QUANTERA

ERA-NET Cofund in Quantum Technologies

QuantERA Mid-term Strategic Conference

Granada, 13-14 November 2019

QuaSeRT: Optomechanical QUAntum SEnsors at Room Temperature

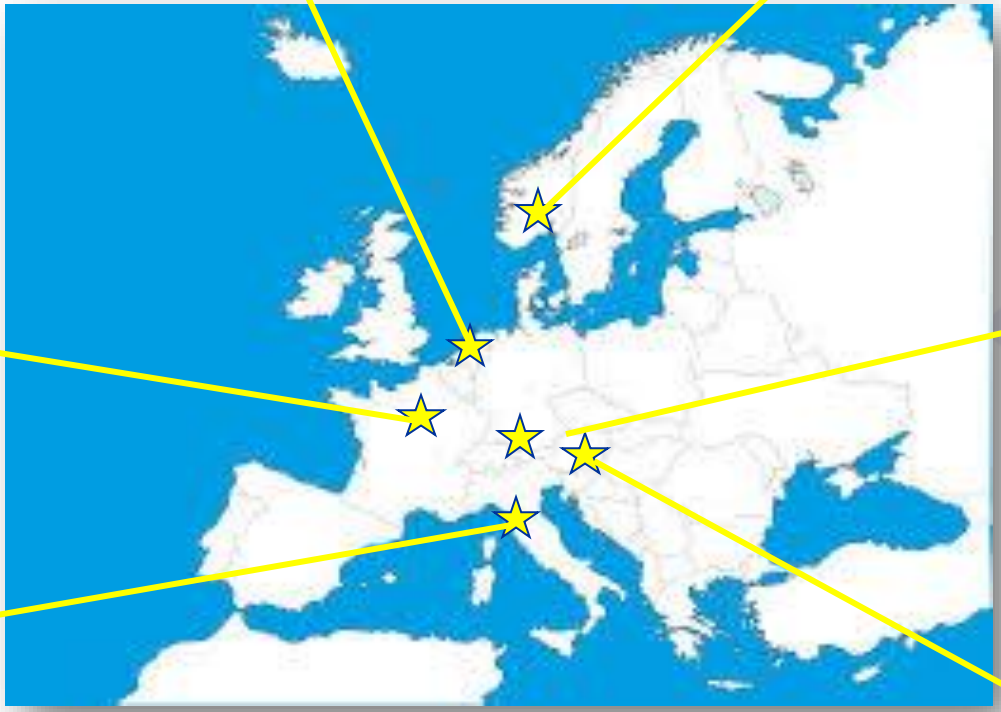
Francesco Marin

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731473.

