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
Optomechanics for quantum technologies

- Manipulating quantum fields
- Quantum strategies for detection
- Thermal noise, decoherence
- High optomechanical gain
- Low optical and mechanical losses
- Macroscopic quantum object
- Quantum correlations / entanglement between em field and mechanical oscillator
Four experimental platforms
Large coupling due to small volume co-localized optical and mechanical modes
Frequency ~ 1 GHz
SiN membranes

Weak mechanical damping
Frequency ~ 1 MHz
Extremely weak gas damping

Mass $\sim 10^{-18}$ kg

Frequency $\sim 100$ 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

> 50 millions
Cooling of a levitated nanosphere by coherent scattering

Preliminary results: mean phonon number $< 3$

Non-classical states of the mechanical oscillators

Asymmetry in the motional sideband

$T = 7\text{K}$

Non-classical states of the mechanical oscillators

Asymmetry in the motional sideband

Quantum signature of squeezing

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

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
- ... 

Networking

Project web site

Meetings

Kickoff: Konstanz, June 2018

Mid-Term: Florence, June 2019

Next: Vienna, 2020

Post-Doc and PhD young researchers

Popularization events

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