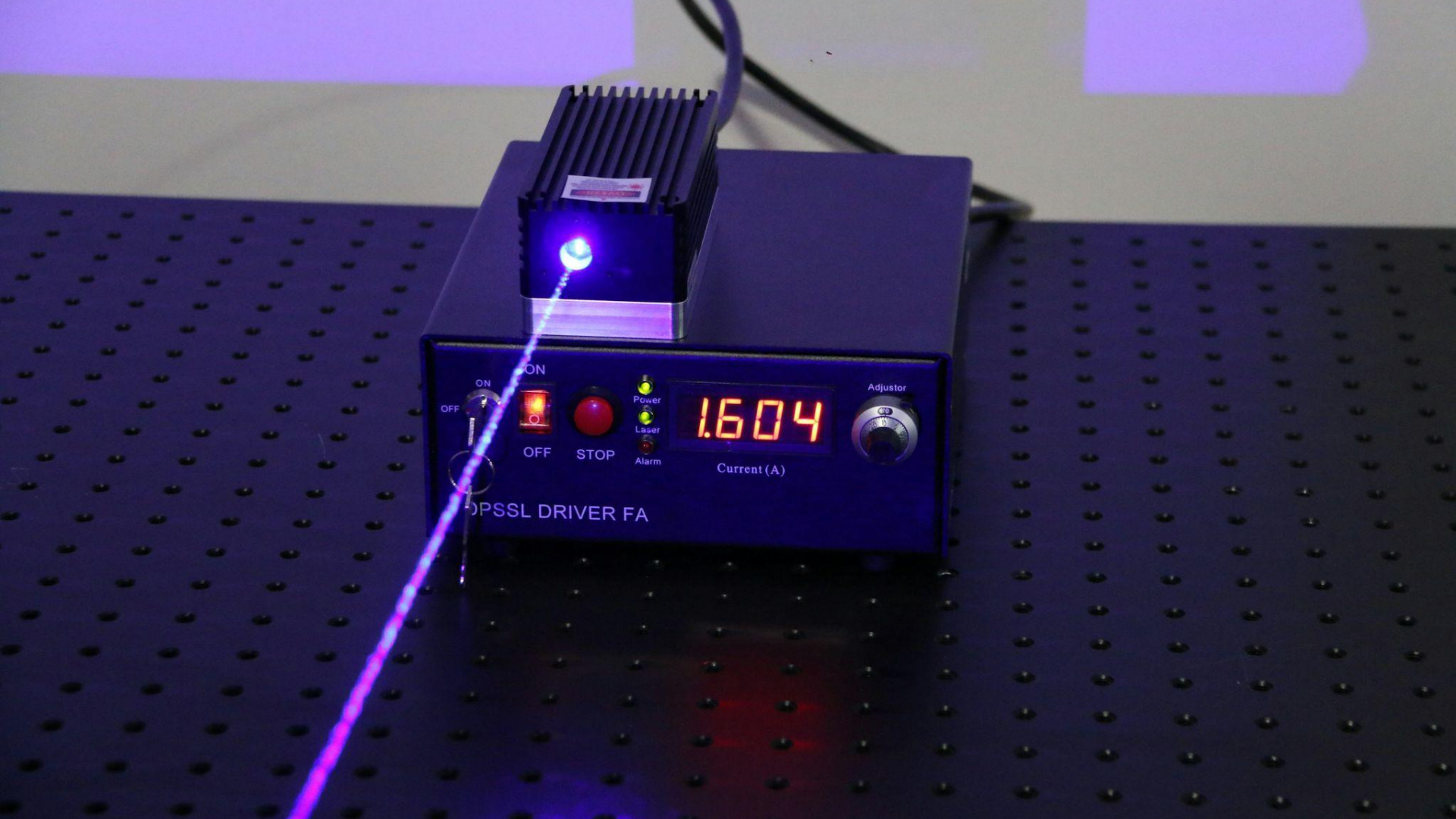
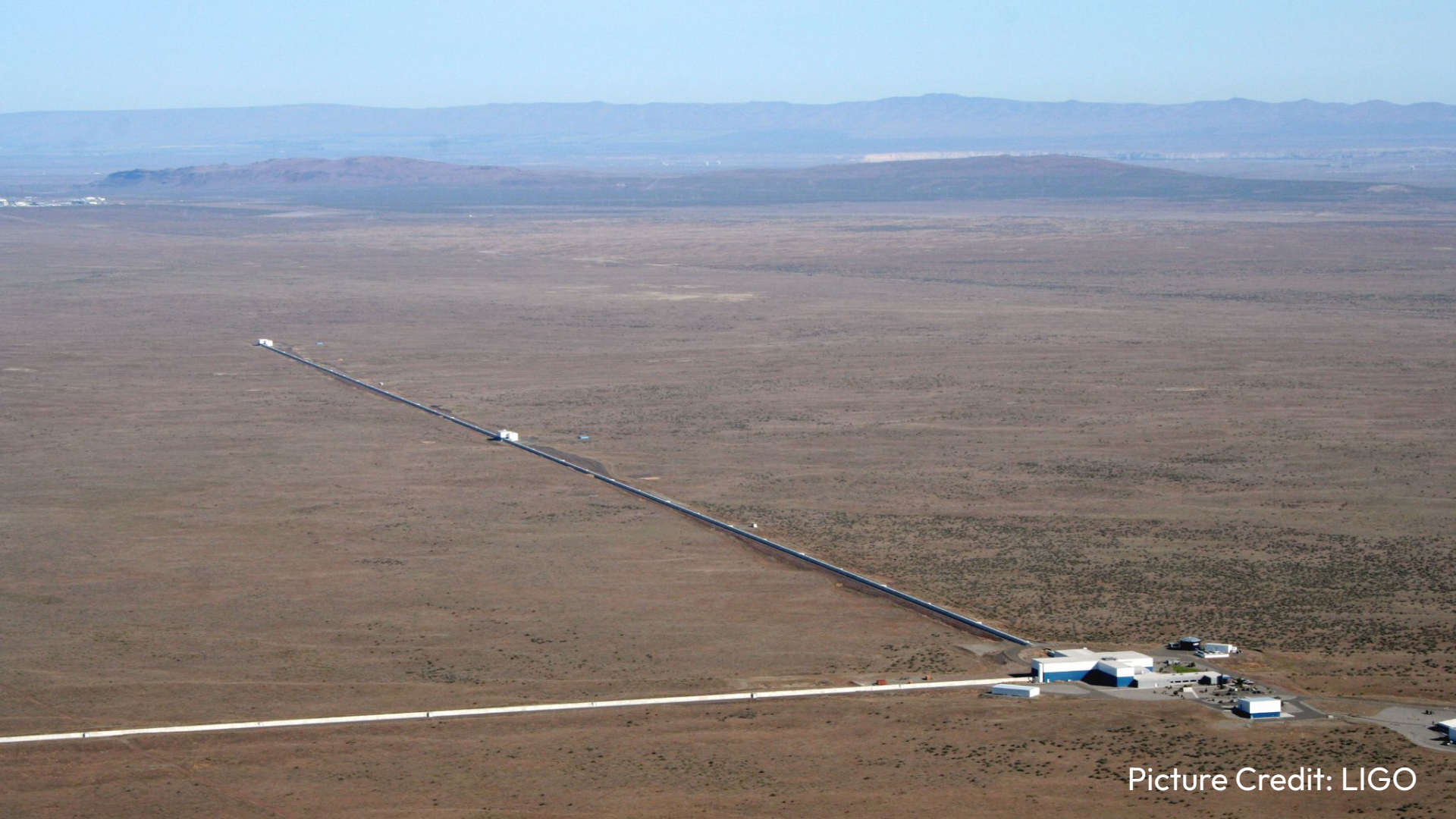