The QuaSeRT consortium

TU Delft

University of South-Eastern Norway



Universität Konstanz

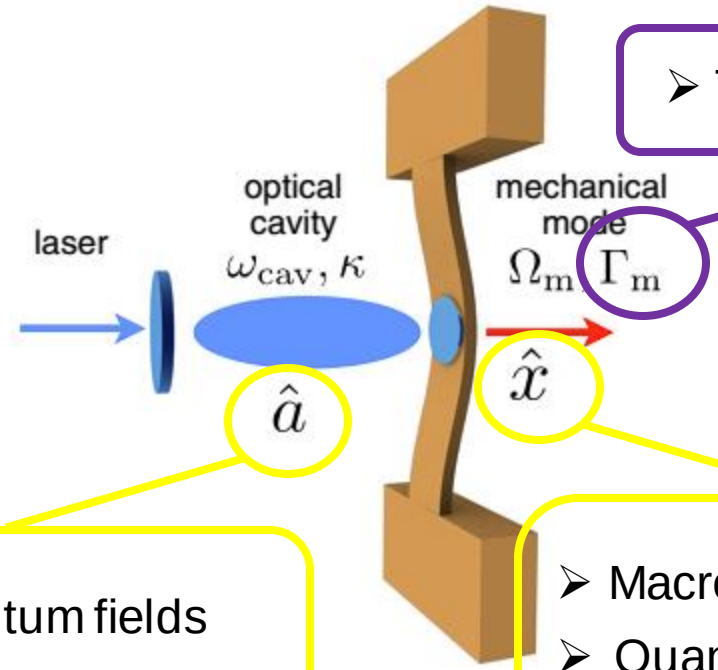
cnrs

PARIS DIDEROT

INO-CNR Istituto Nazionale di Ottica

universität wien

Optomechanics for quantum technologies



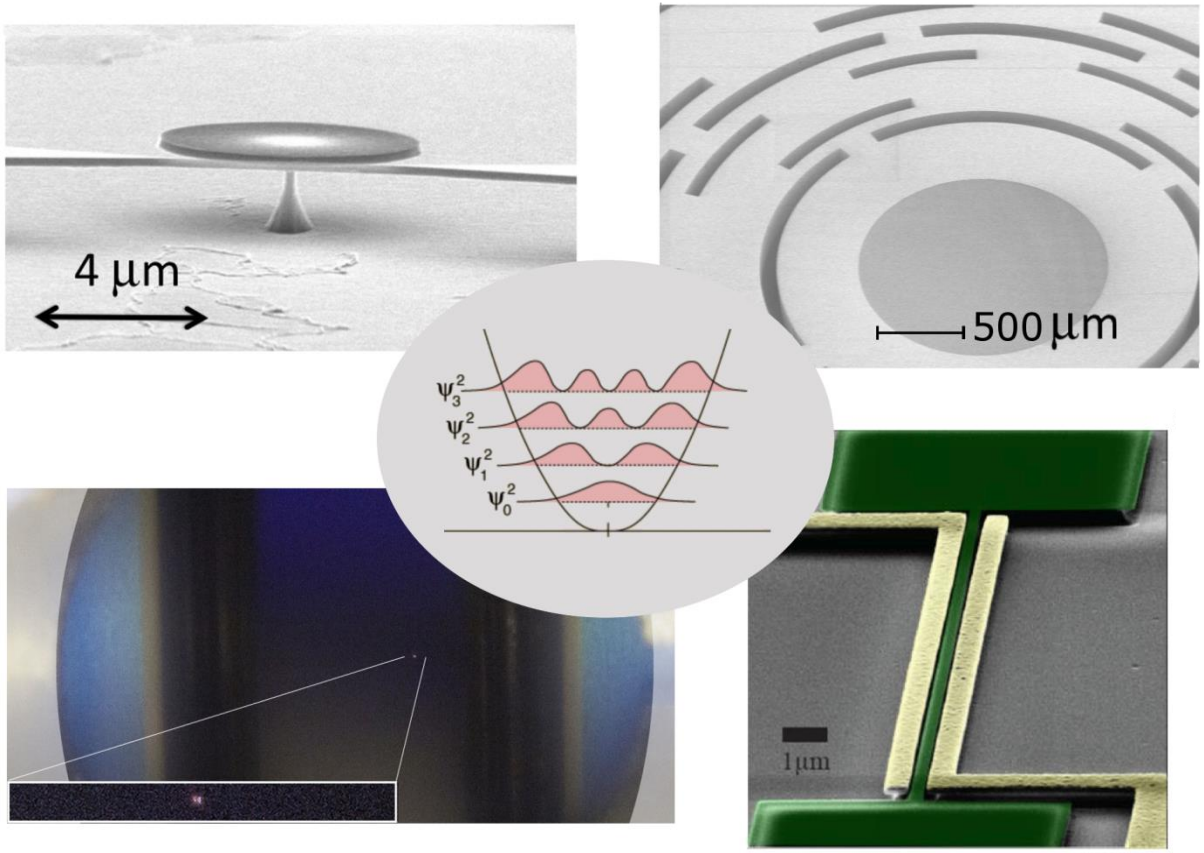
- Thermal noise, decoherence

- **High optomechanical gain**
- **Low optical and mechanical losses**

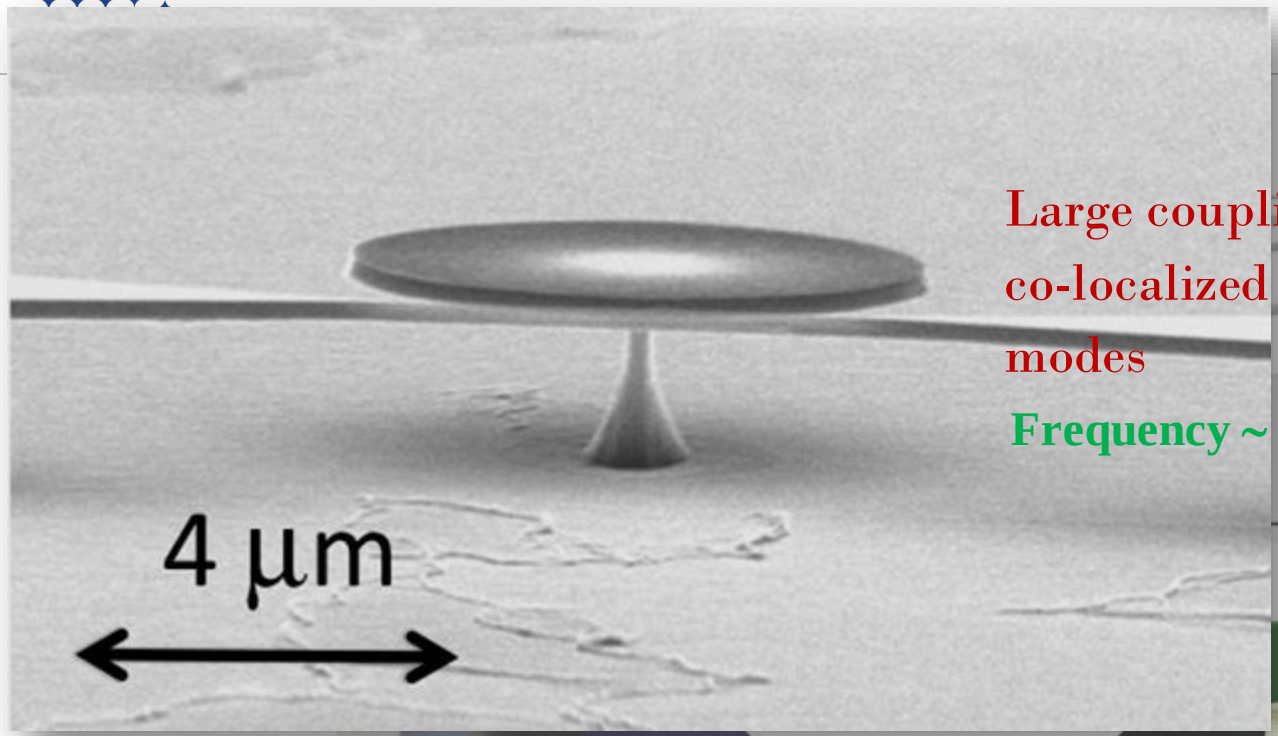
- Manipulating quantum fields
- Quantum strategies for detection

- Macroscopic quantum object
- Quantum correlations / entanglement between em field and mechanical oscillator

