

*T. Eberle, S. Steinlechner, J. Bauchrowitz,  
V. Händchen, H. Müller-Ebhardt and R. Schnabel*

Demonstration of a  
**squeezed zero-area  
Sagnac interferometer**  
for future gravitational wave detectors

Max Planck Institut  
for Gravitational Physics  
AG Quantum Interferometry



Centre for Quantum Engineering  
and Space Time Research



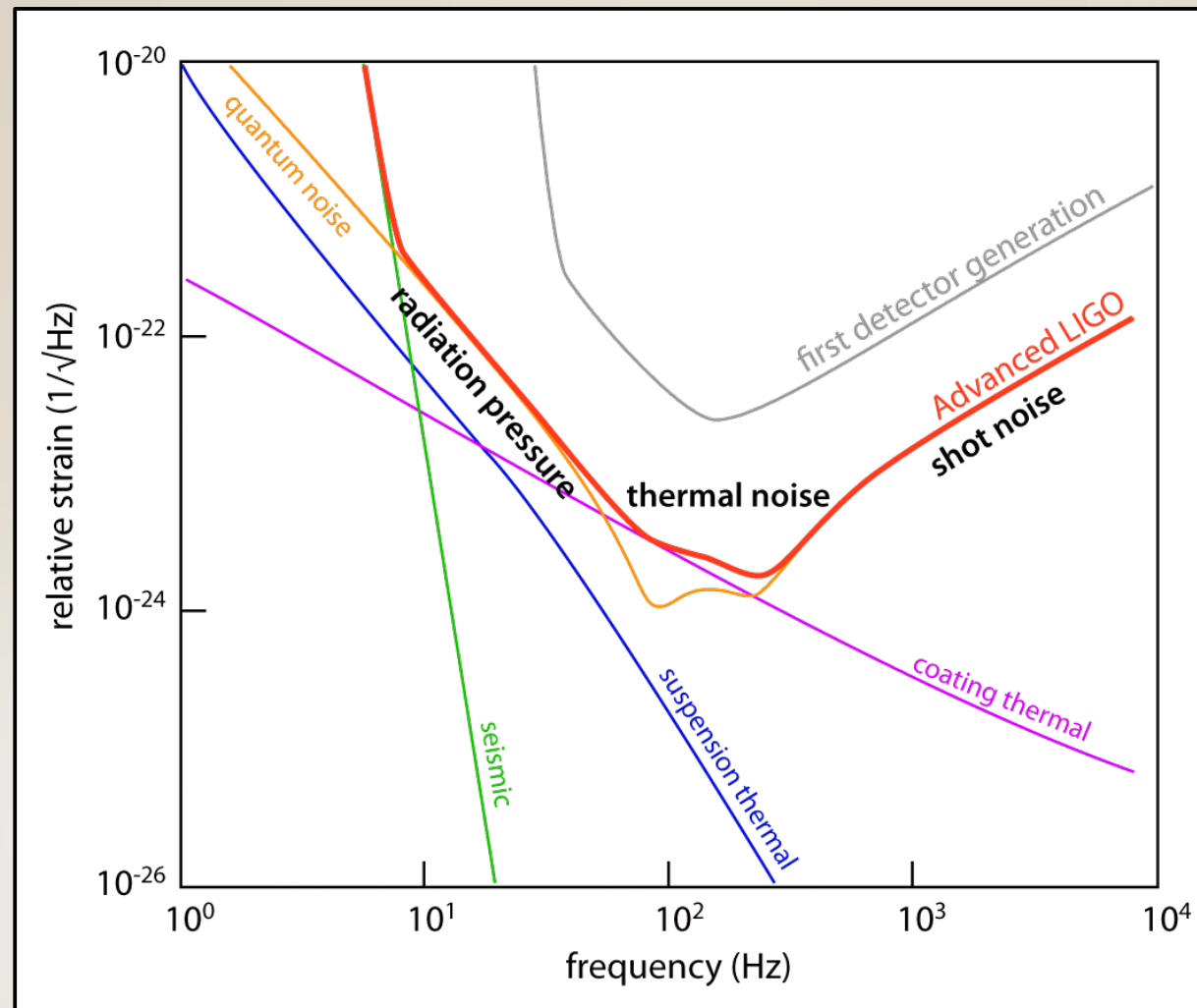
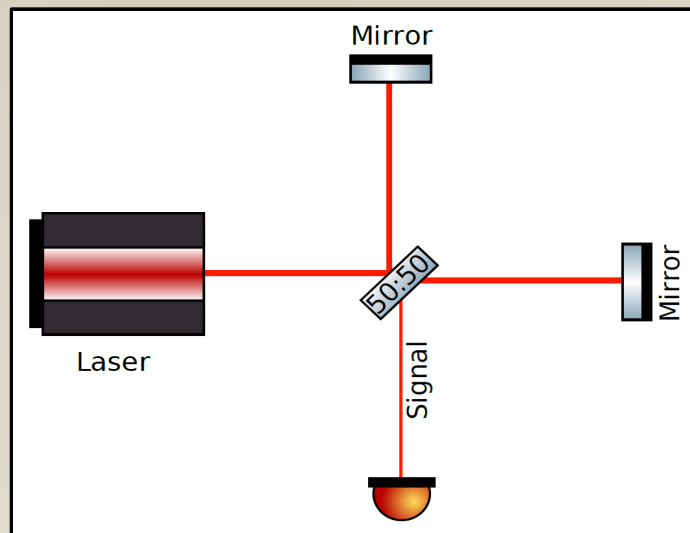
Leibniz Universität Hannover



Institute for Gravitational Physics, Leibniz Universität Hannover  
and Max Planck Institute for Gravitational Physics (Albert  
Einstein Institute)

