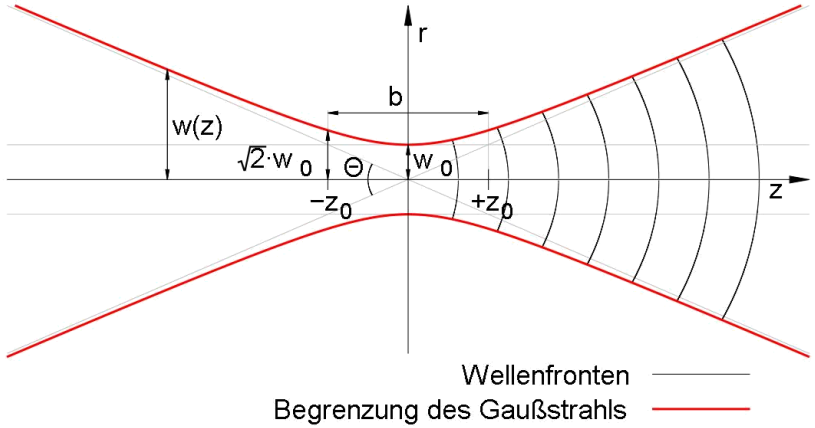
ILP 8 - Interferometrische Messung der thermischen Bewegung einer Membran auf Pikometer-Skala

PASCAL GEWECKE

Scientific context

ILP 8

Optics and interference
Gaussian beams



Physics II, III, VI

Scientific context

ILP 8

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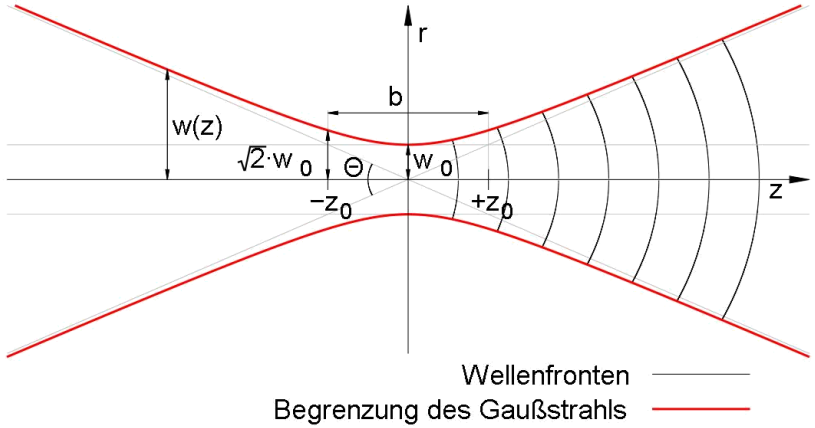
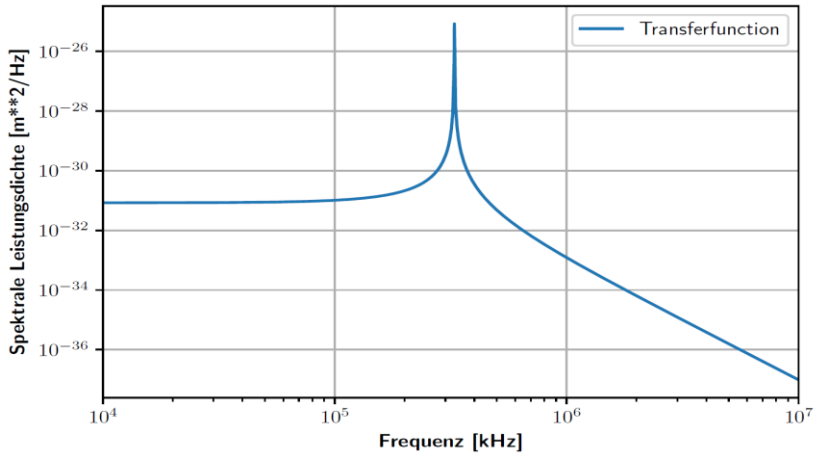
Gaussian beams