Four experimental platforms

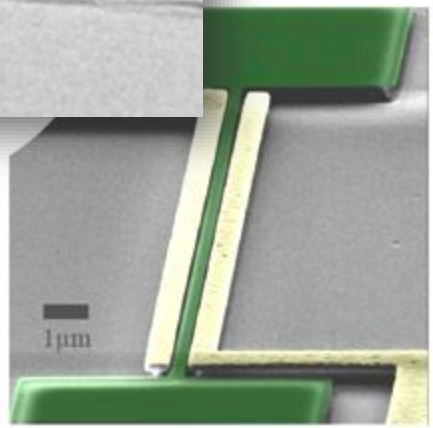


Semiconductor microdisks



Large coupling due to small volume co-localized optical and mechanical modes

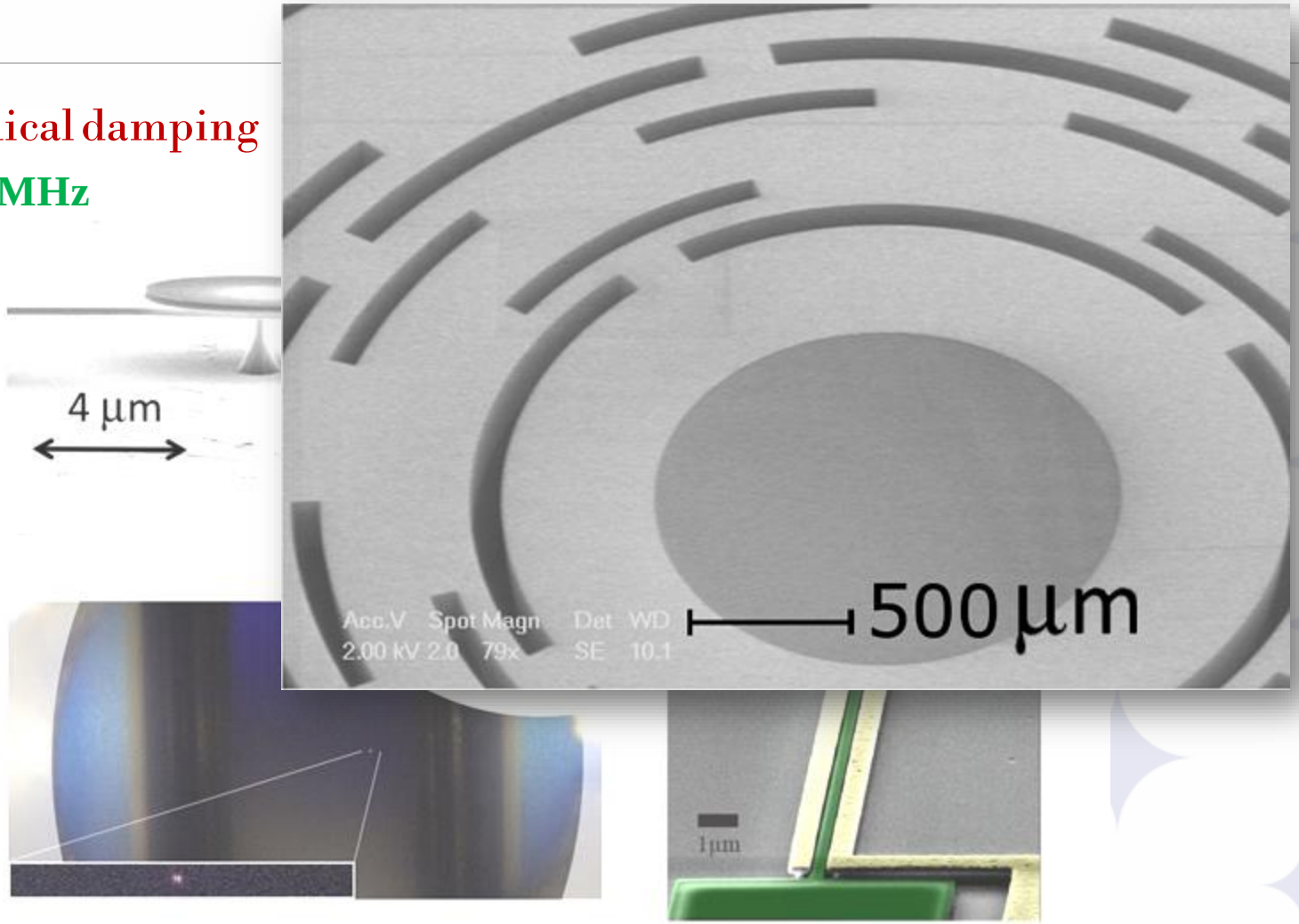
Frequency ~ 1 GHz



SiN membranes

Weak mechanical damping

Frequency ~ 1 MHz

