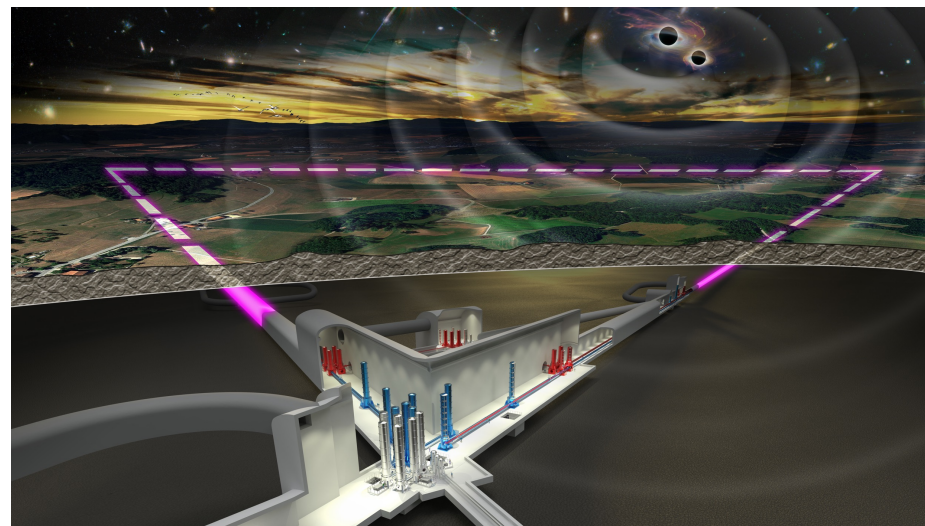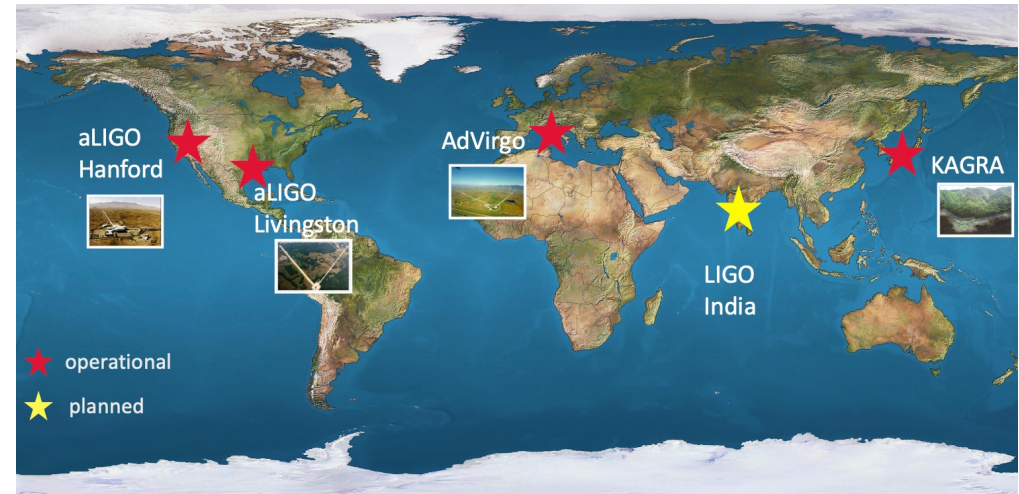# Squeezed-vacuum techniques for quantum noise reduction in interferometric gravitational-wave detectors