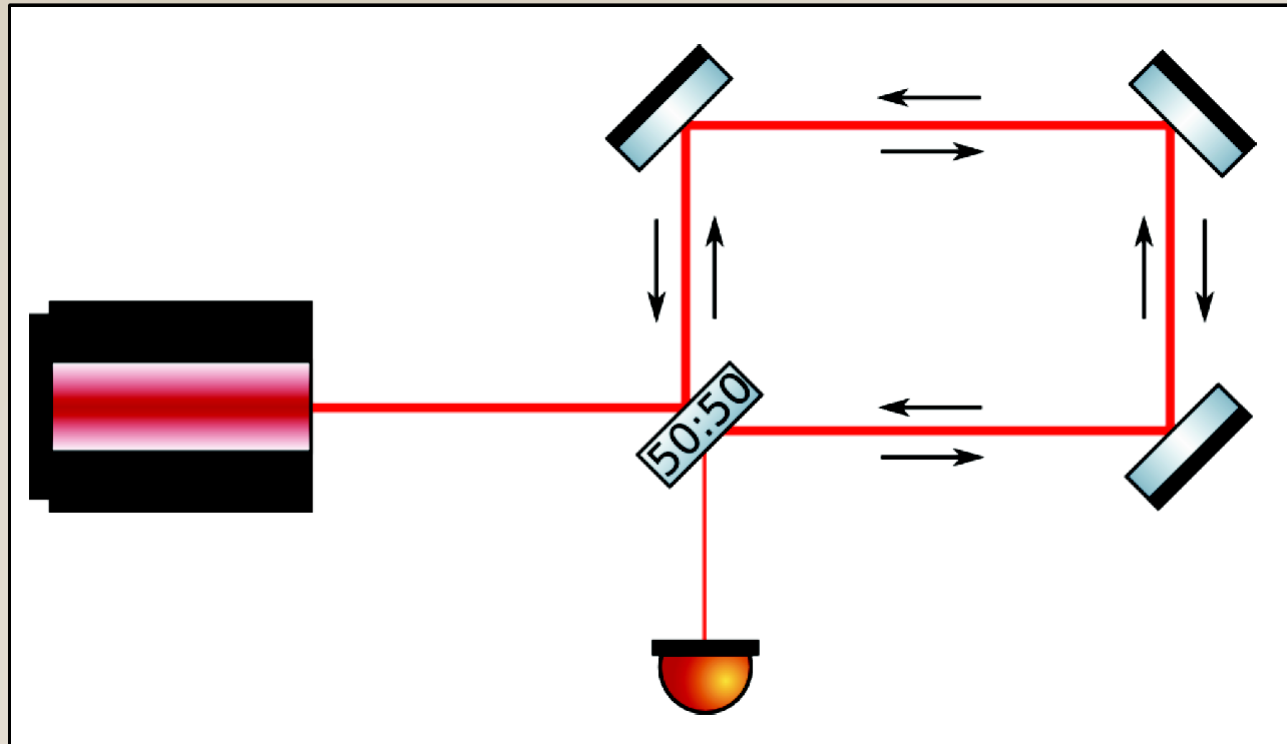
Callinstr. 38, 30167 Hannover, Germany

## Michelson interferometer



[www.squeezed-light.de](http://www.squeezed-light.de)

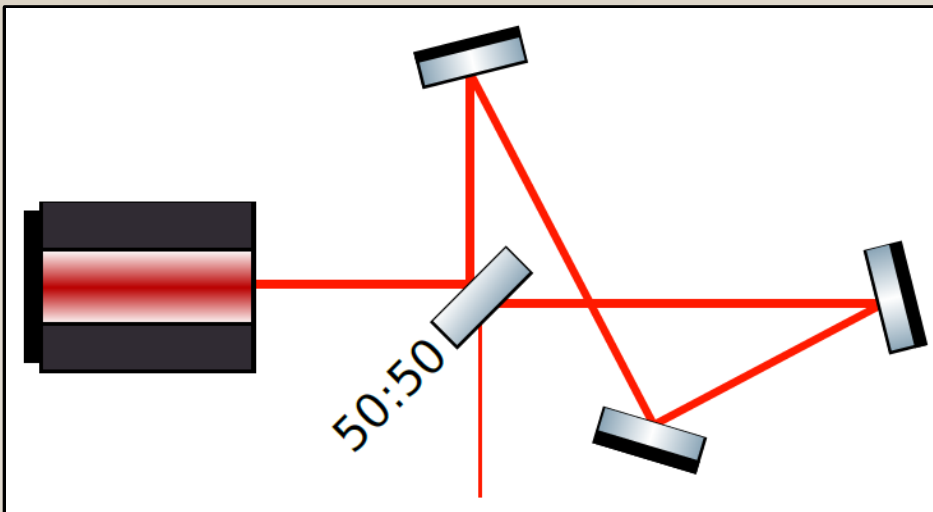
# The Sagnac interferometer



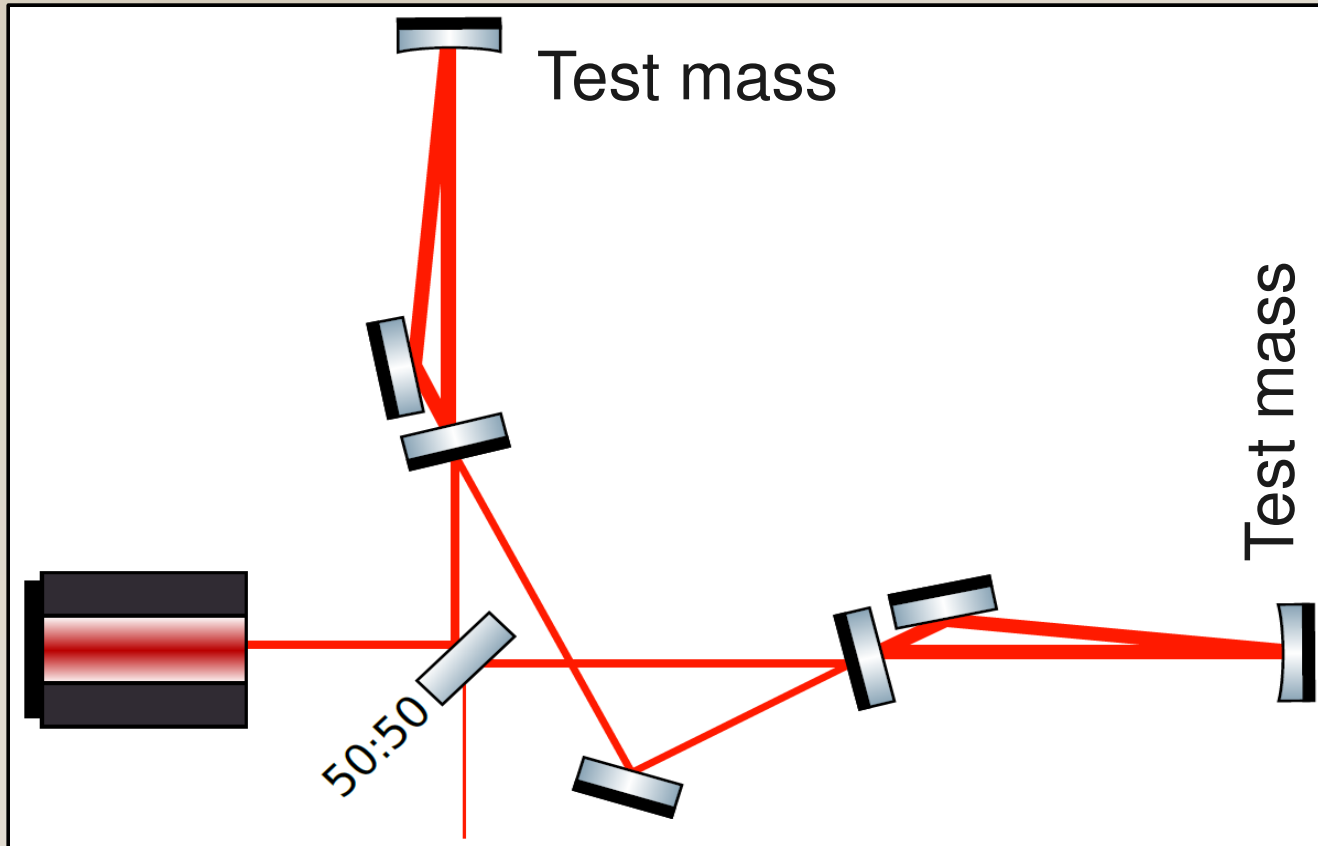
- Sensitive to rotations
- Always dark at the south output port (with perfect 50:50 splitting ratio)
- Not sensitive to reciprocal phase shifts