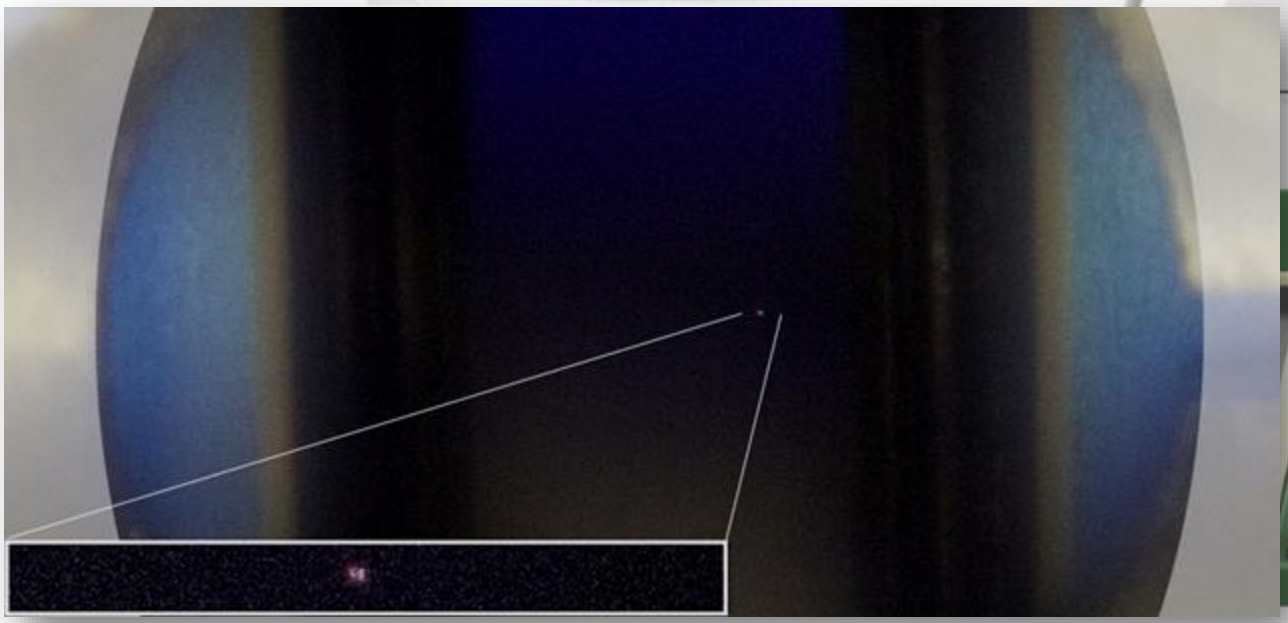


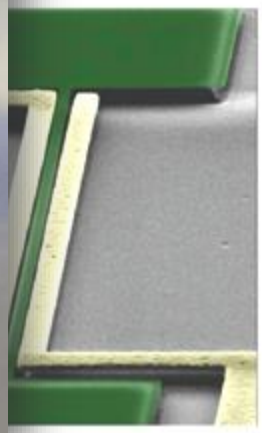
Levitating nanosphere

Extremely weak gas damping

Mass ~ 10^{-18} kg

Frequency ~ 100 kHz



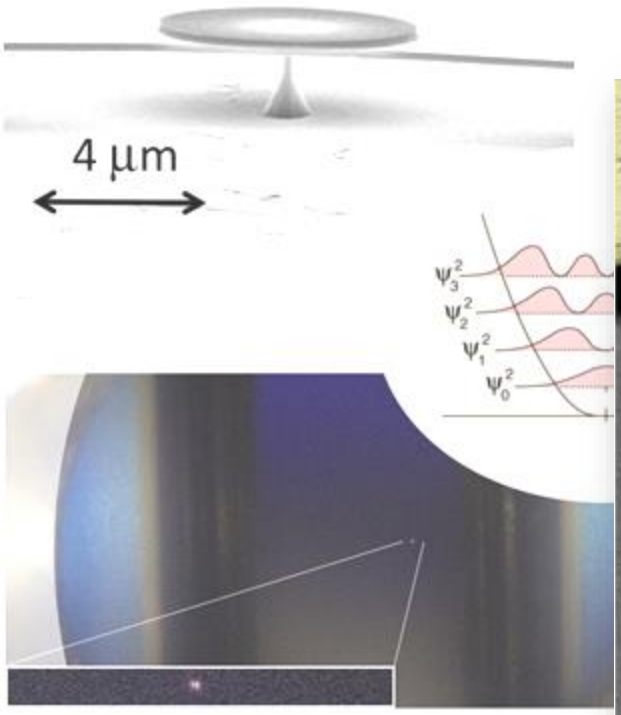


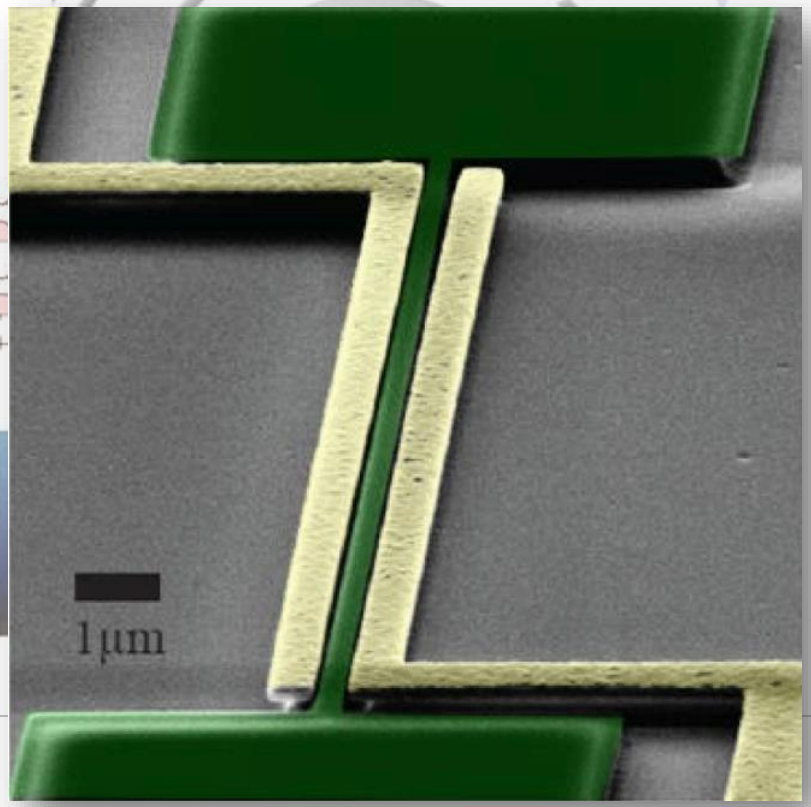
Kiesel, Blaser, Delic, Grass, Kaltenbaek, Aspelmeyer, PNAS 110, 14180 (2013)