Physics II, III, VI

Transferfunctions
Damped harmonic oscillator

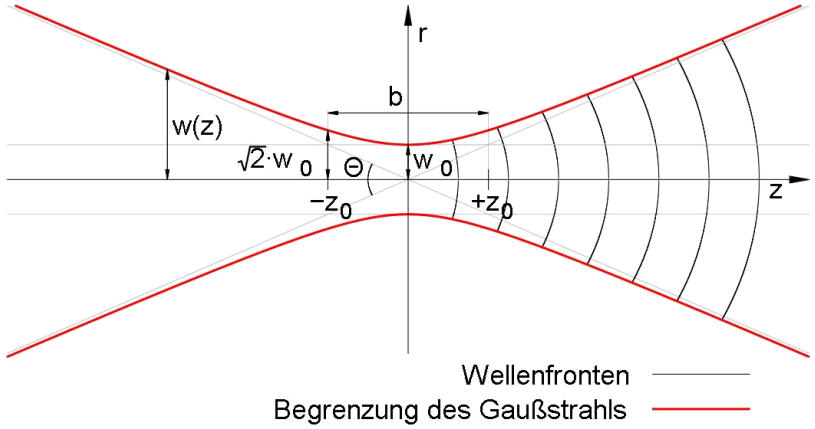


Physics II, III

Scientific context

ILP 8

Optics and interference
Gaussian beams

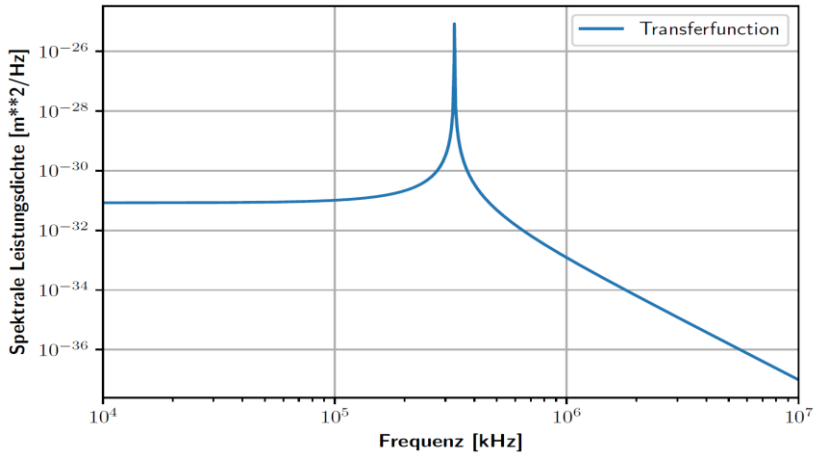


Physics II, III, VI

Additionally the students learn:

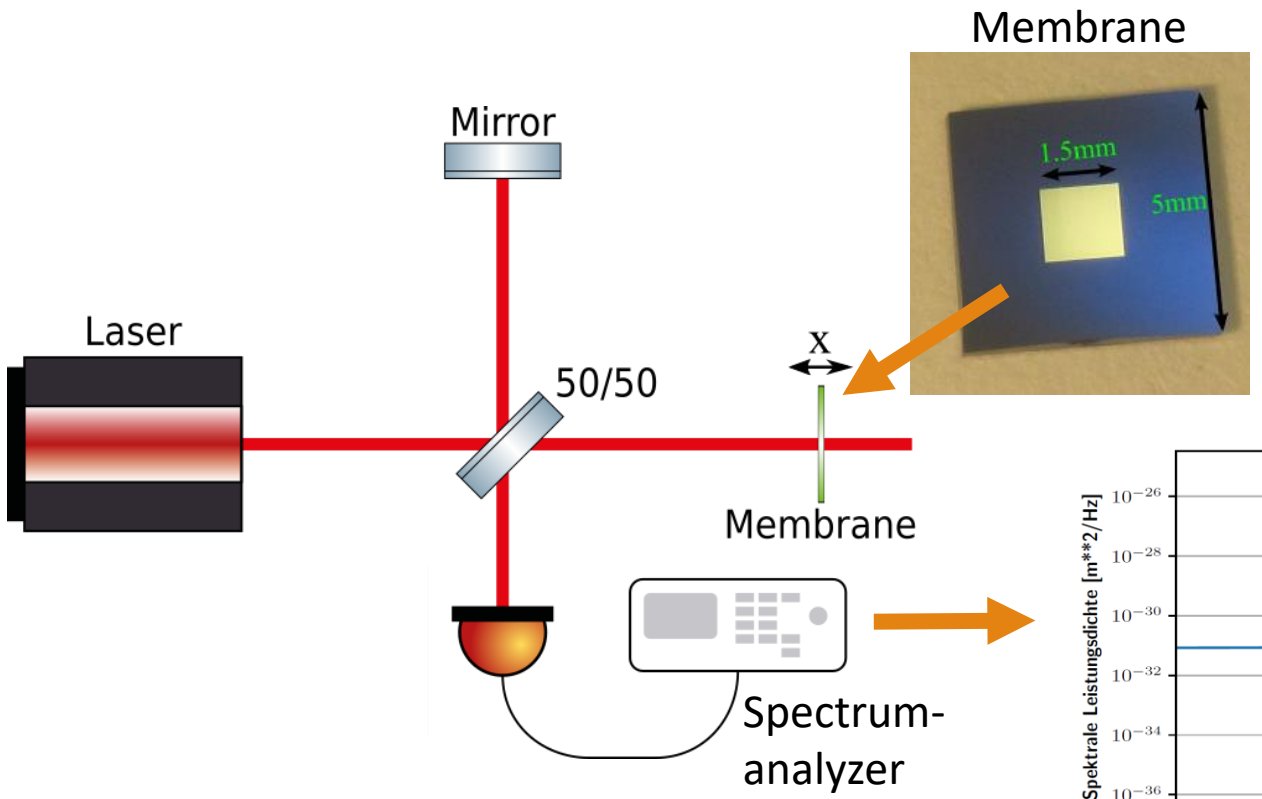
- Working with a vacuumsystem
- Locking schemes and feedback loops
- Birefringence
- Photodiodes