## Features

- Zero-area



# The Sagnac Interferometer as Gravitational Wave Detector

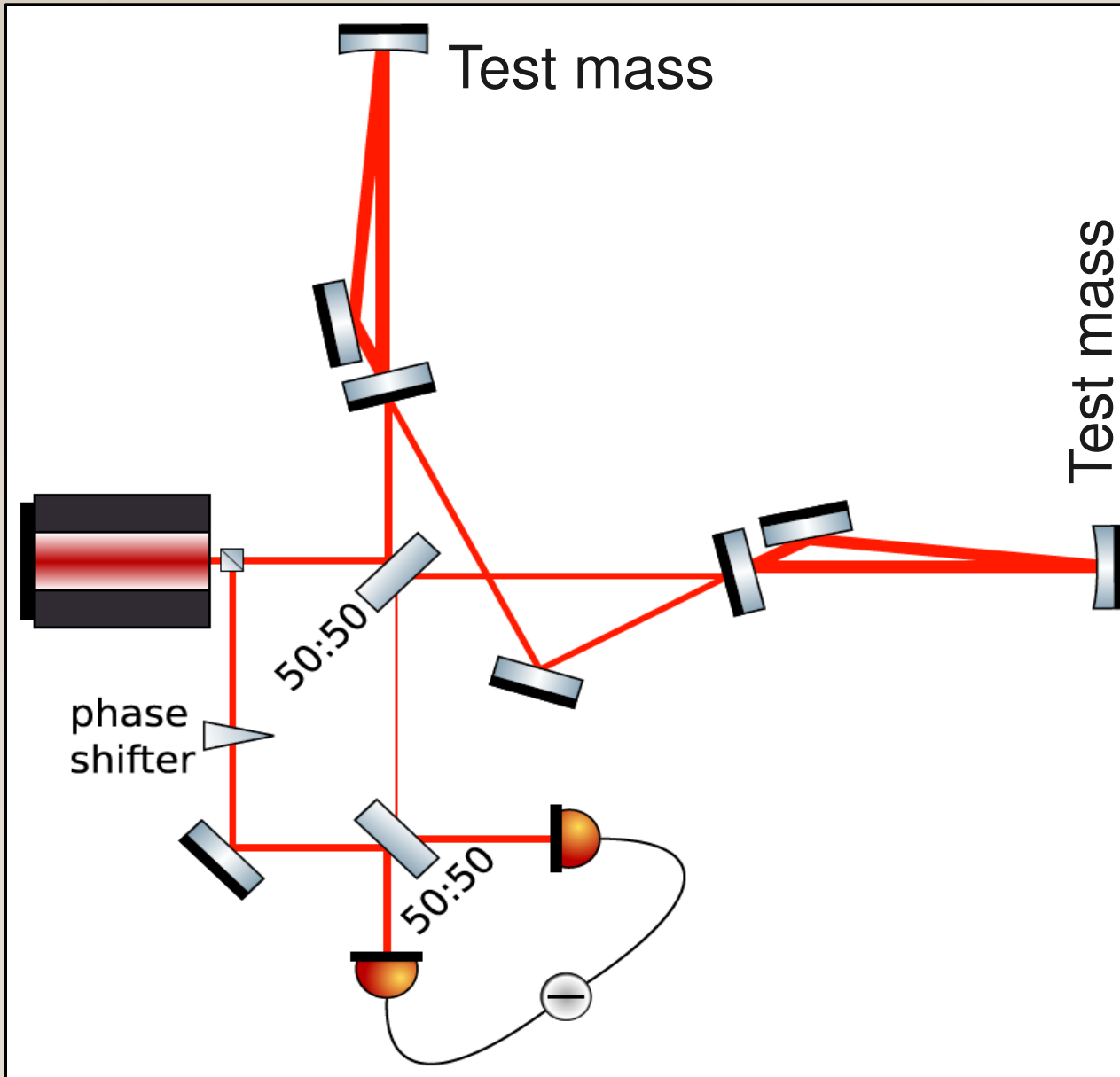


## Features

- Zero-area
- Arm cavities

[www.squeezed-light.de](http://www.squeezed-light.de)

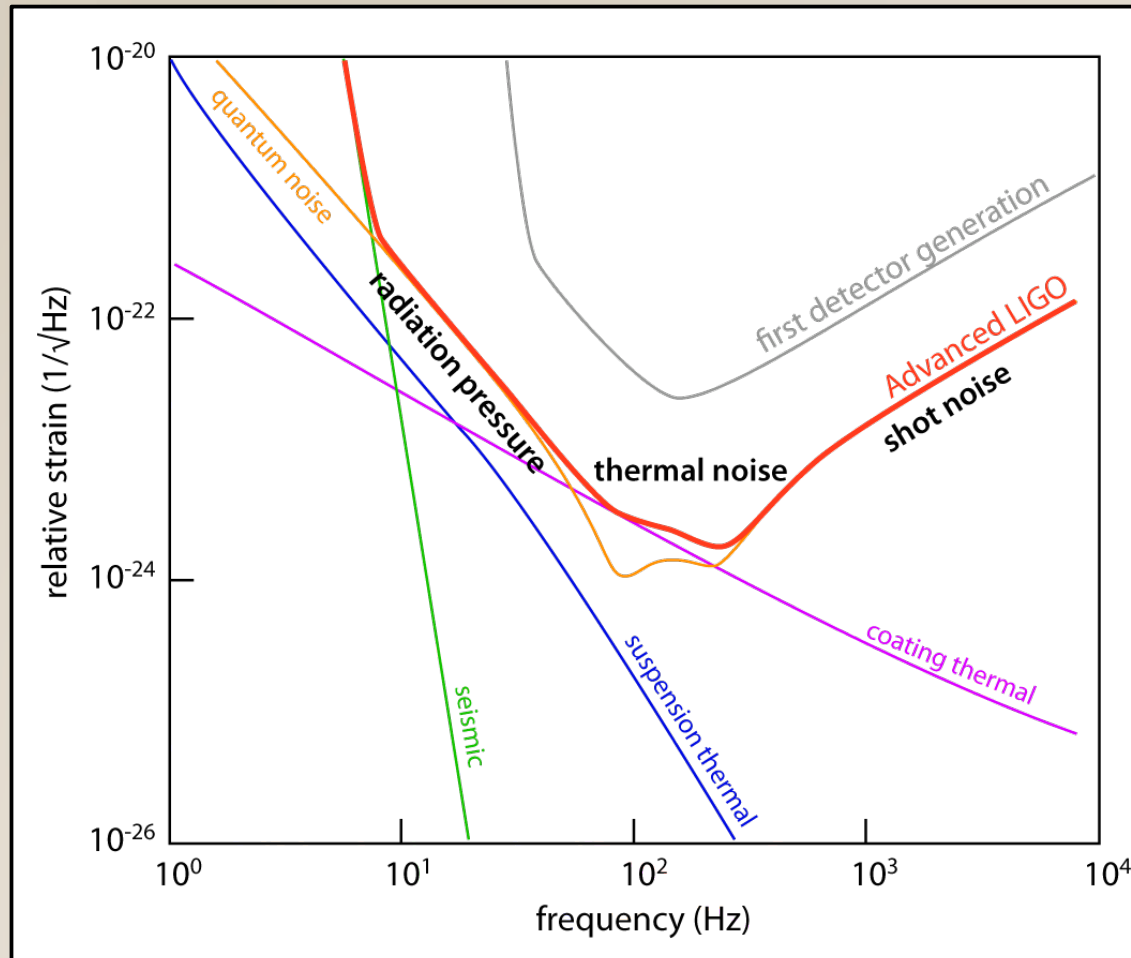
# The Sagnac Interferometer as Gravitational Wave Detector