Electro-mechanical systems

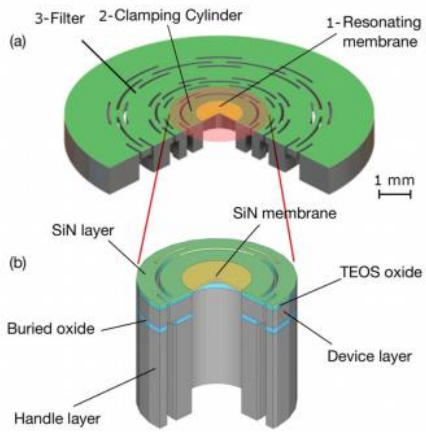
Electro-mechanical system with high-stress SiN nanobeam

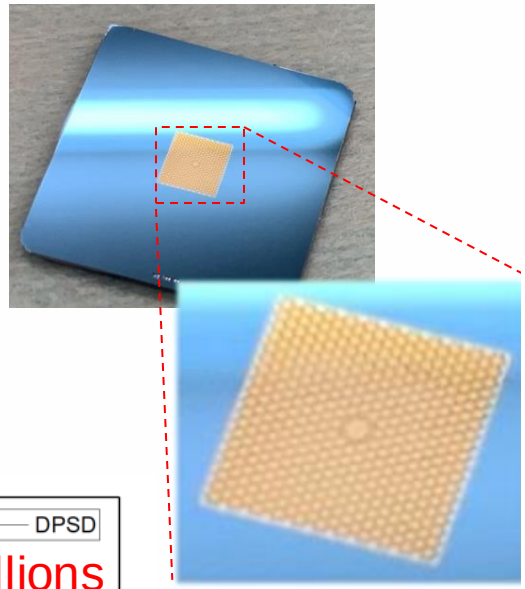
Useful for simulation of quantum protocols