Transferfunctions
Damped harmonic oscillator

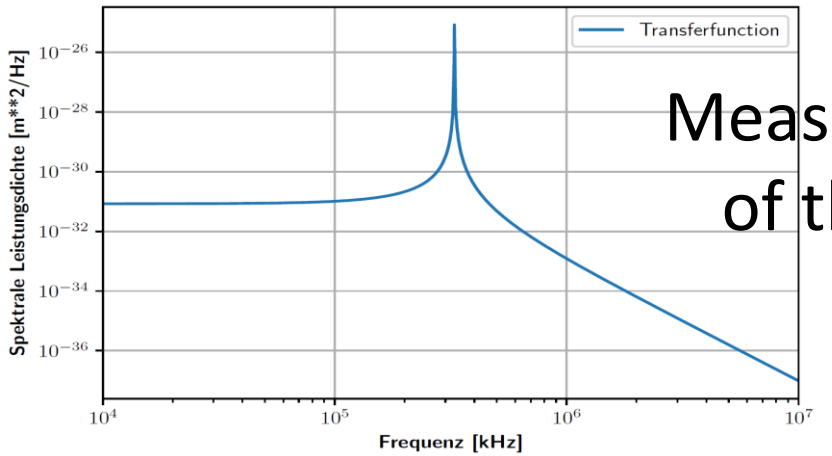


Physics II, III

Aim of the experiment



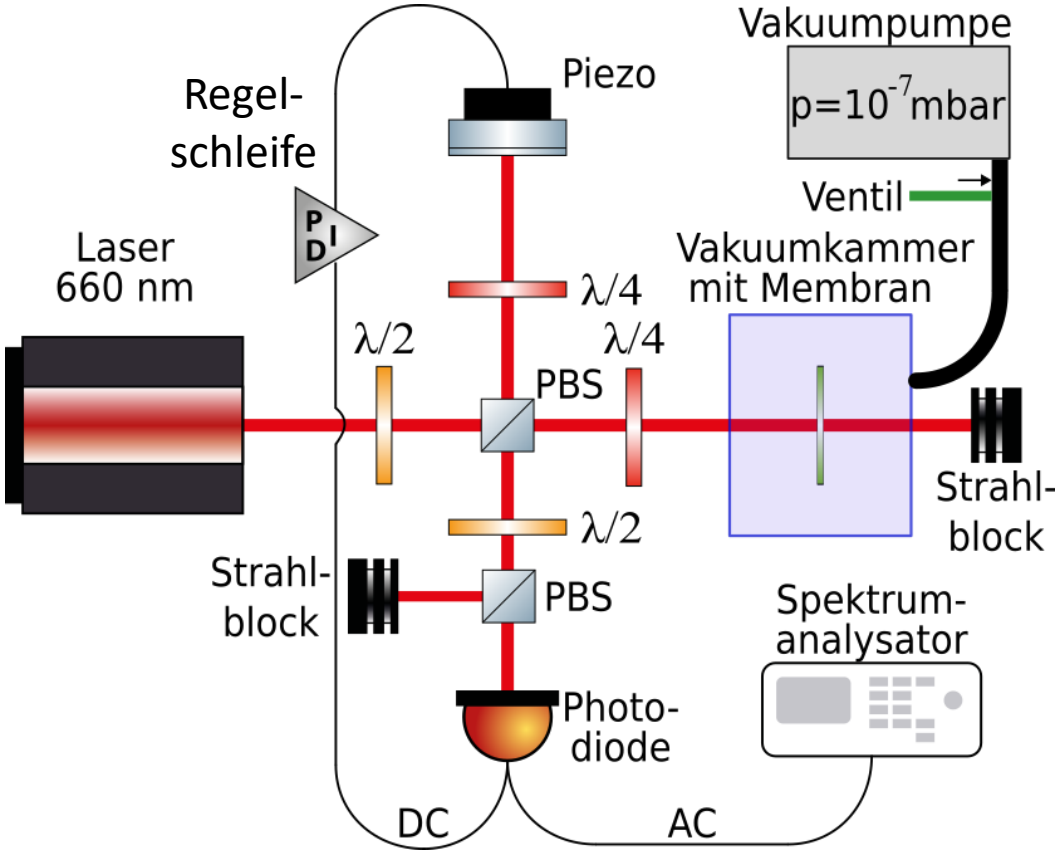
Detection of the thermal motion of a silicon-nitride membrane in an interferometric setup