## Features

- Zero-area
- Arm cavities
- Homodyne Readout

[www.squeezed-light.de](http://www.squeezed-light.de)

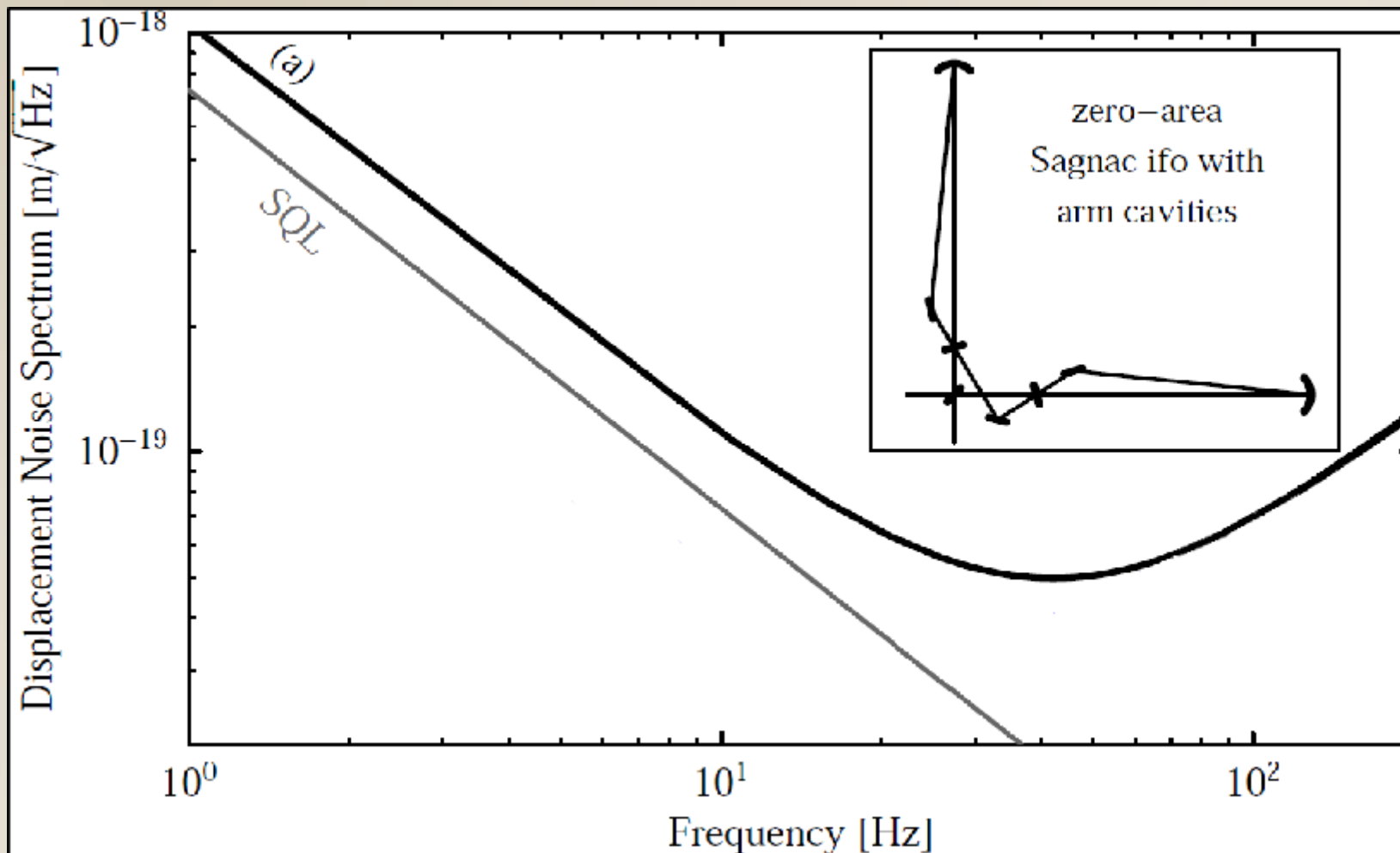


Sagnac Interferometer is a **Quantum Non-Demolition Device**, because

- it is a speed-meter
- The Hamiltonian of a free-falling test mass is  $H=p^2/2m$

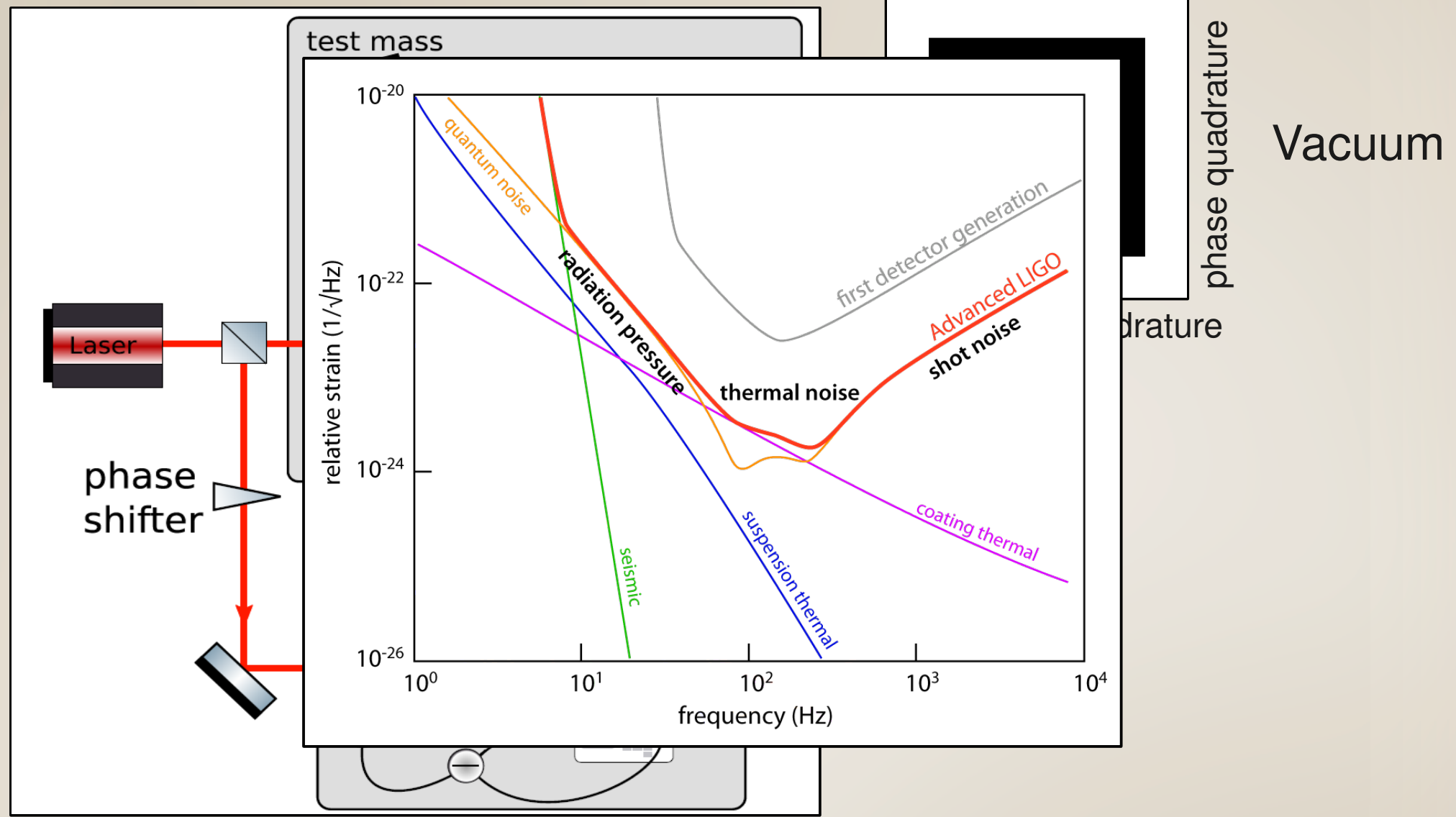
→ **Radiation pressure noise is canceled**