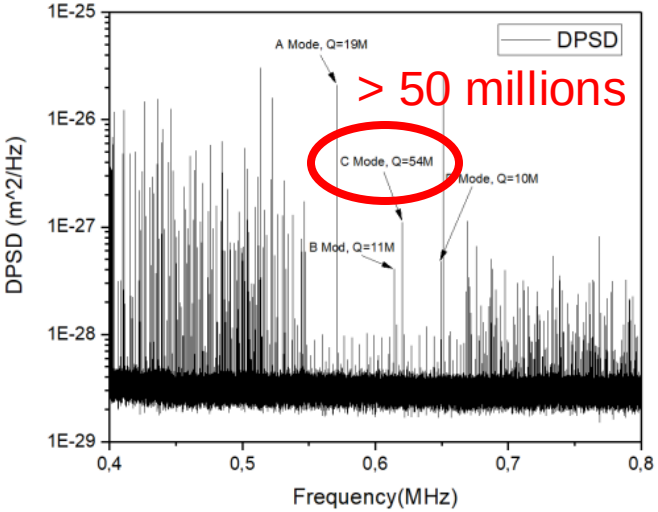


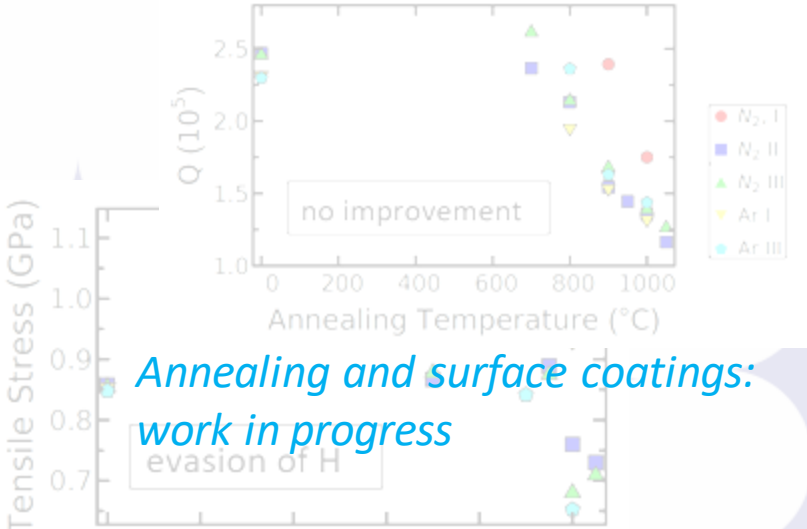


Improving mechanical quality factor at room T

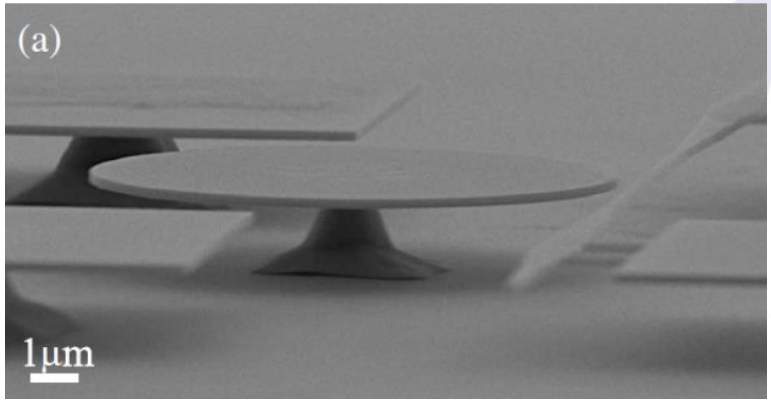




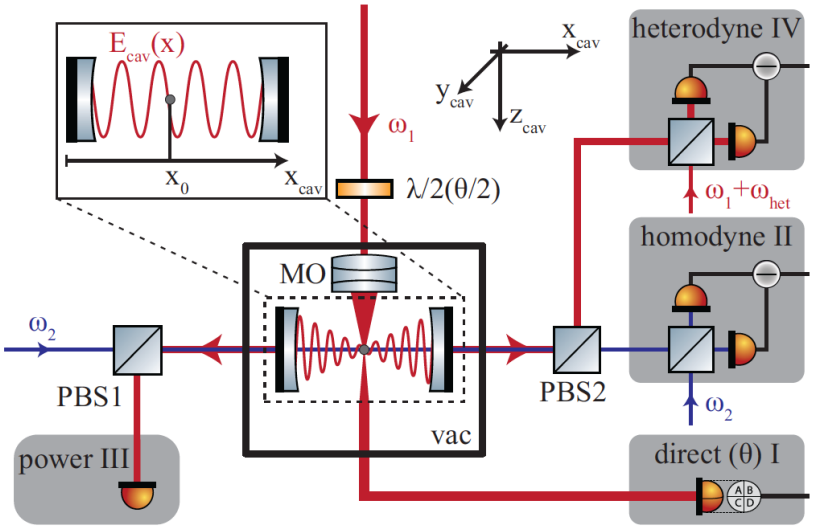


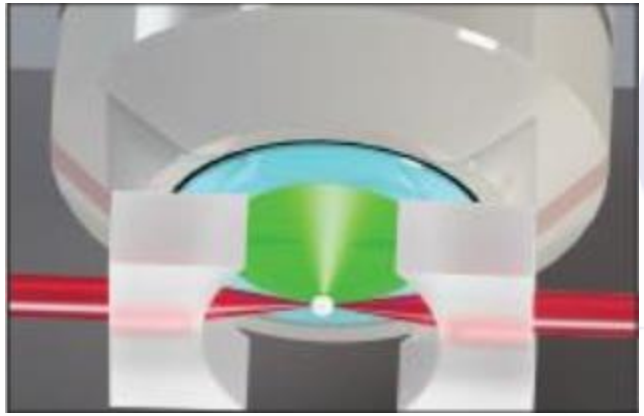


Annealing and surface coatings: work in progress



Cooling of a levitated nanosphere by coherent scattering

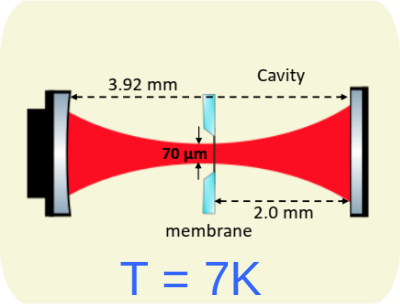


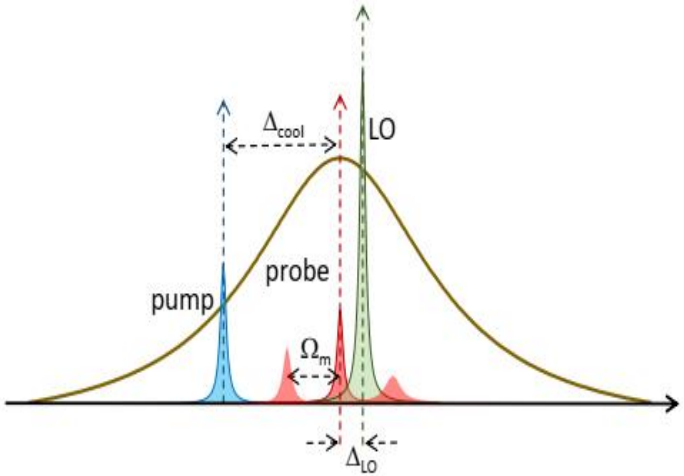


U. Delic et al., arXiv:1902.06605 (2019)

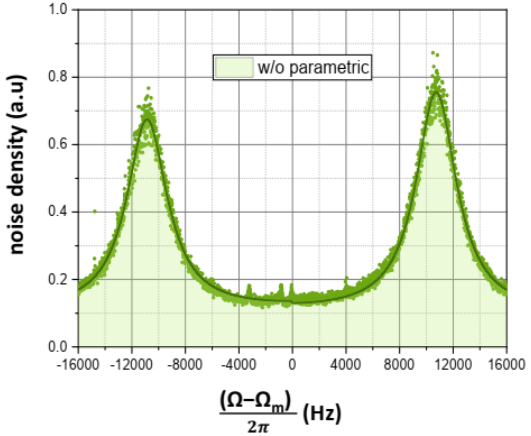
Preliminary results: mean phonon number < 3