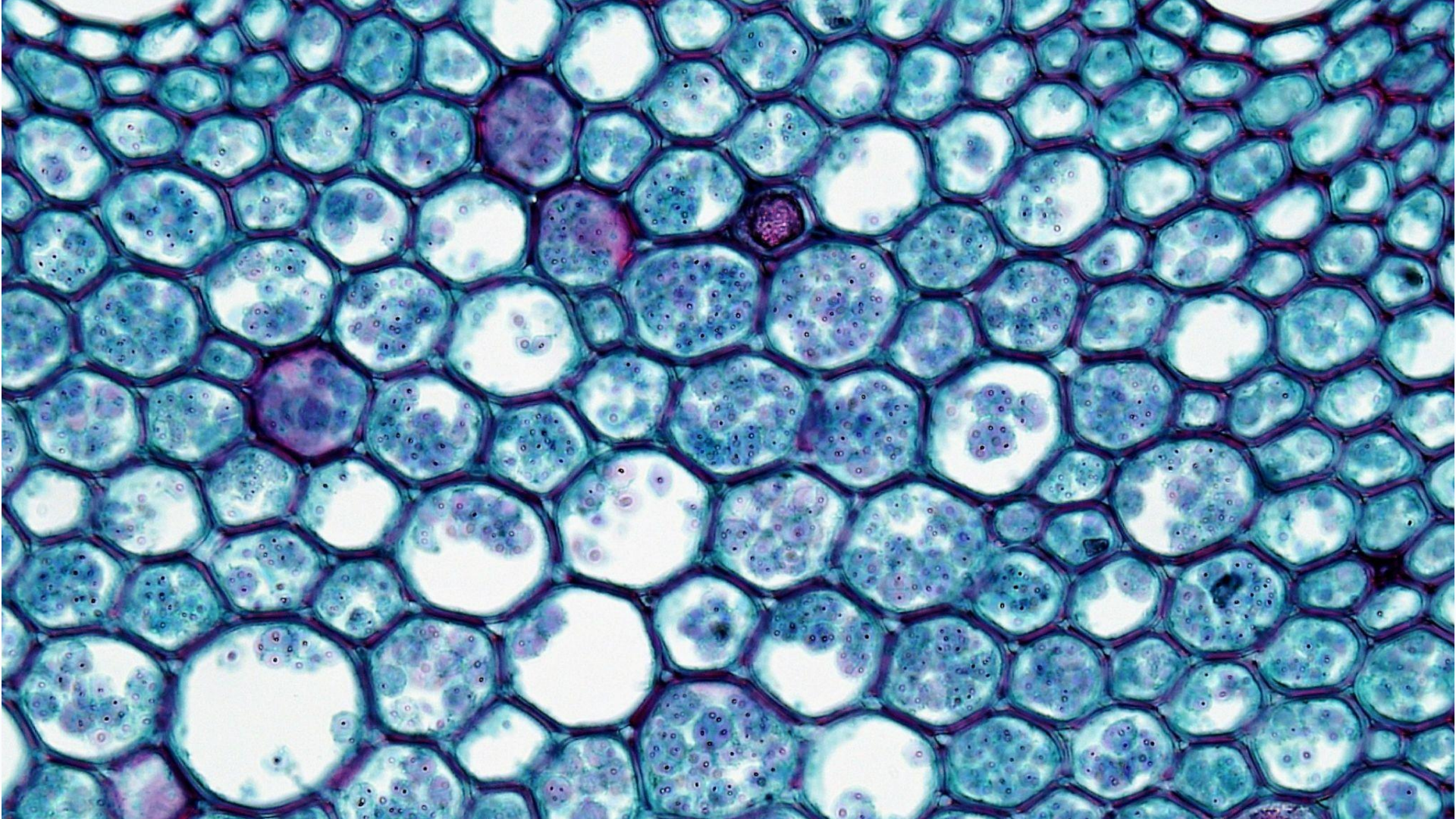
Noisy Labs