# Sensitivity Curve of a Sagnac interferometer





# Shot-noise reduction

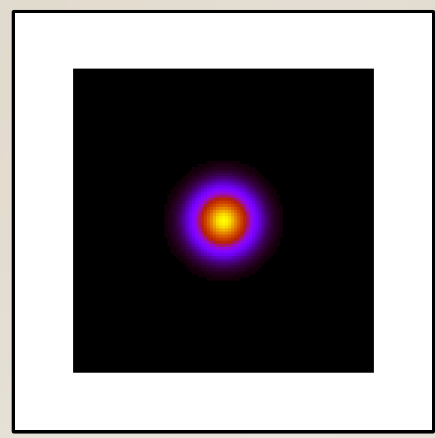
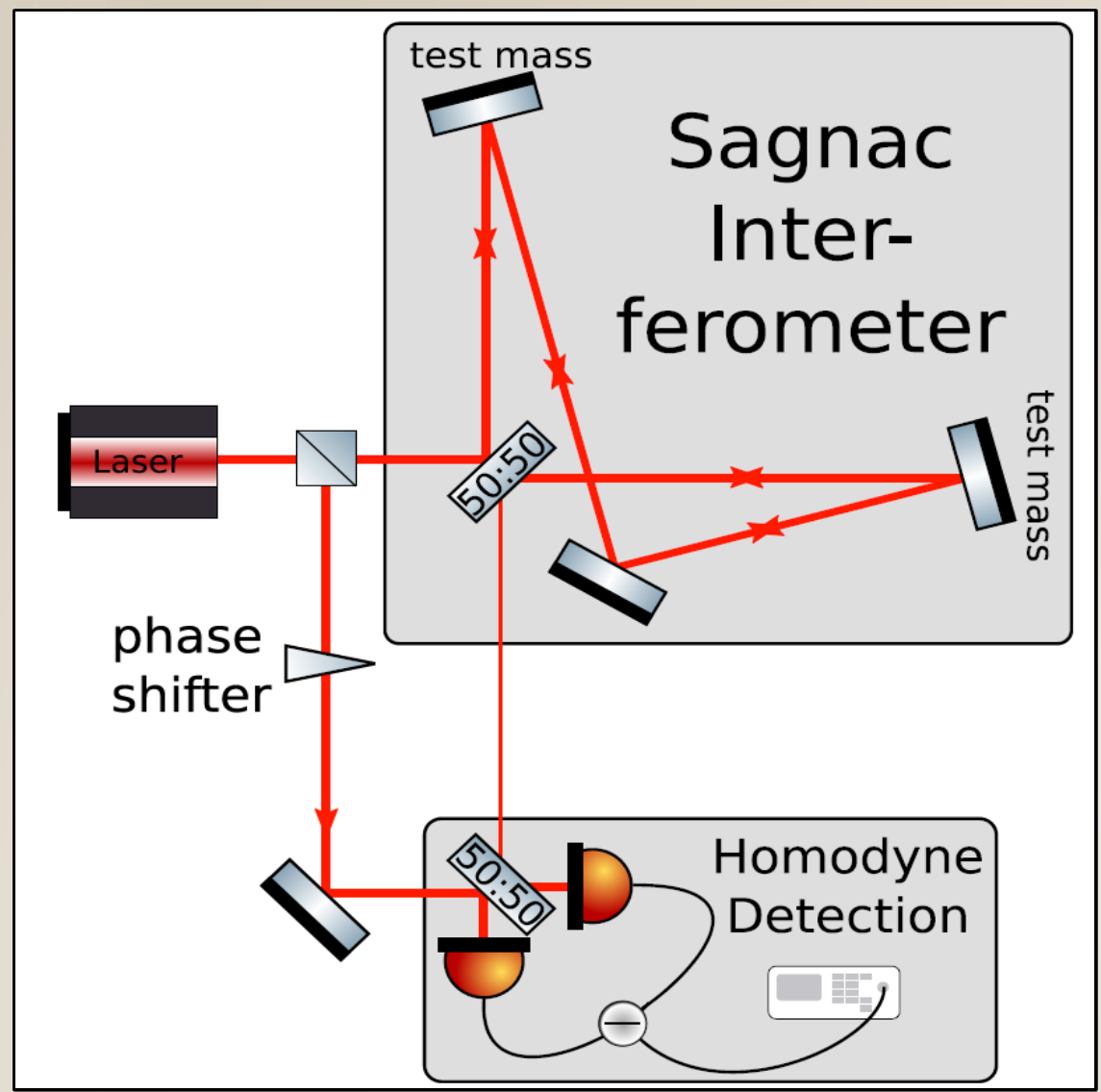


phase quadrature  
brature

Vacuum

[www.squeezed-light.de](http://www.squeezed-light.de)