Measure resonances of the membrane

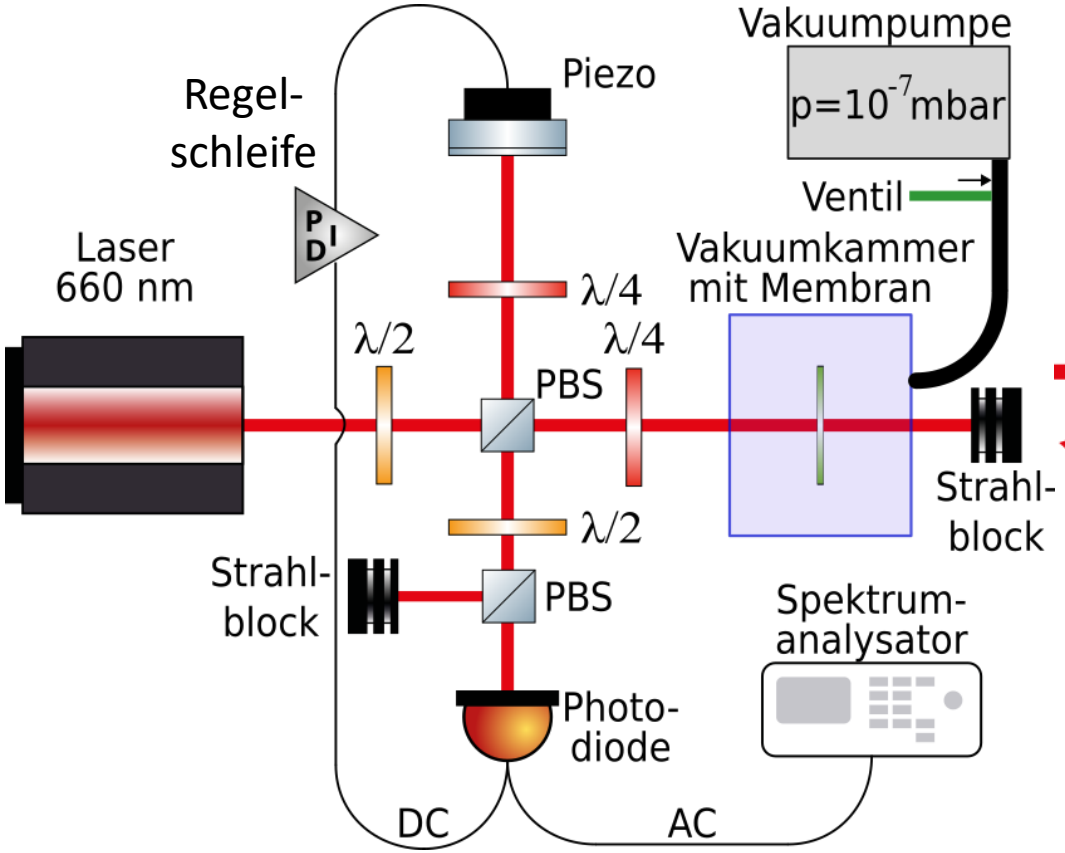
Experimental setup

First stage: Set up of the interferometer

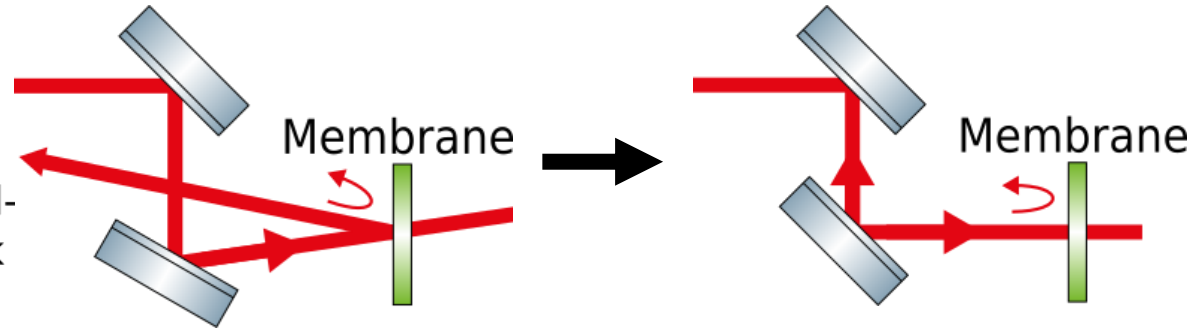