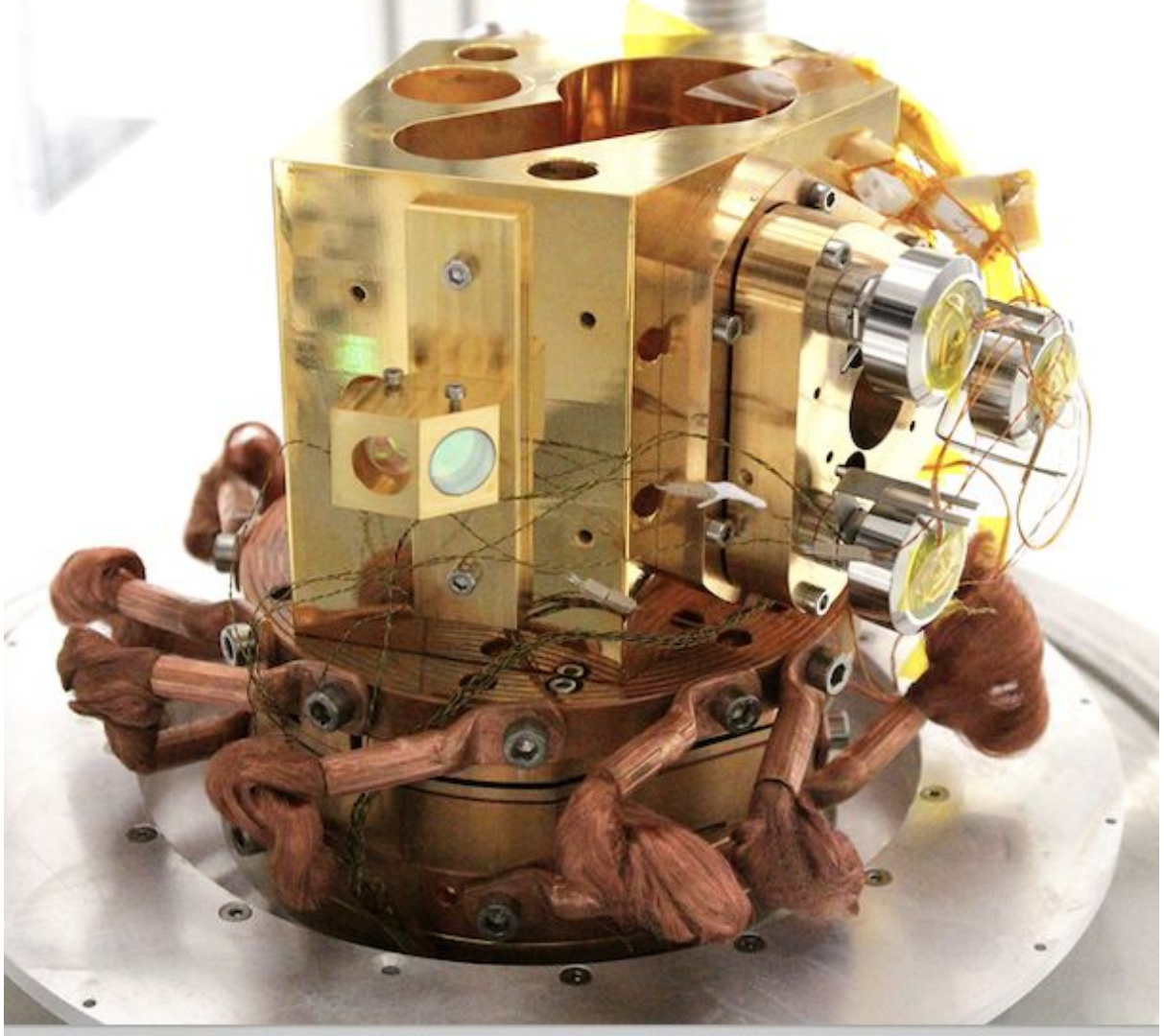
Squeeze Lasers for Quantum Sensing

23.04.2024


ON
OFF
ON
OFF
STOP
Power
Laser
Alarm
1.604
Current (A)
Adjustor
DPSSL DRIVER FA


Picture Credit: LIGO





Measurement sensitivity limited by quantum noise

Measurement sensitivity limited by quantum noise

$$\frac{\text{Signal}}{\text{Noise}} \propto \frac{N}{\sqrt{N}}$$

Measurement sensitivity limited by quantum noise

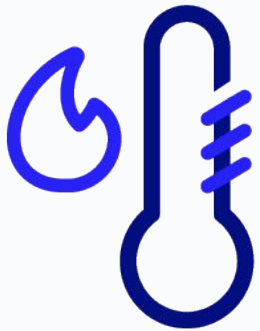
$$\frac{\text{Signal}}{\text{Noise}} \propto \frac{N}{\sqrt{N}}$$

To increase the signal-to-noise ratio:

... use more power
... increase measurement time

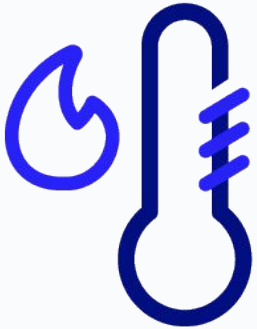


Increasing the power or measurement time creates new problems



Heating of samples and destruction of sensitive probes

Increasing the power or measurement time creates new problems

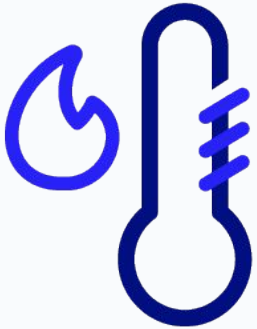


Heating of samples and destruction of sensitive probes



Laser safety

Increasing the power or measurement time creates new problems



Heating of samples and destruction of sensitive probes



Laser safety



Costs

How can the sensitivity be increased beyond the quantum limit?

Use squeezed light!

A gravitational wave observatory operating beyond the quantum shot-noise limit

The LIGO Scientific Collaboration

Nature Physics **7**, 962–965 (2011) | Cite this article

15k Accesses | **662** Citations | **63** Altmetric | Metrics

Biological measurement beyond the quantum limit

Michael A. Taylor, Jiri Janousek, Vincent Daria, Joachim Knittel, Boris Hage, Hans-A. Bachor & Warwick P. Bowen

Nature Photonics **7**, 229–233 (2013) | Cite this article

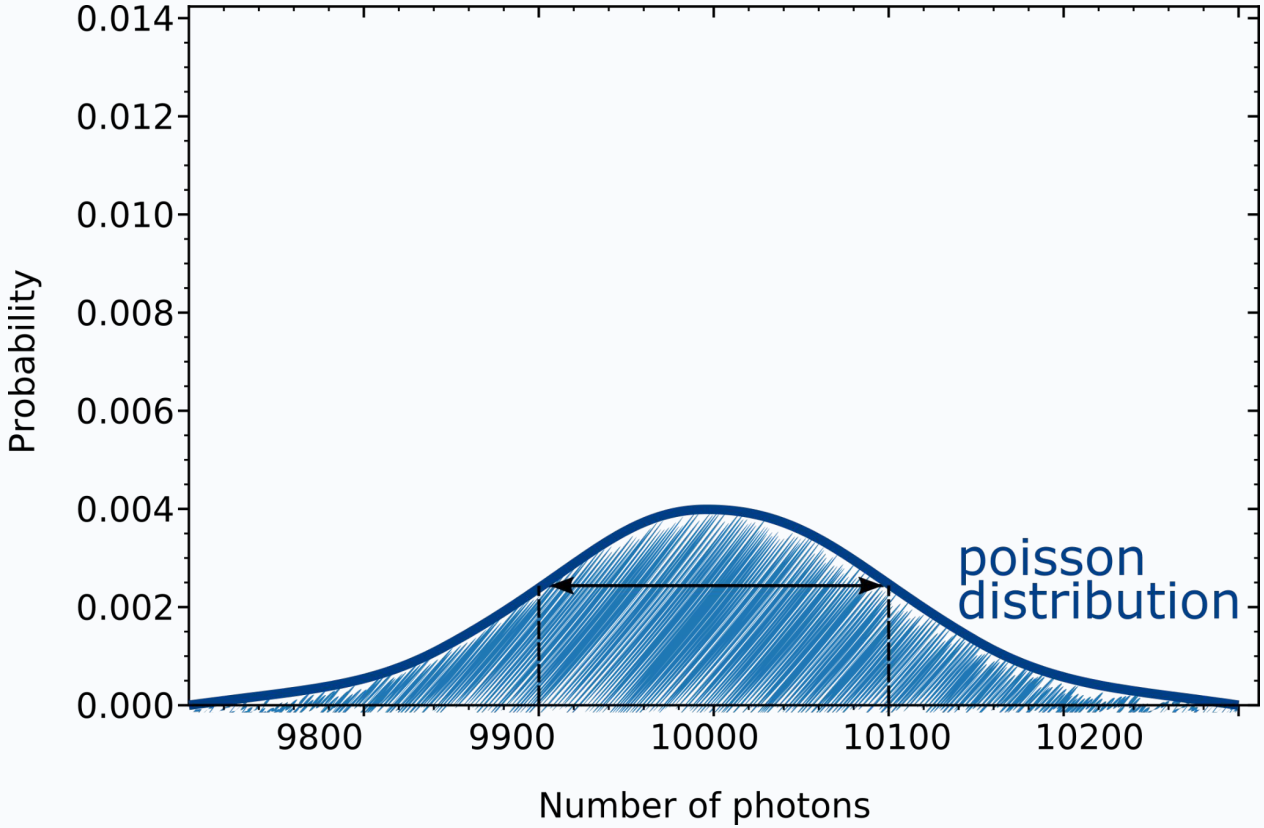
13k Accesses | **365** Citations | **68** Altmetric | Metrics



