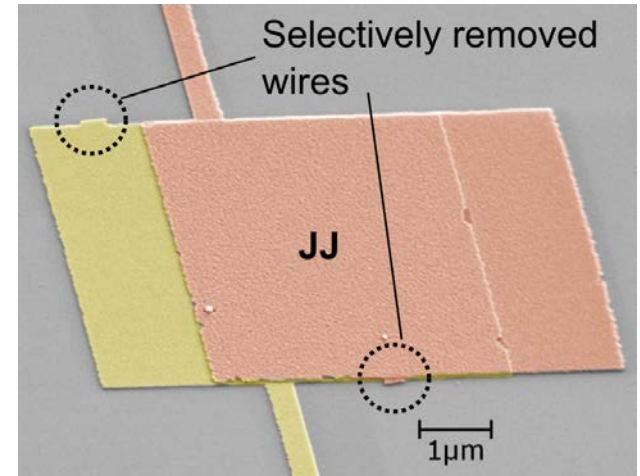
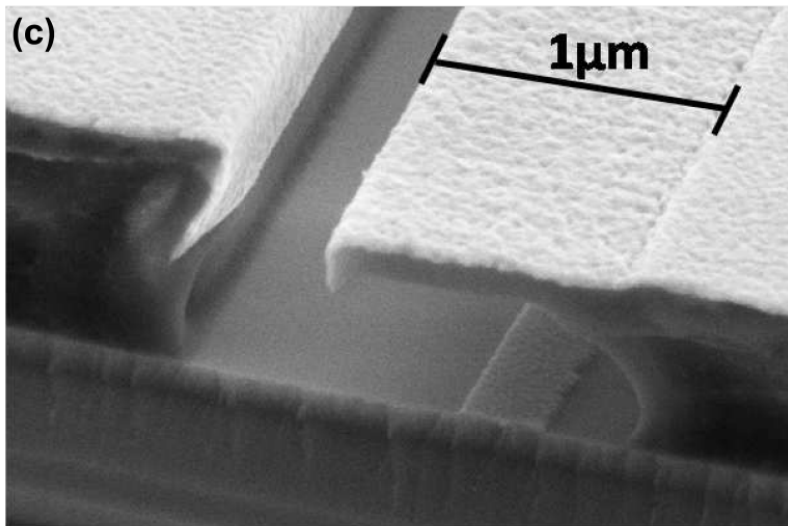


- Entanglement between the 2 degrees of freedom
- Coherent frequency conversion
- Open the way to High Fidelity Readout (E. Dumur, A. Feofanov and O. Buisson)

E. Hoskinson and F. Lecocq, et al, *Phys. Rev. Lett.* (2009)
 F. Lecocq, et al, *Phys. Rev. Lett.* (2011)
 F. Lecocq, et al, *Phys. Rev. Lett.* (2012)



**E-beam lithography @ 100kV
on bilayer resist PMMA/MMA
+
Aluminum angle evaporation**



No suspended bridge

- Less mechanical issues
- Junction size from $10^{-2} \mu\text{m}^2$ to $10^4 \mu\text{m}^2$
- Easy cleaning of resist residues (RIE, IBE)

F. Lecocq, et al, *Nanotechnology* (2011)

Pop et al, *JVST B* (2012)



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Experimental team

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Cecile Naud

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