Experimental setup

First stage: Set up of the interferometer

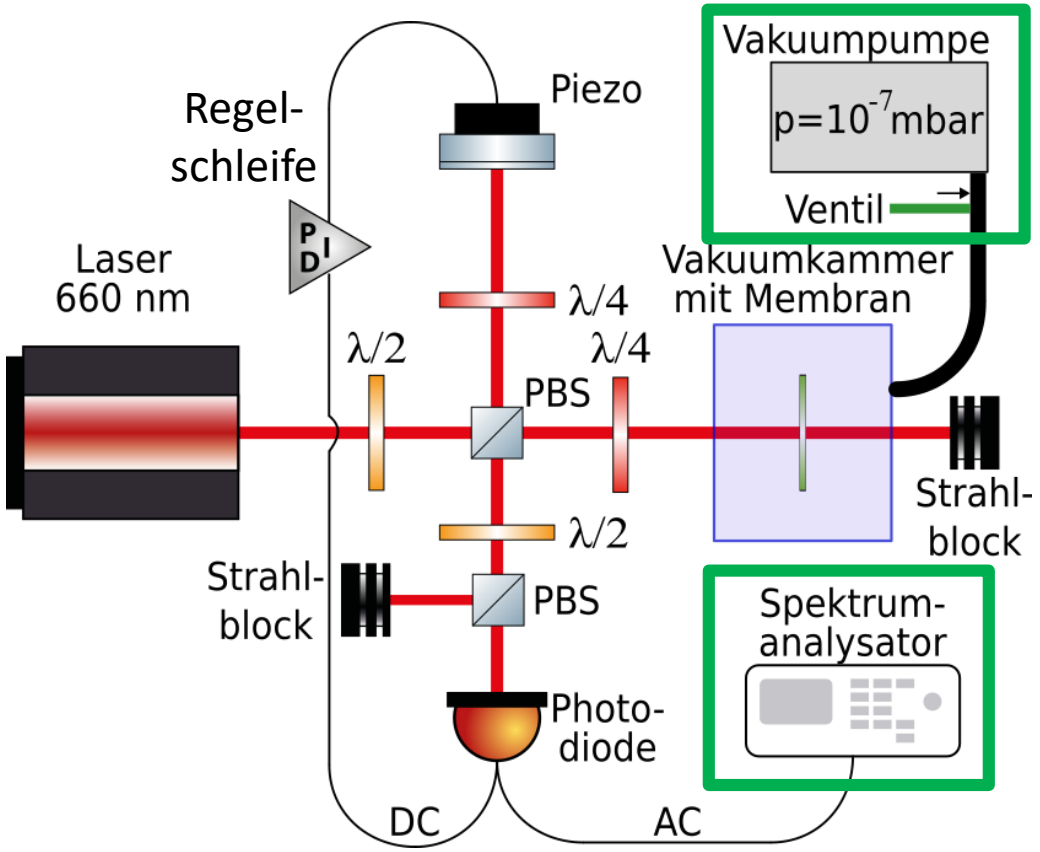


Beam walking for aligning retro-reflective beam using mirrors (and lenses)