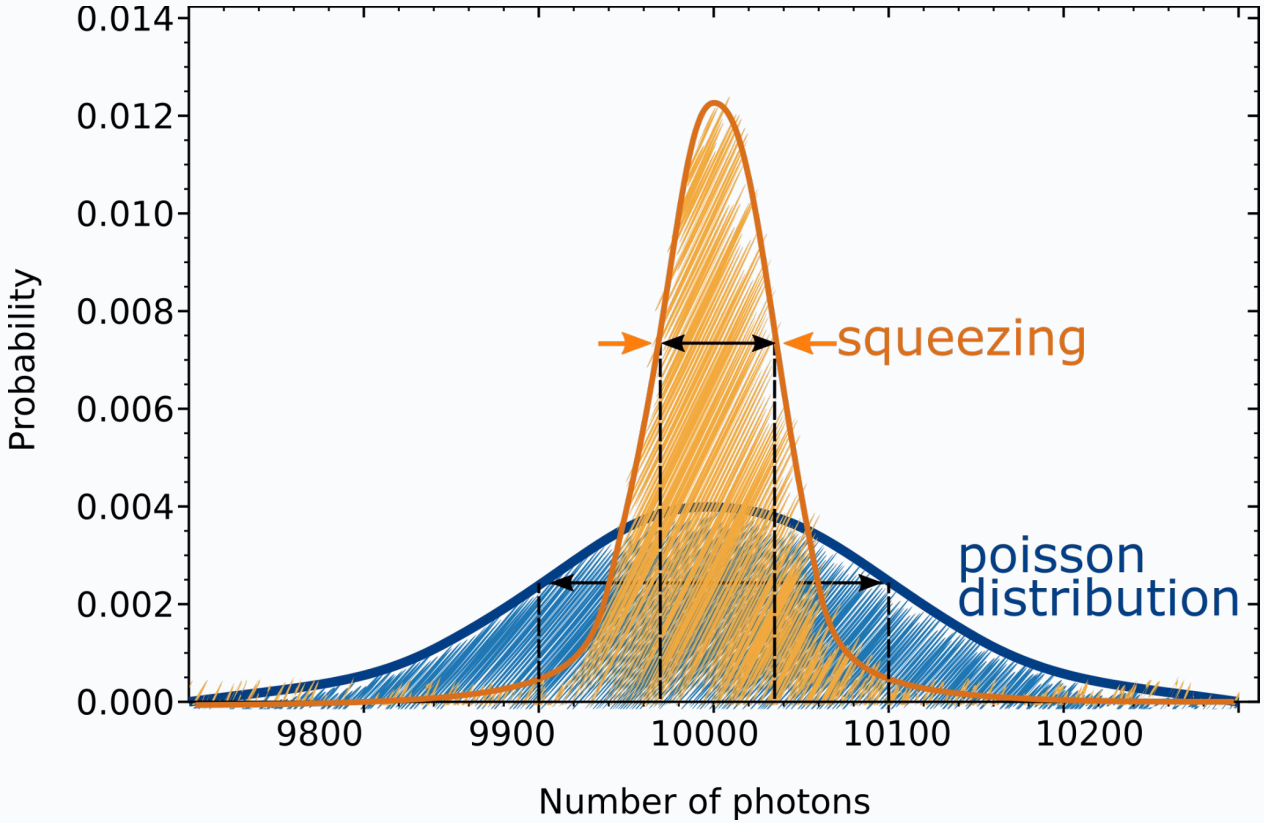
Quantum-enhanced continuous-wave stimulated Raman scattering spectroscopy

RAYSSA B. DE ANDRADE,[1,*] HUGO KERDONCUFF,[2] KIRSTINE BERG-SØRENSEN,[1] TOBIAS GEHRING,[1] MIKAEL LASSEN,[2] AND ULRIK L. ANDERSEN[1]

Noisy Labs


0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Probability
9800
9900
10000
10100
10200
Number of photons
poisson
distribution

Noisy Labs


0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Probability
squeezing
poisson
distribution
9800
9900
10000
10100
10200
Number of photons

Noisy Labs

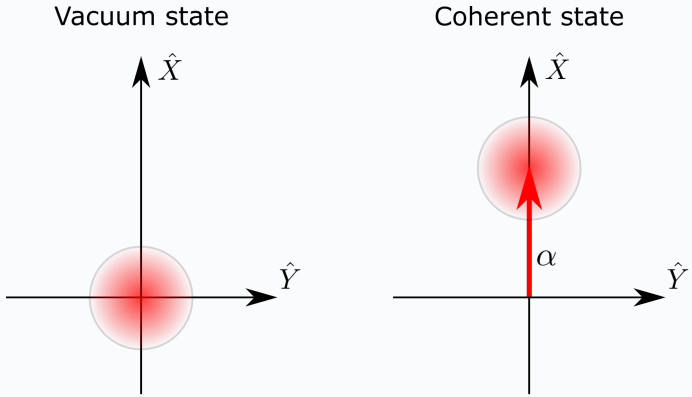
$$\frac{\text{Signal}}{\text{Noise}} \propto \frac{N}{\sqrt{\beta N}}$$

Squeezed light in phase space

Heisenberg's uncertainty principle for the phase- and amplitude quadrature:

$$\Delta\hat{X} \cdot \Delta\hat{Y} \geq 1$$

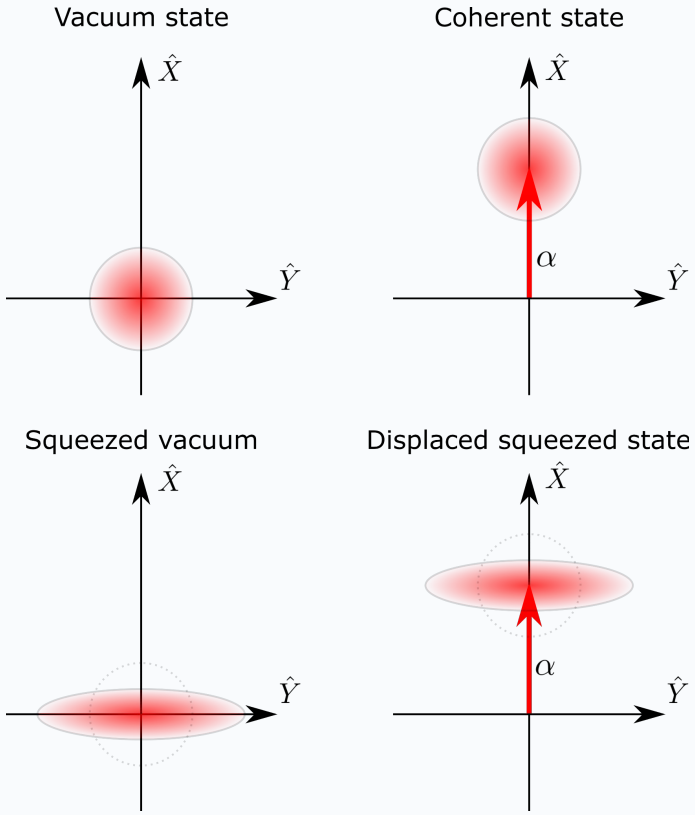
The noise power in a vacuum state or coherent state is the reference for characterizing squeezed light



Squeezed light in phase space

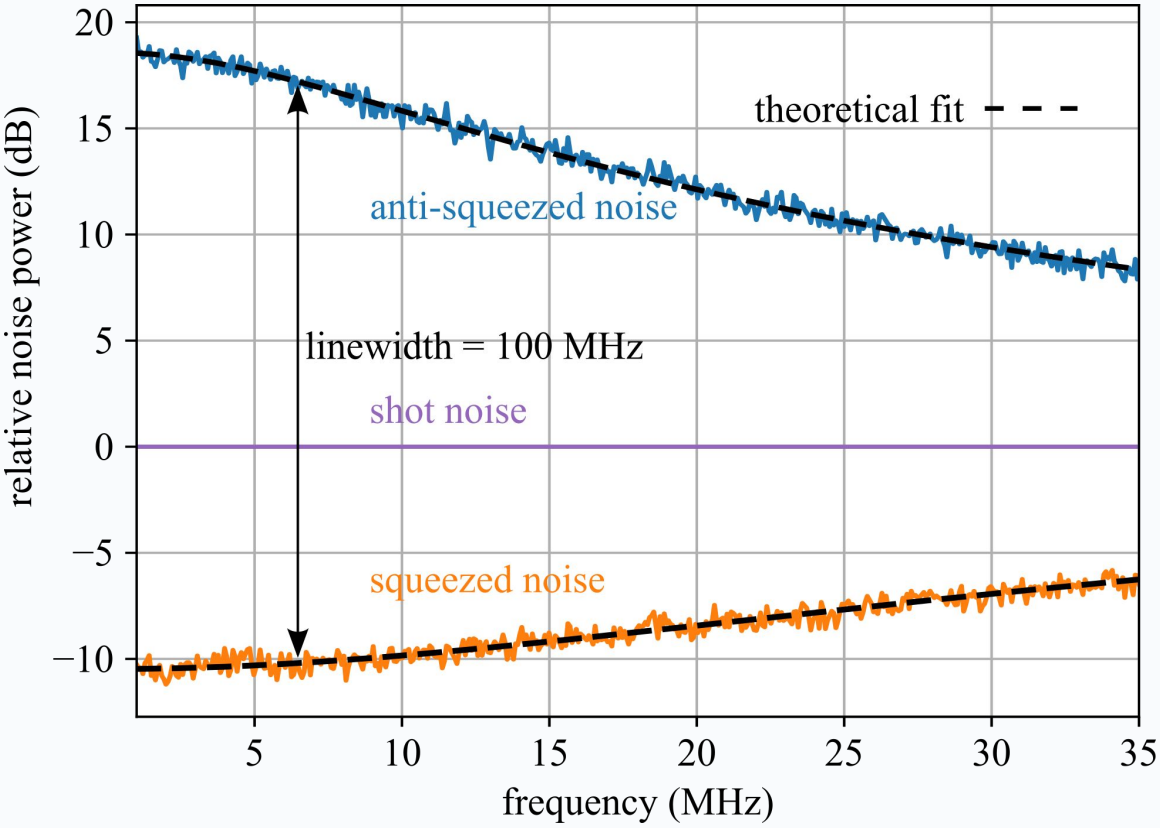
Noise in one quadrature decreased
at the expense of increasing noise
in the orthogonal quadrature