# Shot-noise reduction

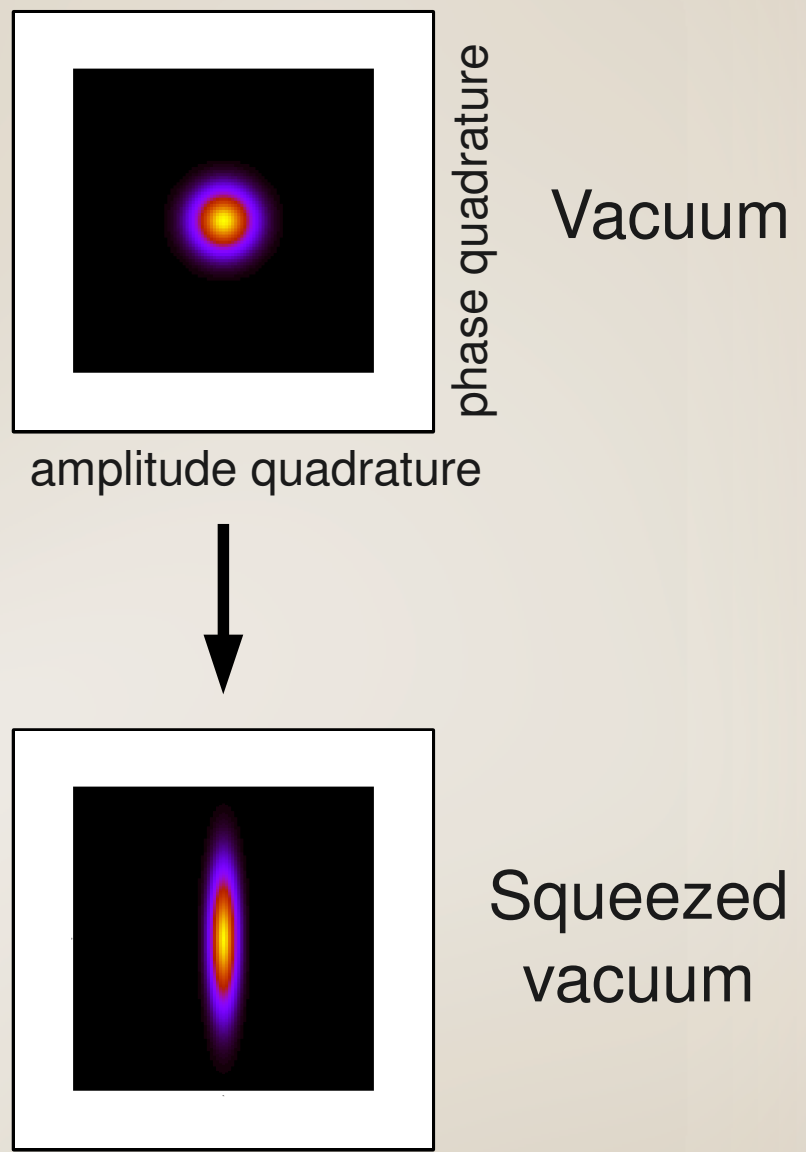
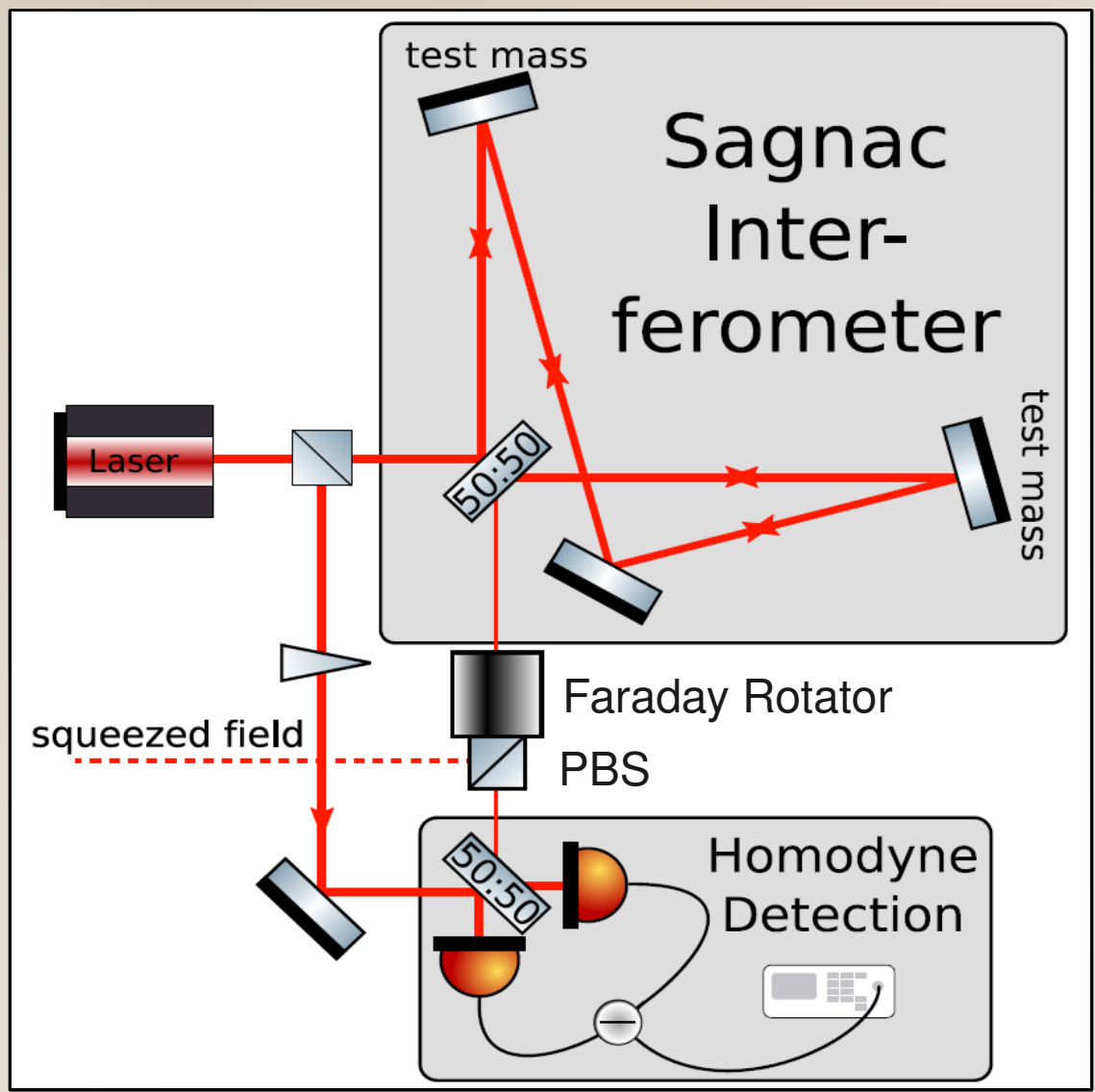


