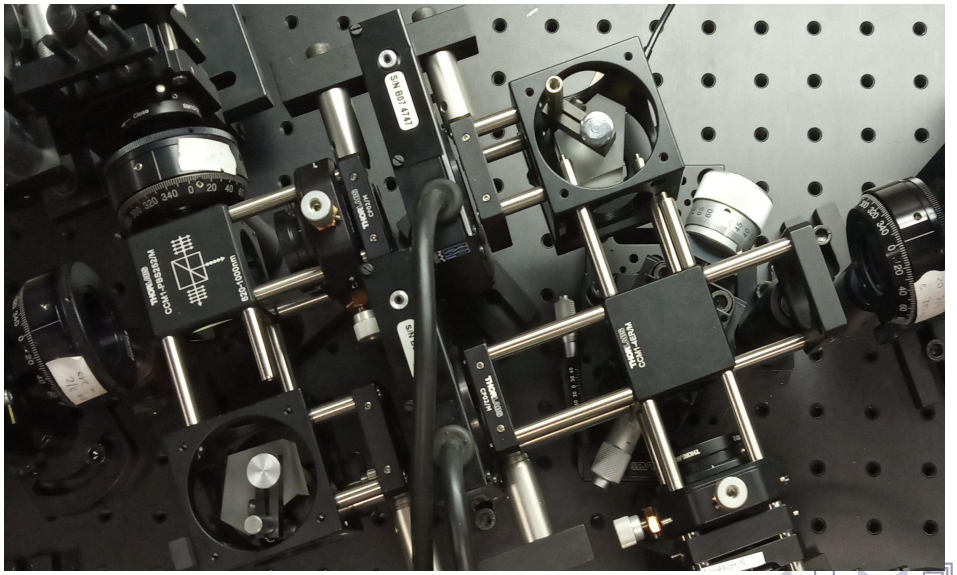
Interferometers in the service of quantum information processing

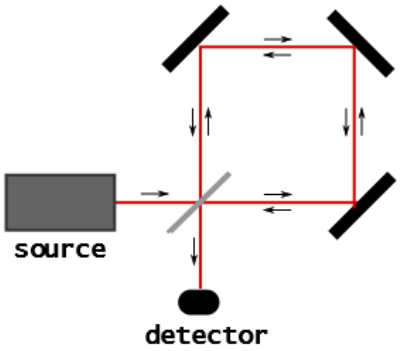
Antonín Černoch

Joint Laboratory of Optics of Palacký University and Institute of Physics of AS ČR