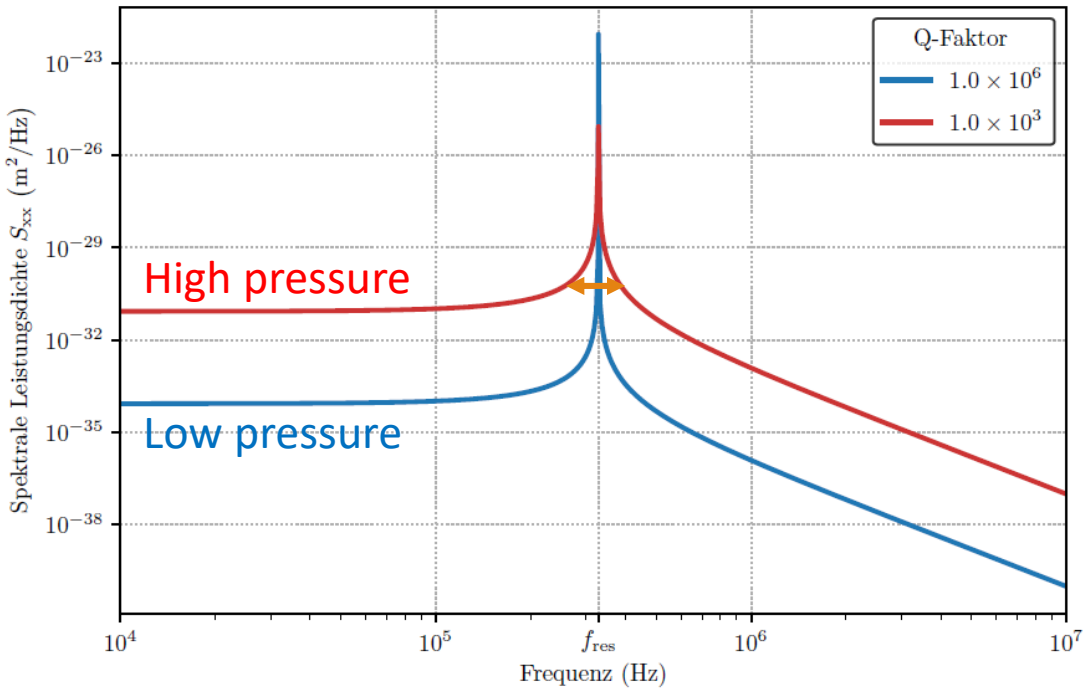


Experimental setup

Second stage: Characterization of the membrane



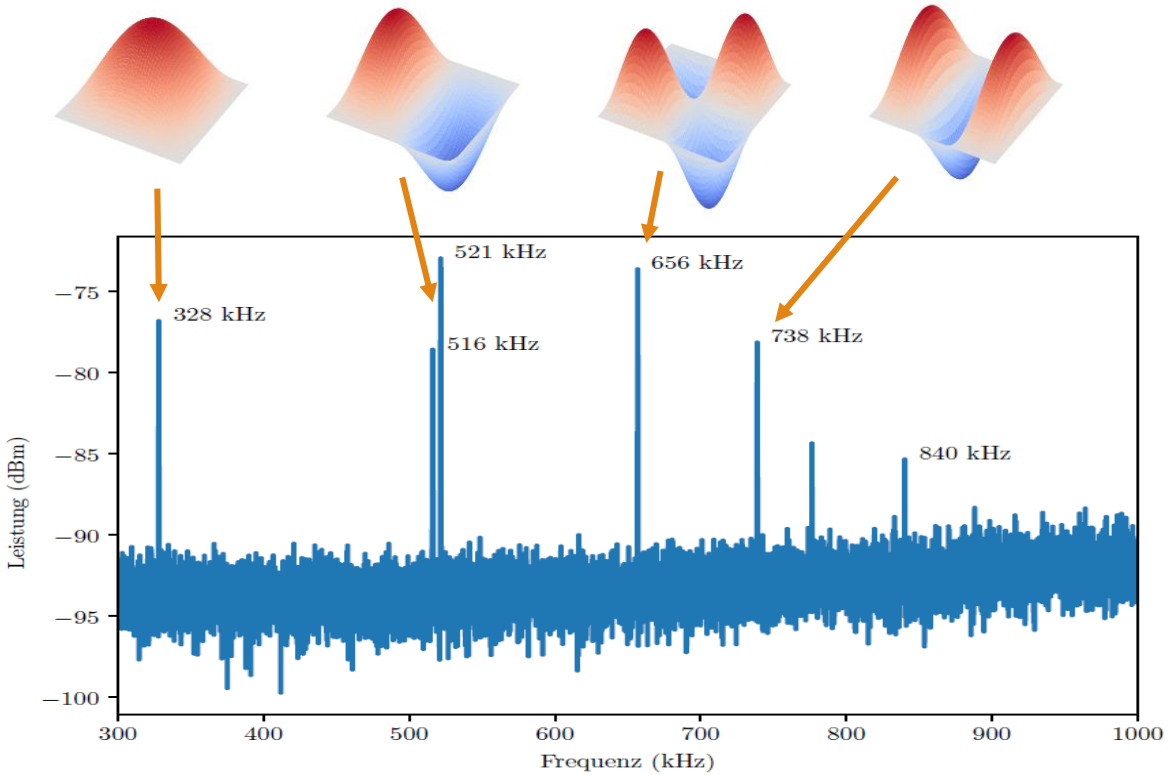
Quality-factor: $Q = \frac{f_{res}}{\Delta f}$