phase quadrature

Vacuum

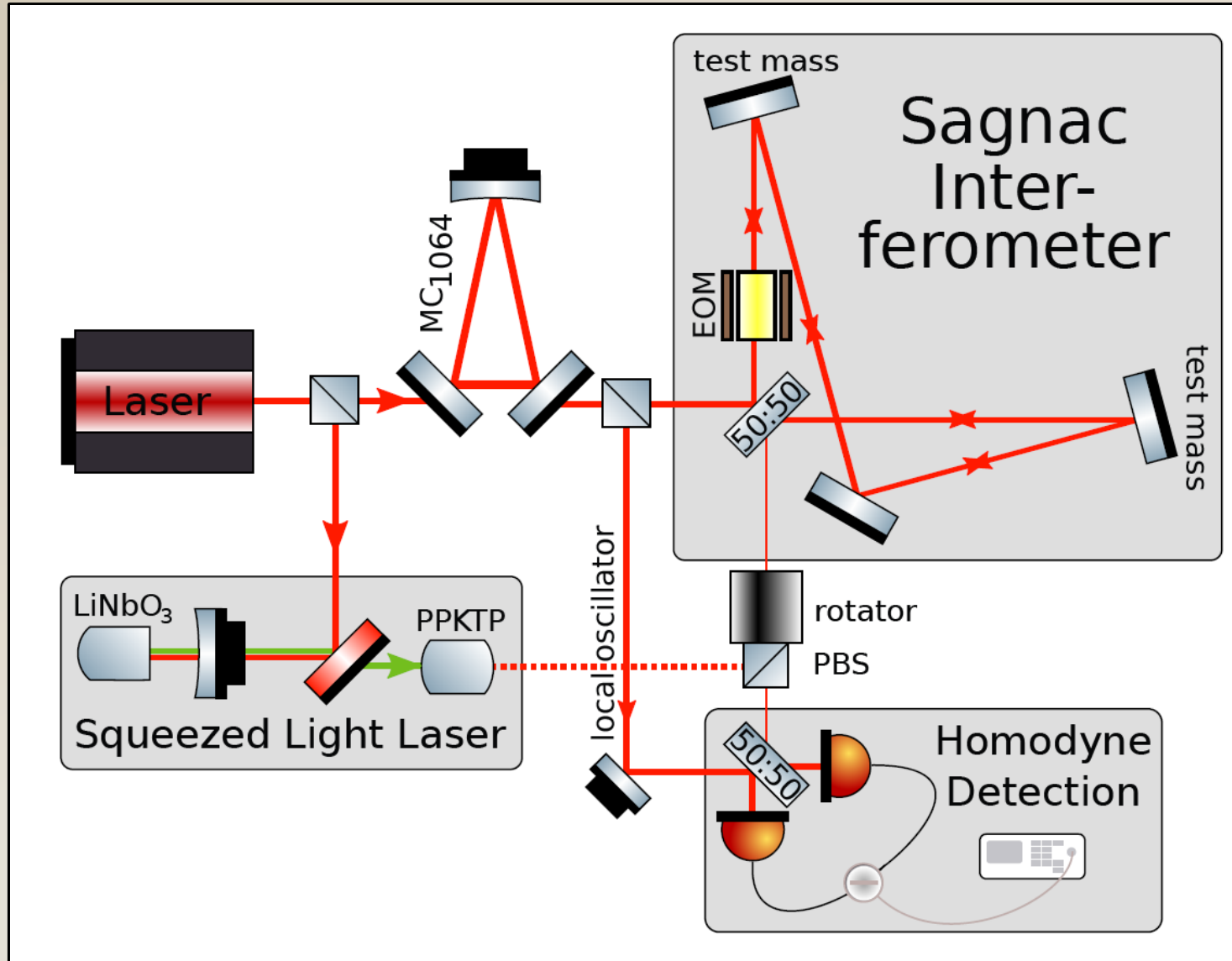
amplitude quadrature

# Shot-noise reduction



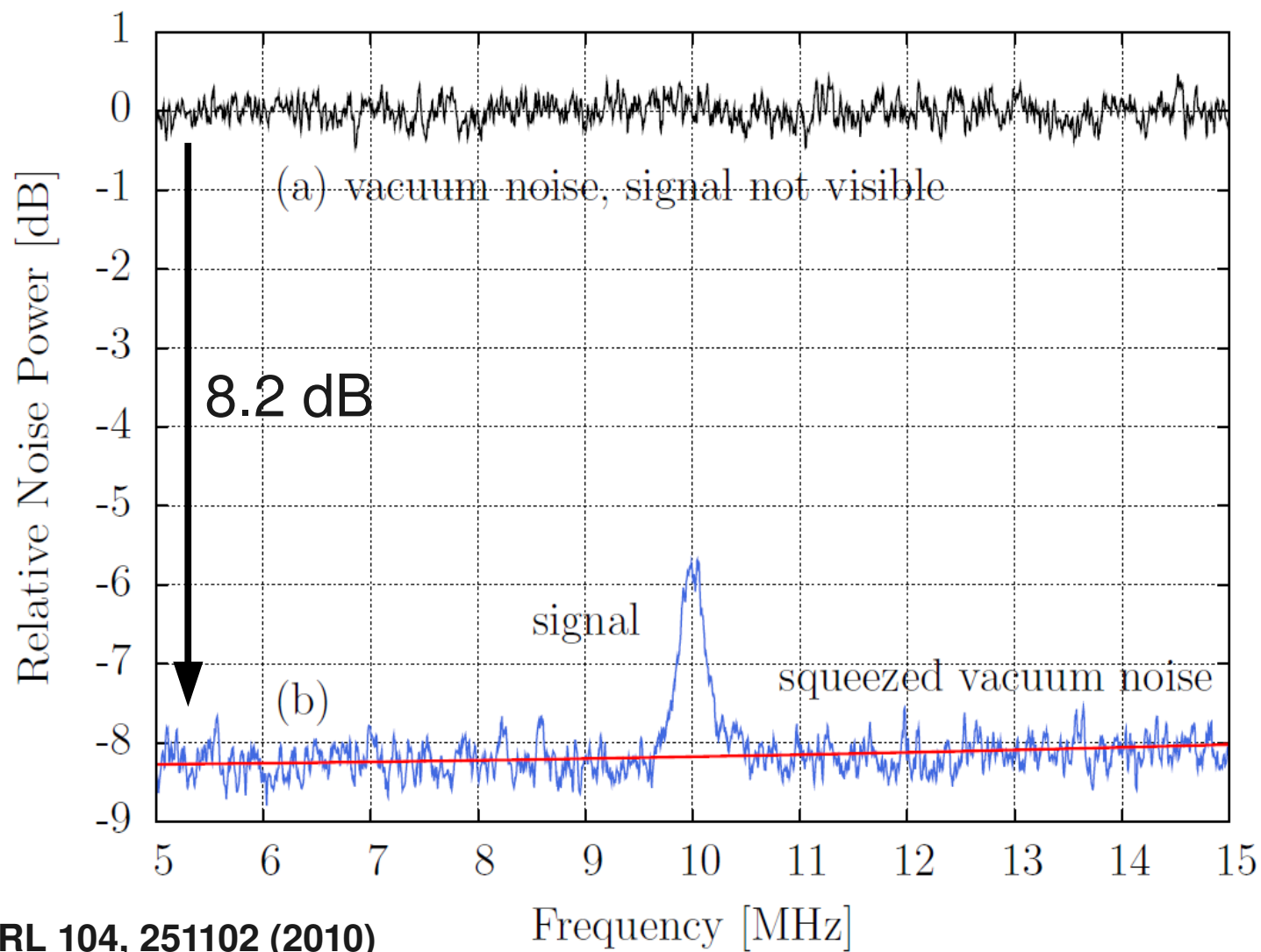
[www.squeezed-light.de](http://www.squeezed-light.de)