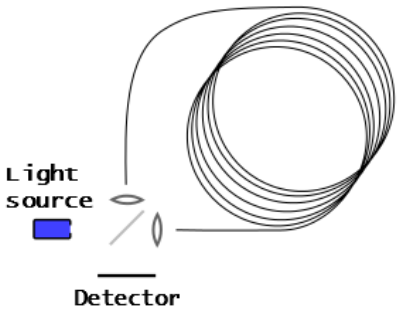


Content

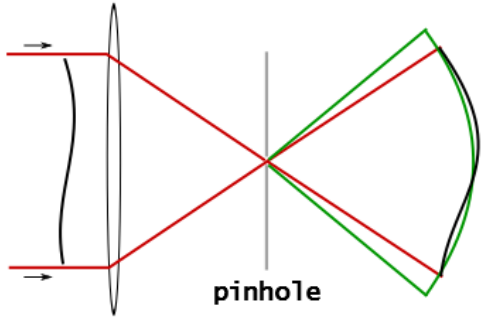
Plenty of possible constructions



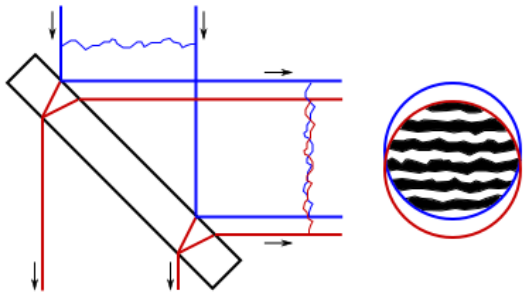
Sagnac



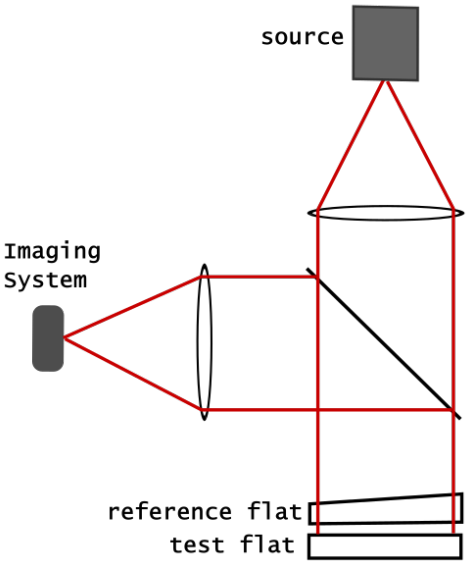
Fiber-Optic Gyroscope