Data analysis with the spectrum analyzer

Spectrum analyzer:

- Very important tool to measure signals
- Can measure spectra or time series



Spectrum

Data analysis with the spectrum analyzer

Spectrum analyzer:

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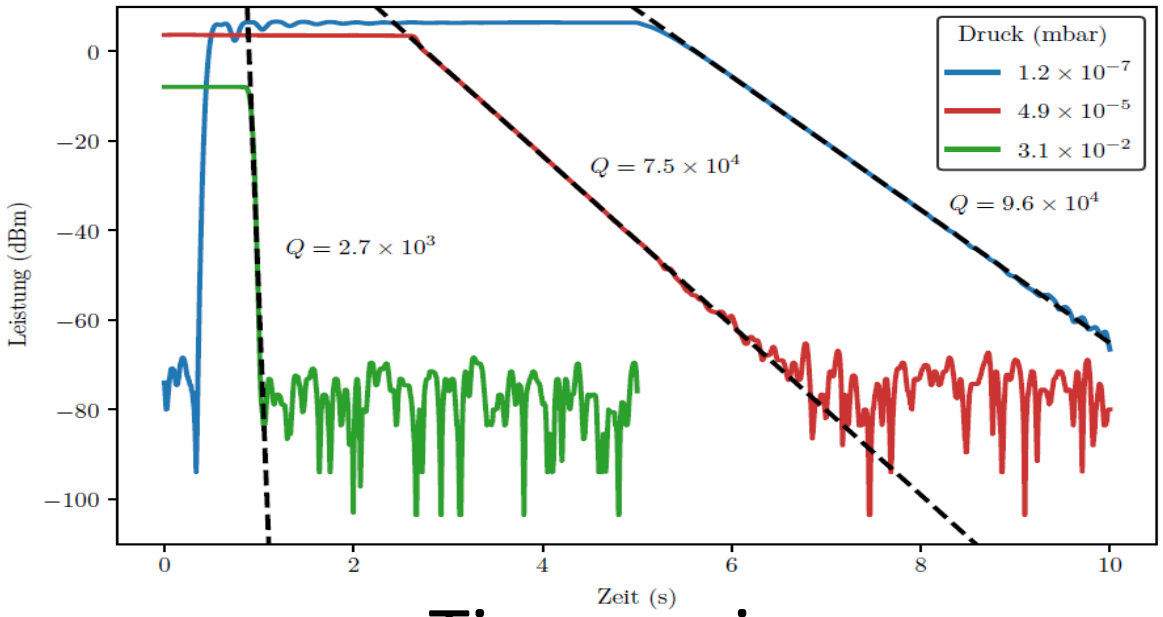
Ring-down

1. Externally exciting the membrane
2. Measure dissipation of energy
3. Q-factor is proportional to slope
4. Repeat for different pressures