# Experimental Setup

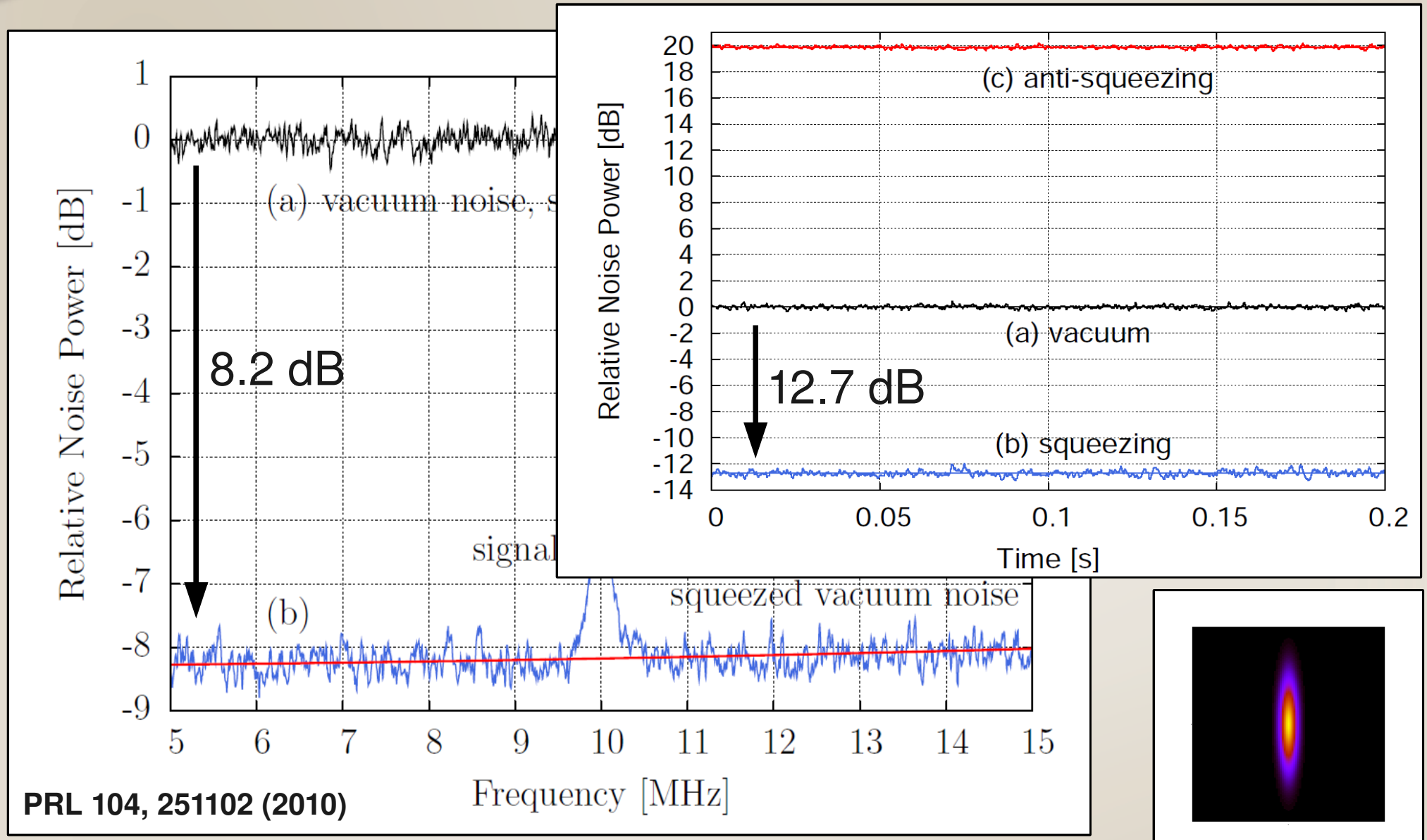


[www.squeezed-light.de](http://www.squeezed-light.de)

## Results

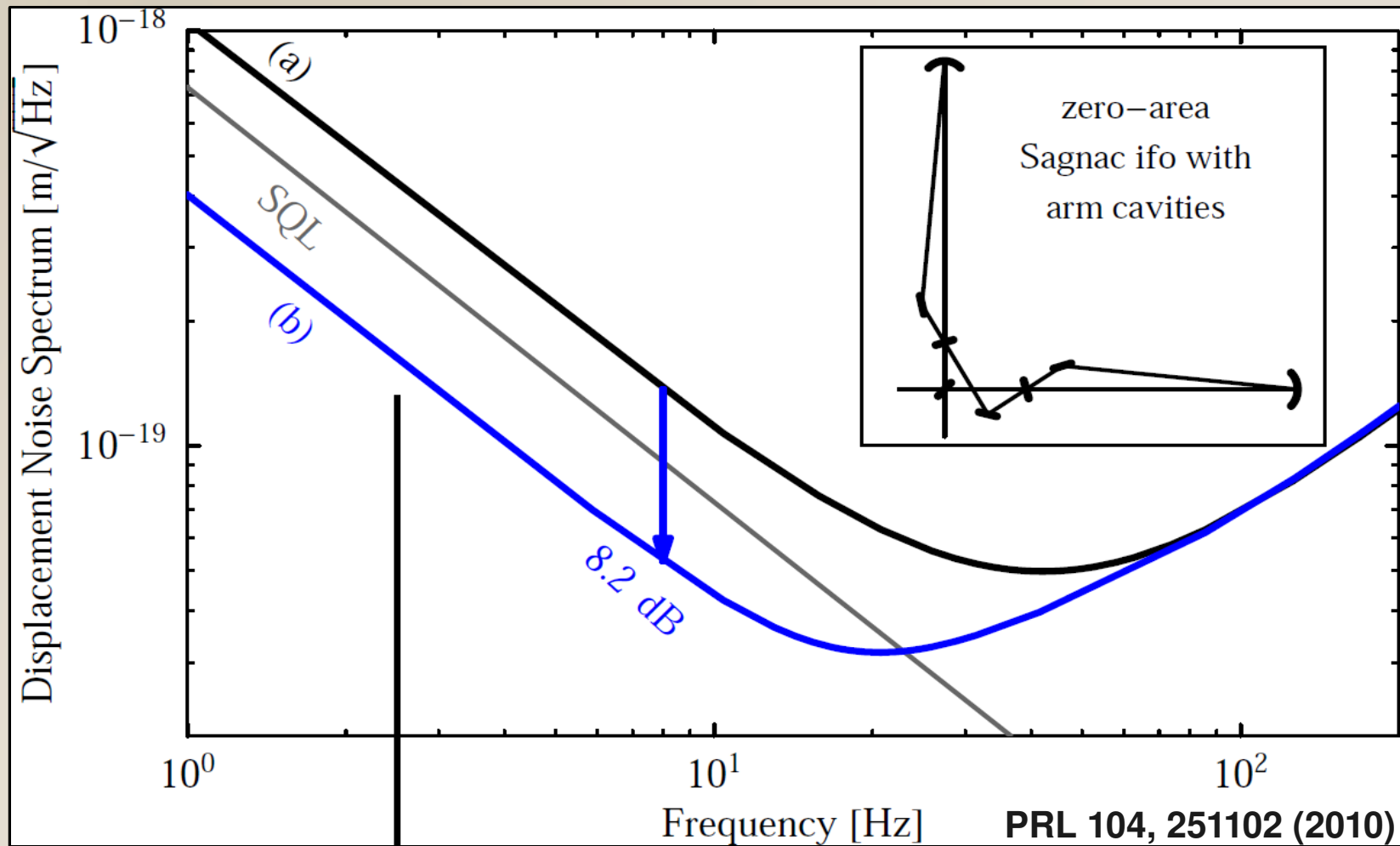


[www.squeezed-light.de](http://www.squeezed-light.de)



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# Theoretical Sensitivity Curve



Broadband reduction of quantum noise with squeezed light without the need of filter cavities

[www.squeezed-light.de](http://www.squeezed-light.de)

## Experimental results:

- 8.2 dB non-classical noise reduction of a zero-area Sagnac ifo
- Generation of 12.7 dB squeezing
  
- Sagnac interferometer might be interesting for future GW detectors
  - Cancels radiation pressure noise
  - Can be enhanced by squeezed light without the need of filter cavities