Non-classical states of the mechanical oscillators



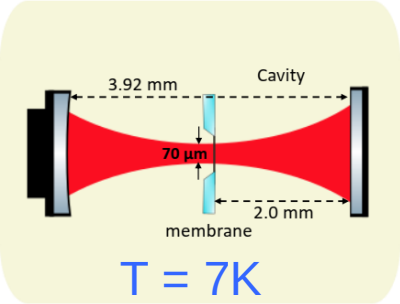


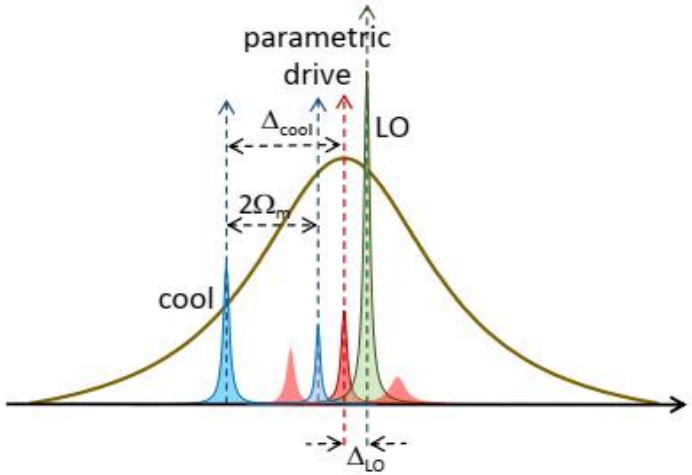
Asymmetry in the motional sideband



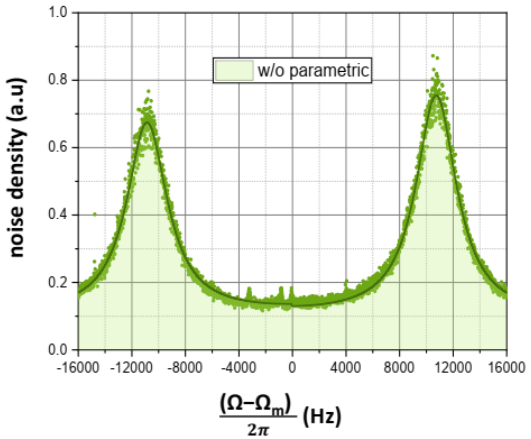
A. Chowdhury et al., arXiv:1907.05148 (2019)

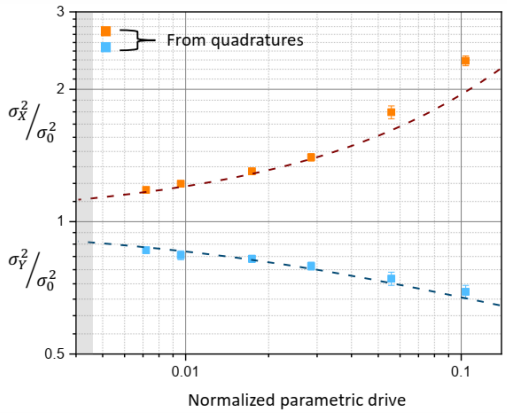
Non-classical states of the mechanical oscillators