$$\left(\frac{\Delta\hat{X}}{10}\right)\left(10\cdot\Delta\hat{Y}\right)\geq 1$$



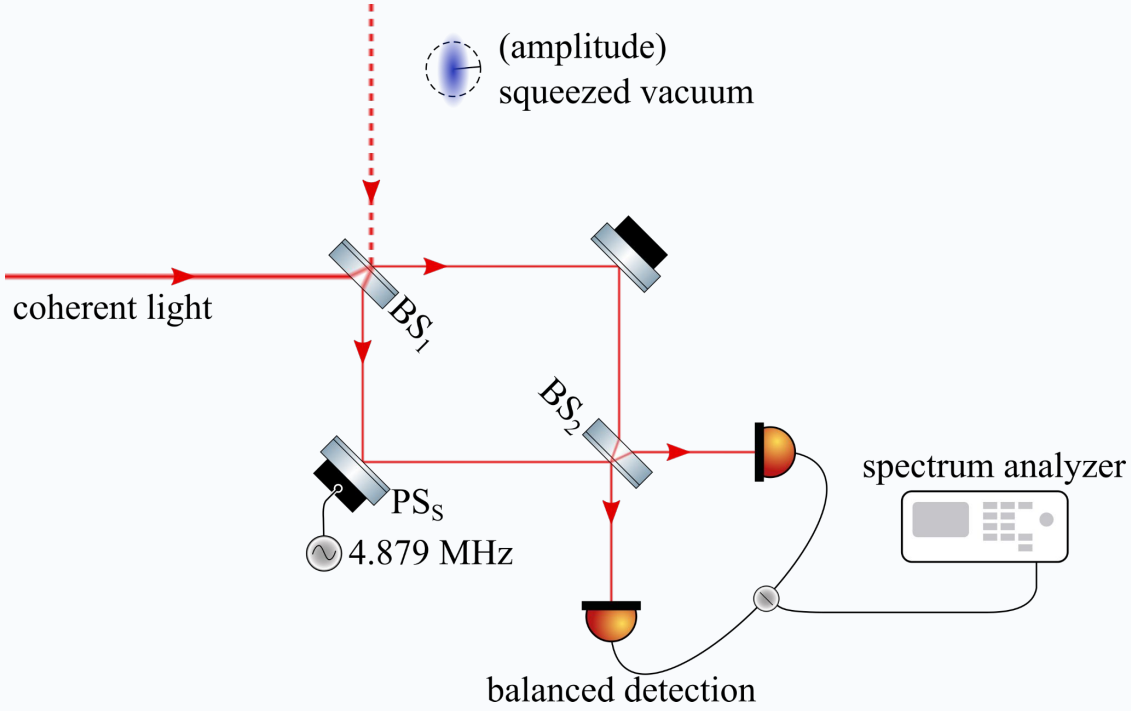
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Up to 10 dB noise reduction in low-loss environment



Noisy Labs

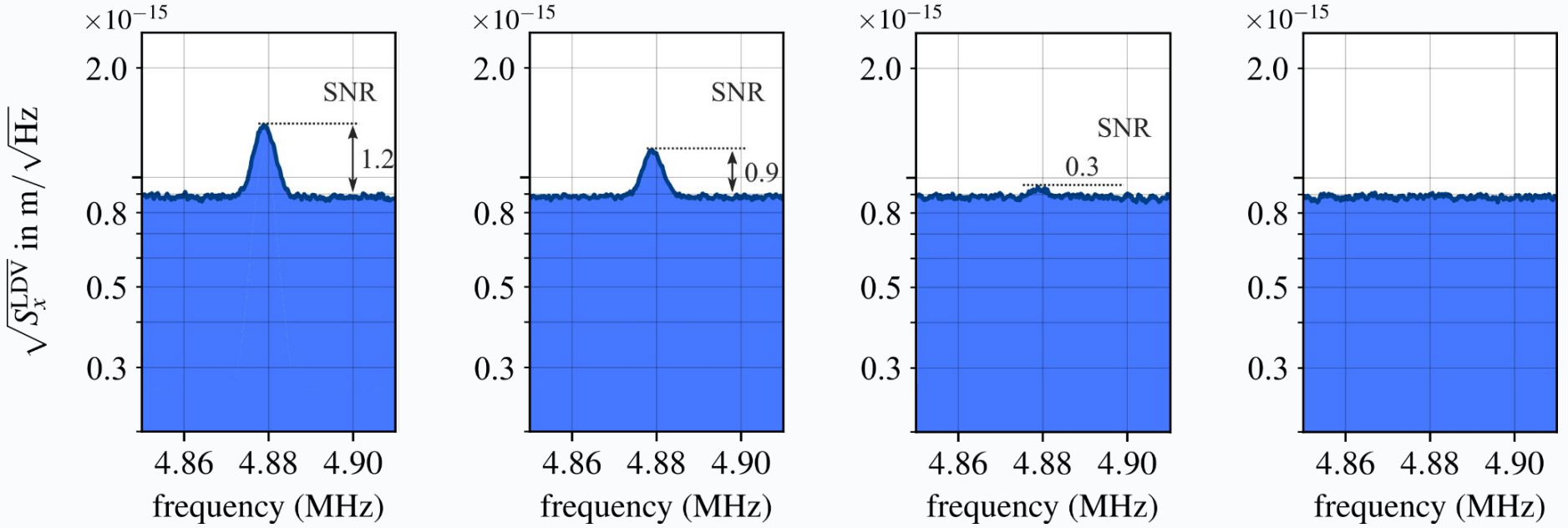
Sub-fm displacement measurement with eye-safe power levels



J. Zander, Squeezed and Entangled Light: From Foundations of Quantum Mechanics to Quantum Sensing, Dissertation 2021, UHH