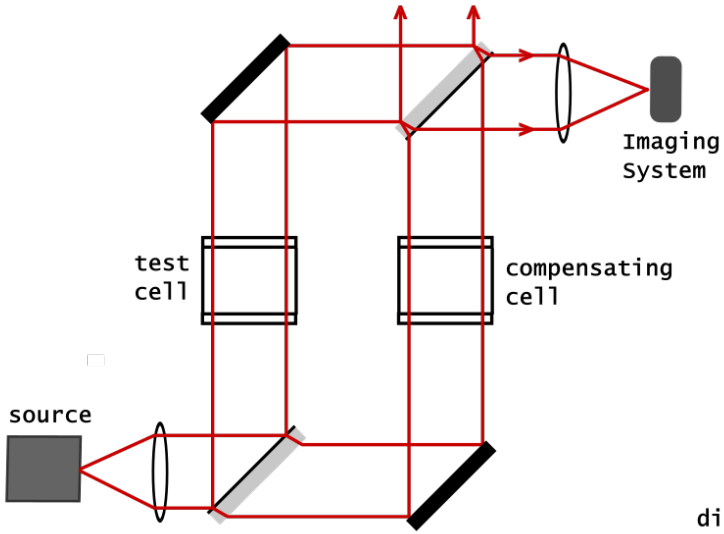
Point Diffraction



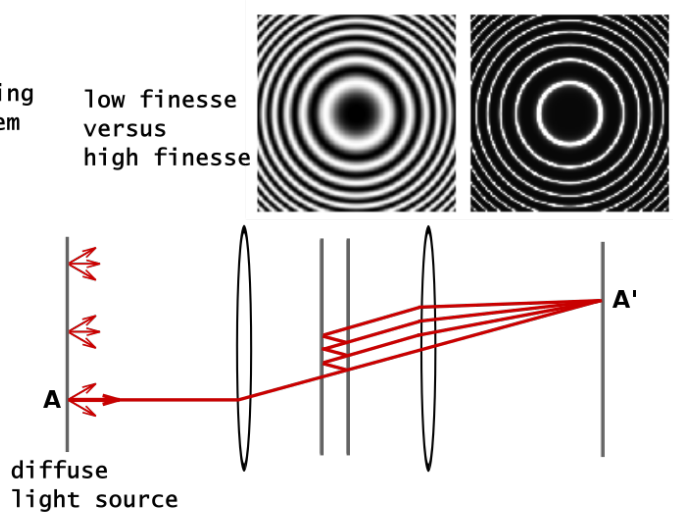
Lateral Shearing



Fizeau

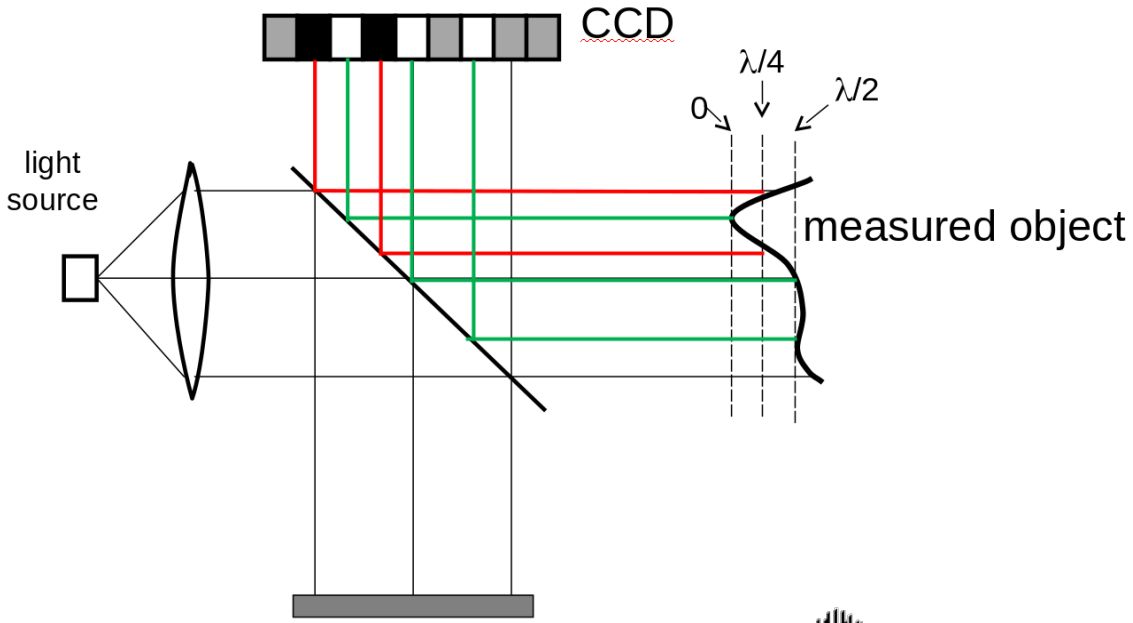


Mach Zehnder



Fabry Perot

White light interferometry