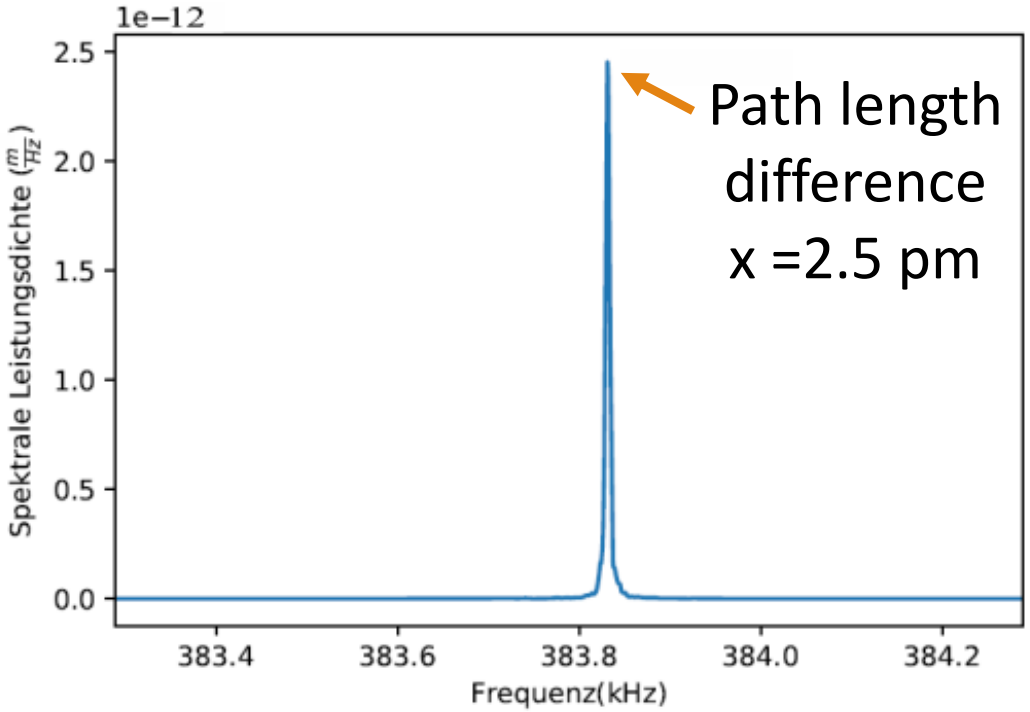


Time-series

Key results

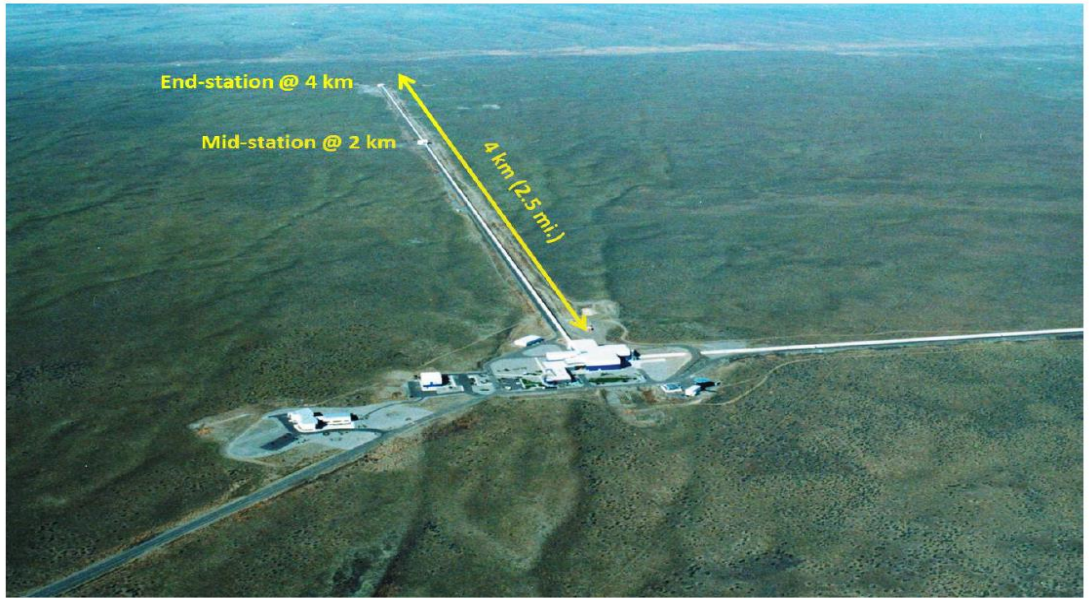
What the students learn:

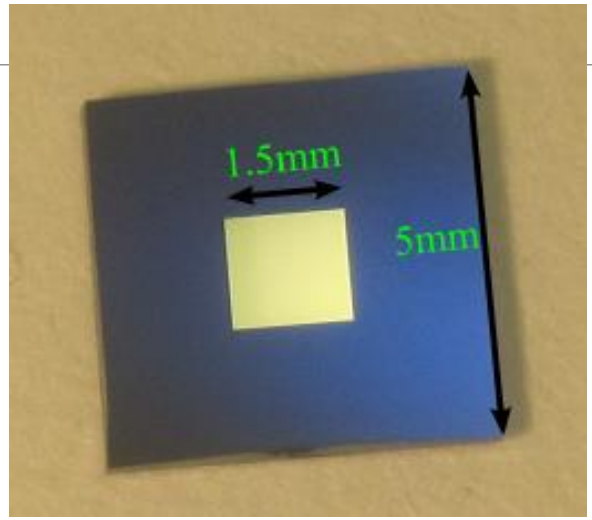
- Interferometers are simple but very precise detectors
- The reached sensitivity is comparable to state of the art experiments
- Skills: Beam walking, working with a spectrum analyzer, general working in the laboratory



Link to modern day physics

Source: [Caltech/MIT/LIGO Lab]





GW-detector (very big interferometers): Can measure path length differences below 1am

→ Noble prize in 2017

SiNi-membranes:

Microelectromechanical systems (MEMS) as cryogenic pressure sensors, accelerometers or gyroscopes

Grading

1 = very complex
5 = very easy

Theory / preparation	Setup / experimental	Data taking	Analysis	Protokol
2-3	2	4	3	3

Thank you for your attention!