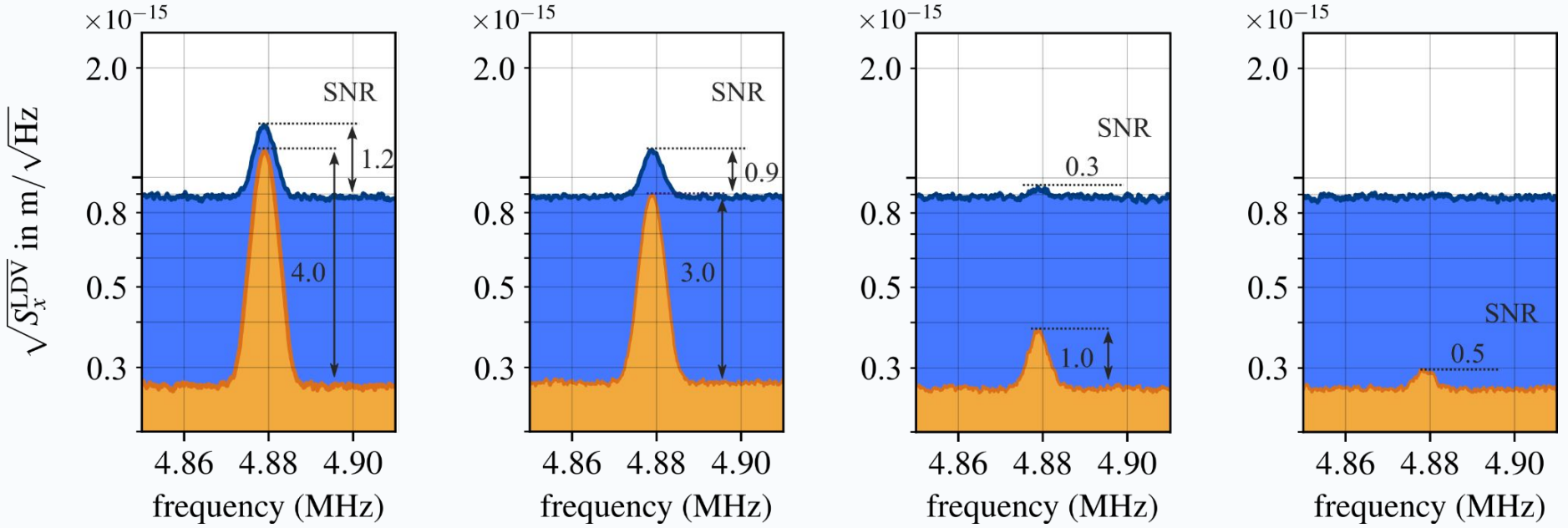
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Sub-fm displacement measurement with eye-safe power levels



Noisy Labs

Sub-fm displacement measurement with eye-safe power levels



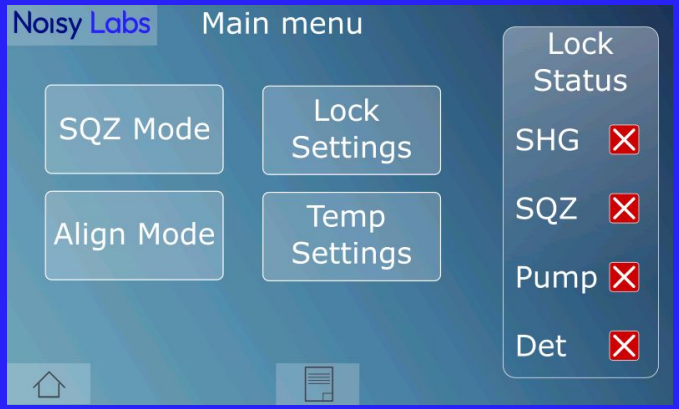
Noisy Labs



Our squeeze lasers – specifications

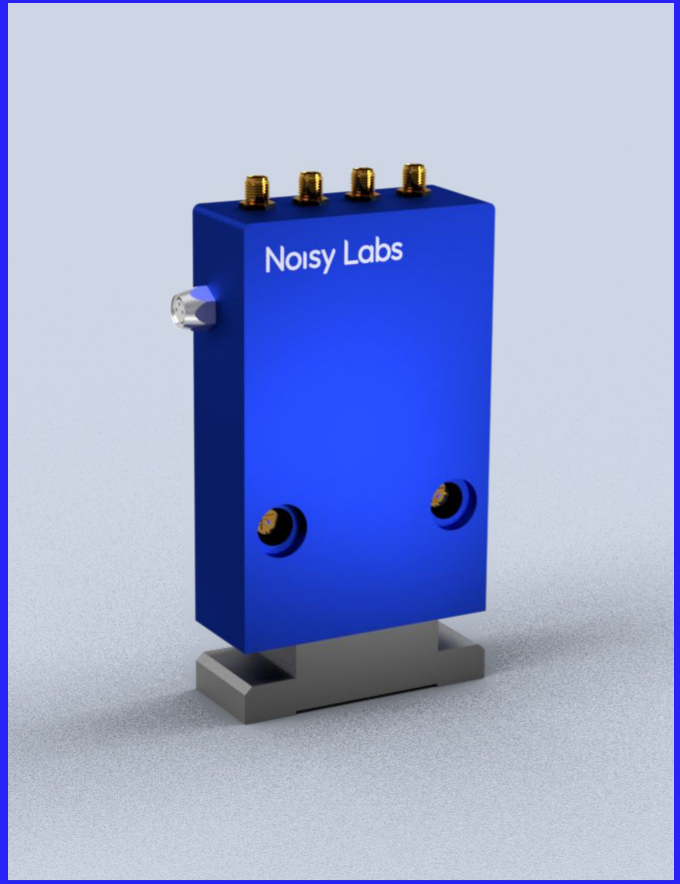
- Up to 10 dB squeezing at 1550 nm or 1064 nm
- Continous wave
- Excellent TEM00 mode
- Locking possibilities for squeezed-light stabilization
- Intuitive user interface
- Control electronics integrated in 19” rack





High quantum efficiency balanced detectors

- Quantum efficiency >95%
- Optimized for 1550 nm or 1064 nm
- Common mode rejection ratio >50dB
- Including demodulation technology for readout stabilization



Additional components available to make working with squeezed light easy

- Squeeze lasers
- Homodyne detectors
- Mode filter cavities + locking systems
- Complementary components
- Consulting
- Customized solutions

We look forward to get in touch with you

axel.schoenbeck@noisy-labs.com

+49 151 11537185

- Squeeze lasers
- Homodyne detectors
- Mode filter cavities + locking systems
- Complementary components
- Consulting
- Customized solutions