Research at APC

Isander Ahrend, <u>Matteo Barsuglia</u>

Eleonora Capocasa, Anne Daumas, Jacques Ding,

Michael Hartman, Pierre Prat

Léon Vidal, Yuhang Zhao

Gravitational-wave detectors

Squeezing

- Quantum noise limits the sensitivity of gravitational-wave detectors (as Virgo,LIGO, KAGRA) in a large part of the spectrum
- Quantum noise is given by vacuum fluctuations entering in the detector
- We can reduce the effect of vacuum fluctuations using special quantum optics techniques : squeezing
- Squeezing has been tested in Virgo and LIGO (+50% sources detected)
- For future detectors more sophisticated squeezing sources are needed
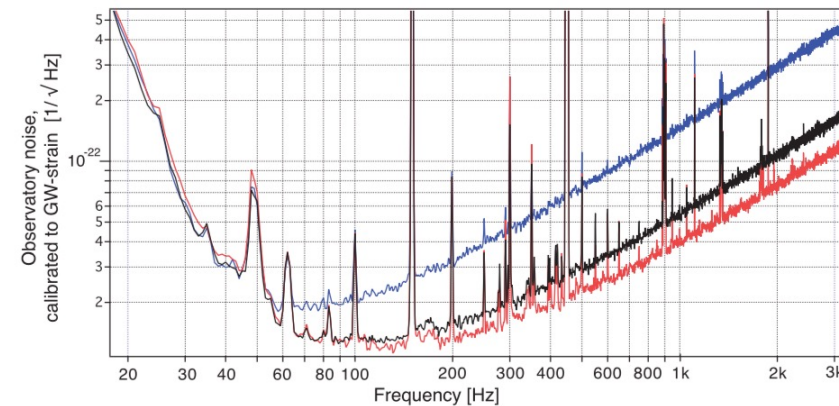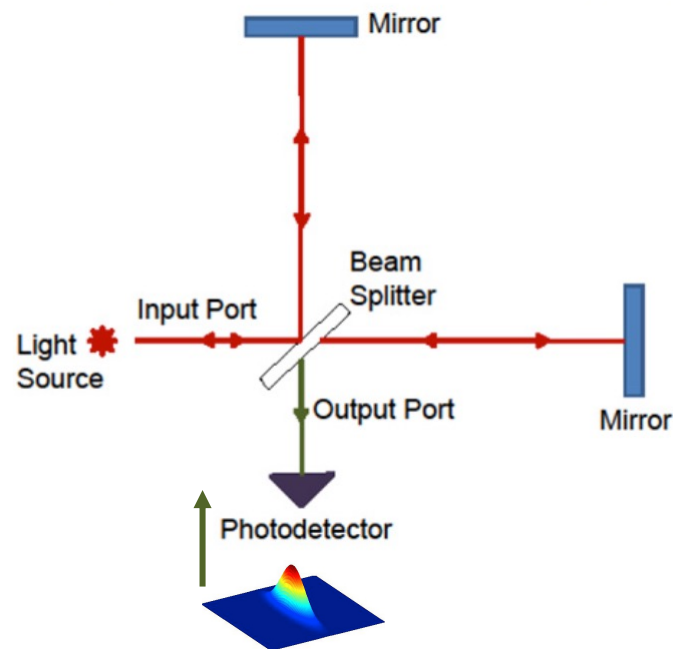
APC group

- Contribution on the first demonstration of frequency dependent squeezing below 100 Hz realised in a full scale prototype (2020) - https://physics.aps.org/articles/v13/s55
- Contributions on the squeezing for Virgo
- Developments of control techniques for squeezing
- Optimization of losses in a 300-m filter cavity

- 2 staff, 2 PhD students, 2 post-docs, 2 engineers
- 10 papers published on squeezing, 1 accepted, 1 in preparation https://quantum-fresco.in2p3.fr/Publications.html
- 2 PhD thesis already concluded on squeezing, 2 PhD thesis on-going
- 1 ANR (Quantum-FRESCO)
- Member of Paris Center for Quantum Technologies (PCQT) member of QuanTech InidEx Paris Cité
- Various international collaborations (i.e. NAOJ-Japan, MIT-KAVLI)
- Responsibilites for squeezing for Einstein Telescope and Virgo_nEXT

Our last work (published on Physical Review D):

https://arxiv.org/abs/2506.02222

Performance of multiple filter-cavity schemes for frequency-dependent squeezing in gravitational-wave detectors, Jacques Ding, Eleonora Capocasa, Isander Ahrend, Fangfei Liu, Yuhang Zhao, Matteo Barsuglia

On going

- Realization of a squeezed vacuum source

- Table top demonstration of non-trivial rotation of the squeezing ellipse
- Mimization of losses to improve squeezing
- Contribution to squeezing for Virgo (O5) and Virgo_nEXT
- Modeling work