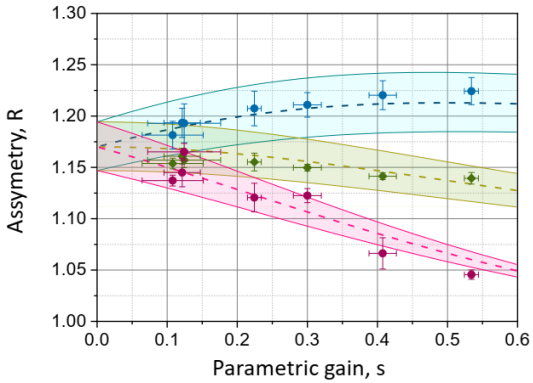


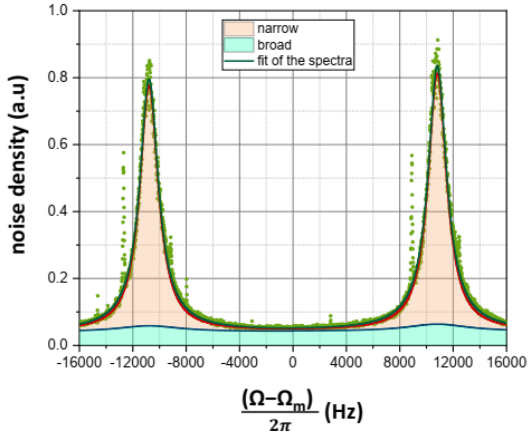
Asymmetry in the motional sideband





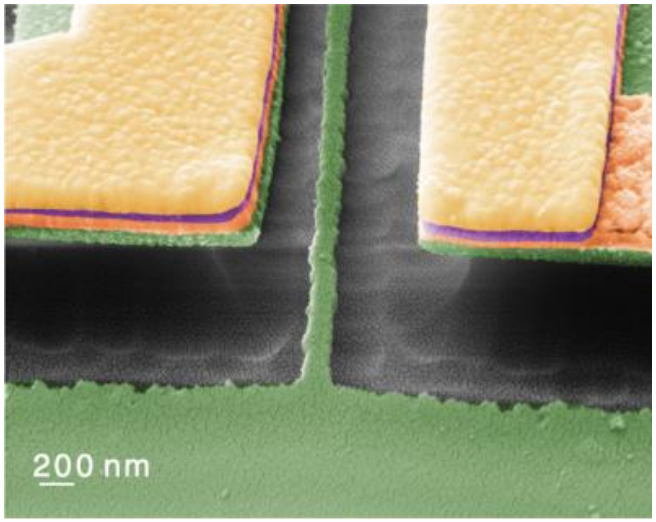
Quantum signature of squeezing

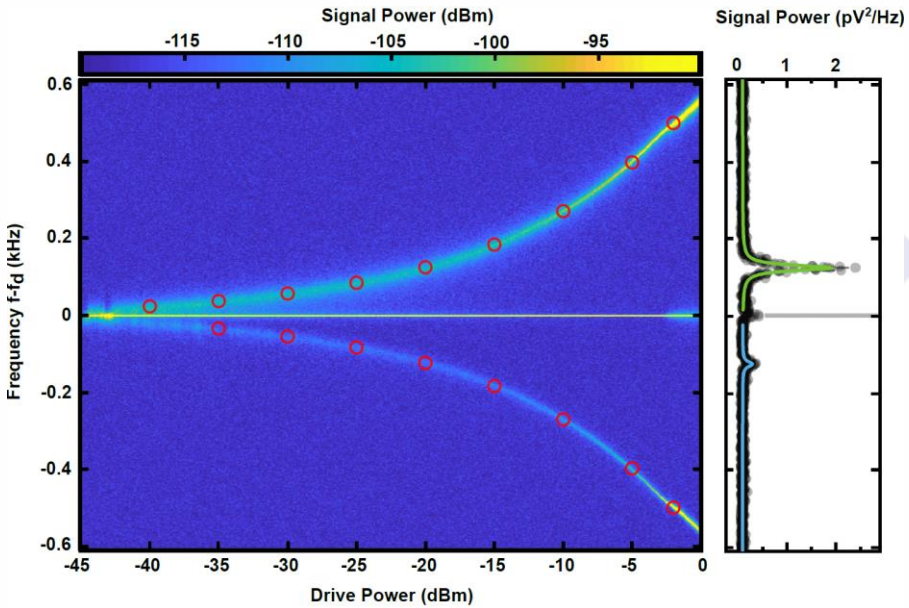




A. Chowdhury et al., arXiv:1907.05148 (2019)

Thermal squeezing in a Duffing oscillator



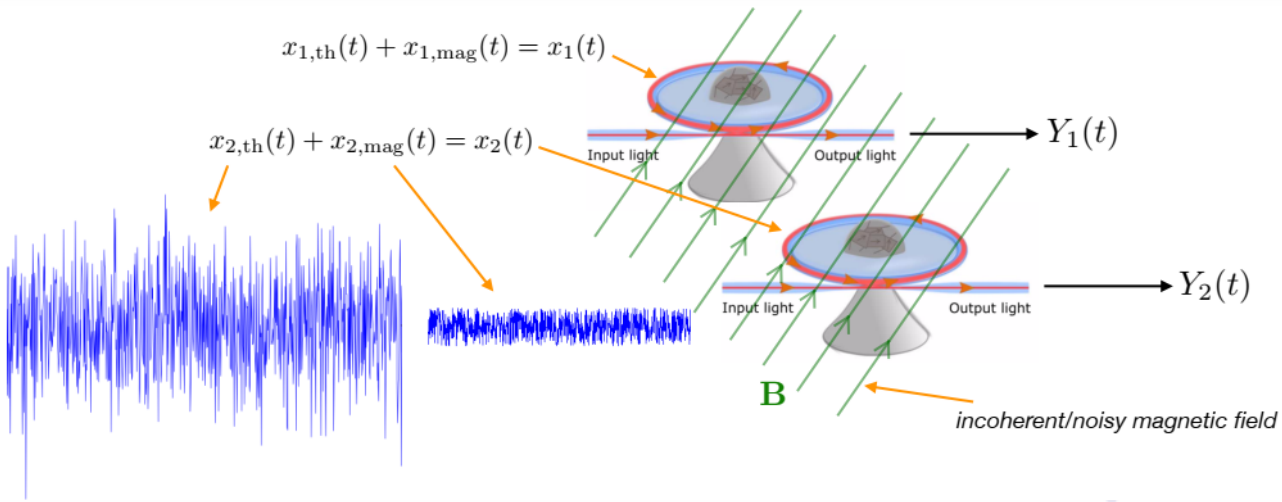


- Clearly resolved satellite peaks: thermally induced small-amplitude vibrations about the stable state of forced vibrations
- Ratio of satellite areas directly reflects squeezing parameter φ:

$$\frac{I_+}{I_-} = \tanh^{-2}(\varphi)$$

J. S. Huber et al., arXiv:1903.07601 (2019)

New protocols for quantum sensing

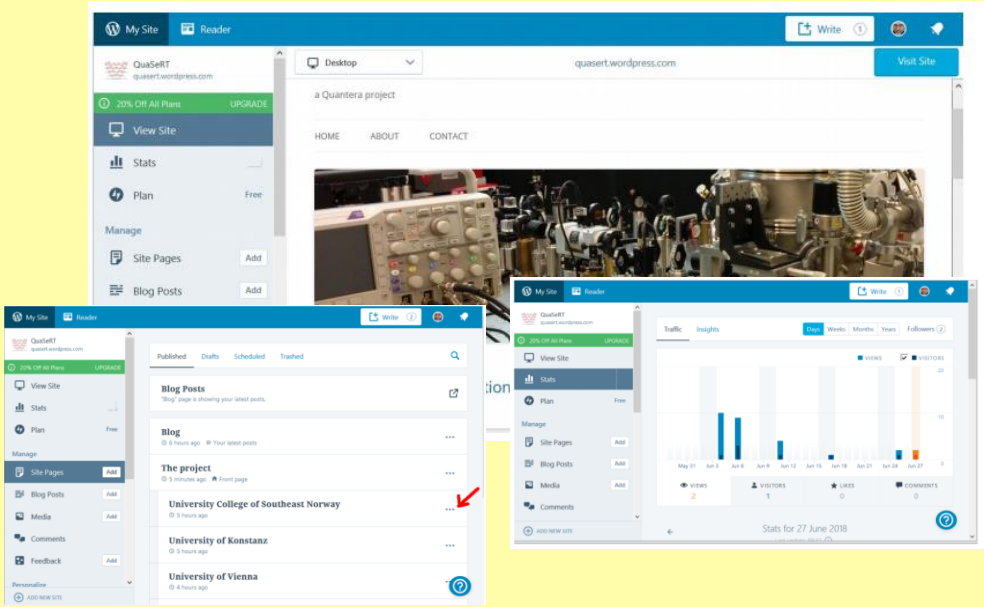


- Exploiting cross-correlation to reveal quantum signals beyond thermal limit
- Exploiting in-loop sub-shot-noise fluctuations in feedback schemes in order to improve sensing
- Bifurcation amplifiers with optically damped mechanical oscillators
- . . .

K. Borkje, Phys. Rev. A 99, 023858 (2019)

Networking

Project web site



https://quasert.wordpress.com/

Meetings

Kickoff : Konstanz, June 2018

Mid-Term : Florence, June 2019

Next : Vienna, 2020

Post-Doc and PhD young researchers

Popularization events

QUANTERA

ERA-NET Cofund in Quantum Technologies

CONTACT

francesco.marin@unifi.it

https://quasert.wordpress.com/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731473.