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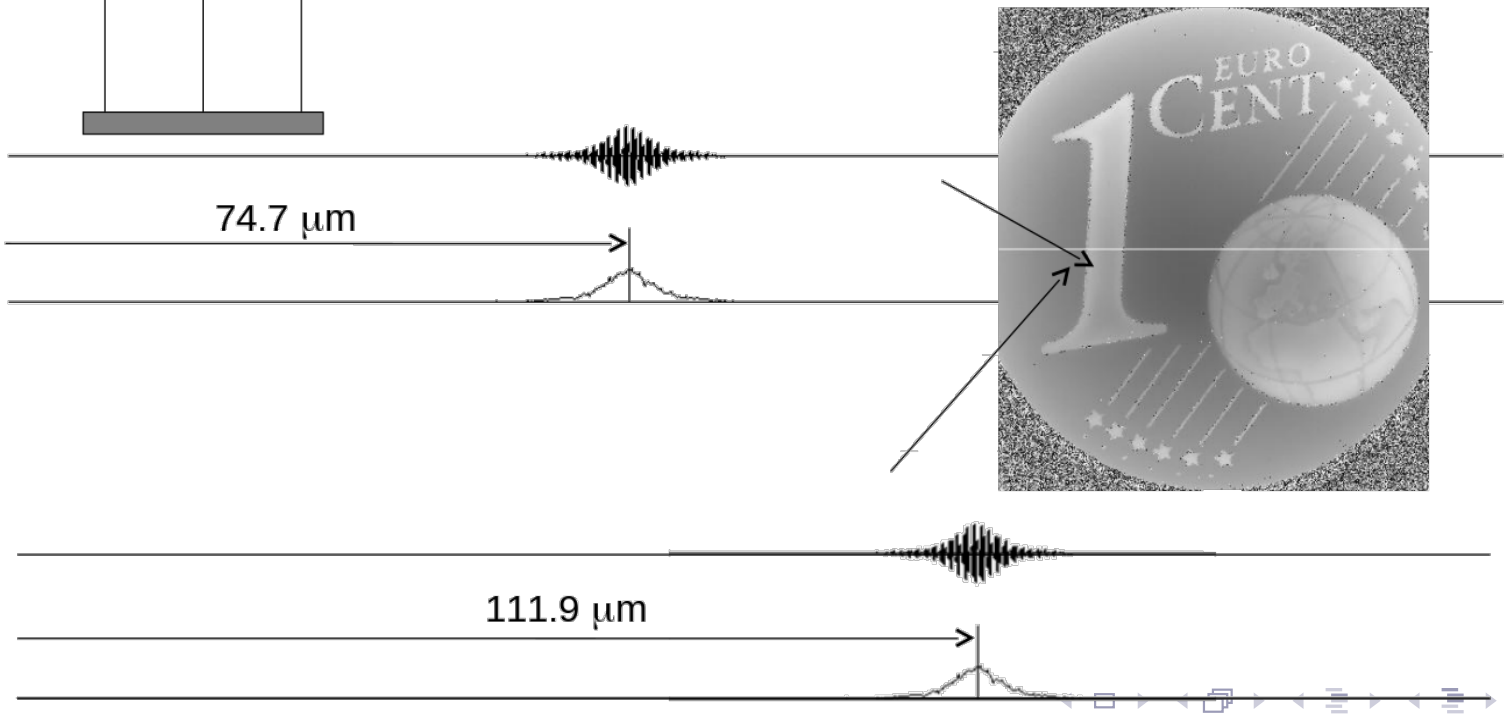
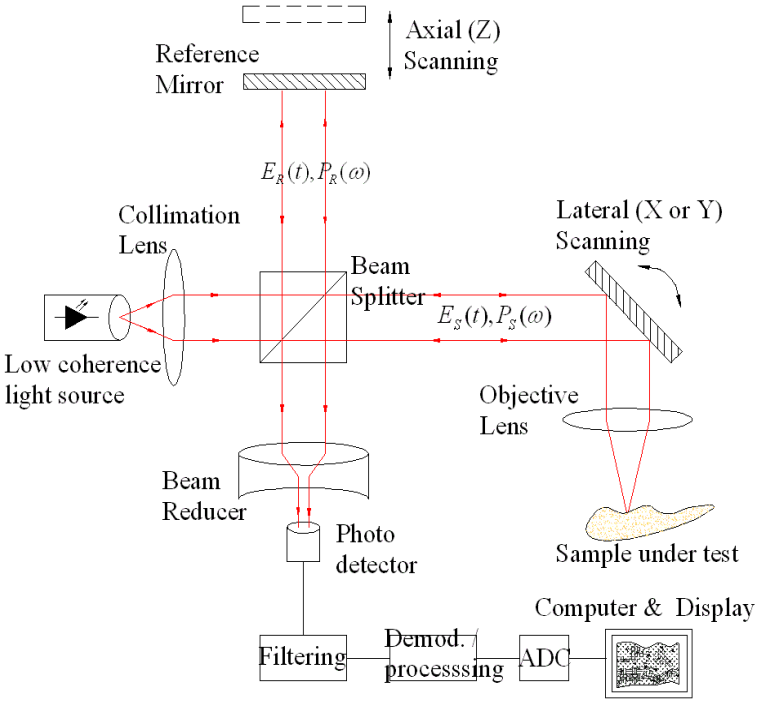
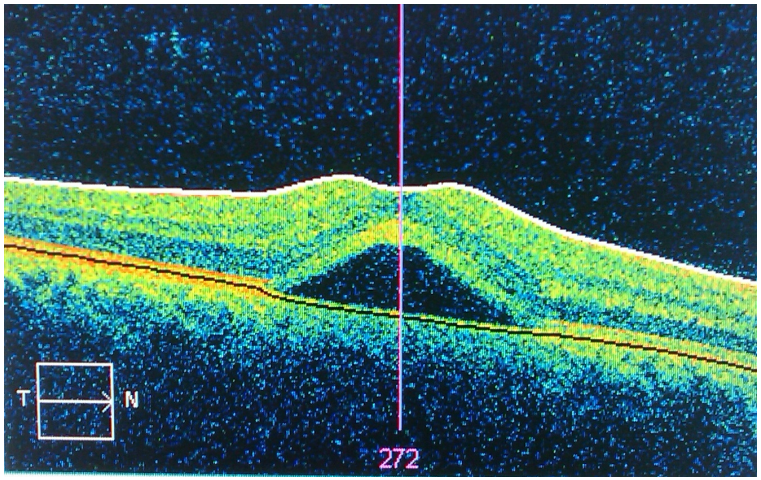
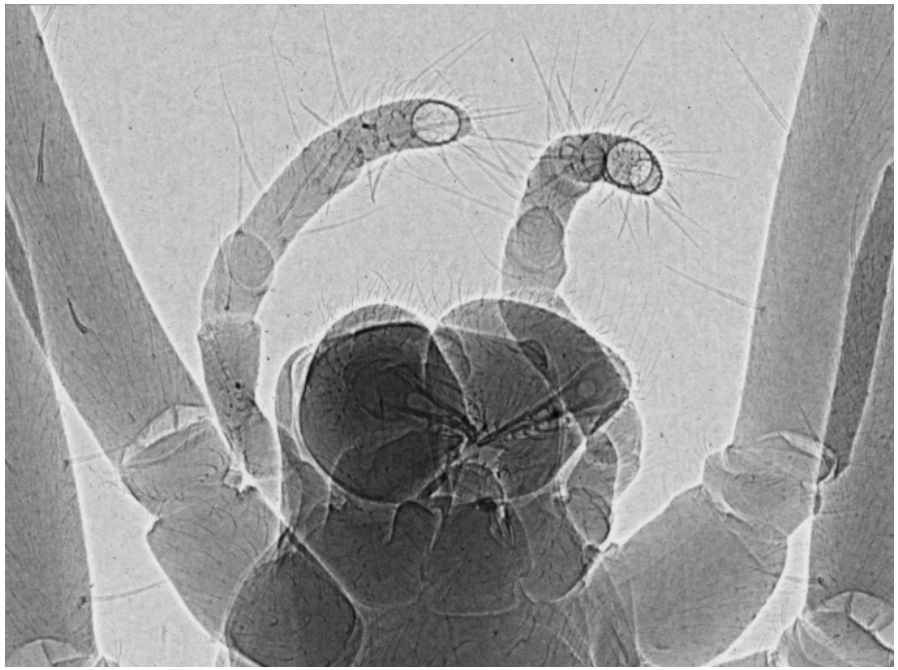


Microscopy

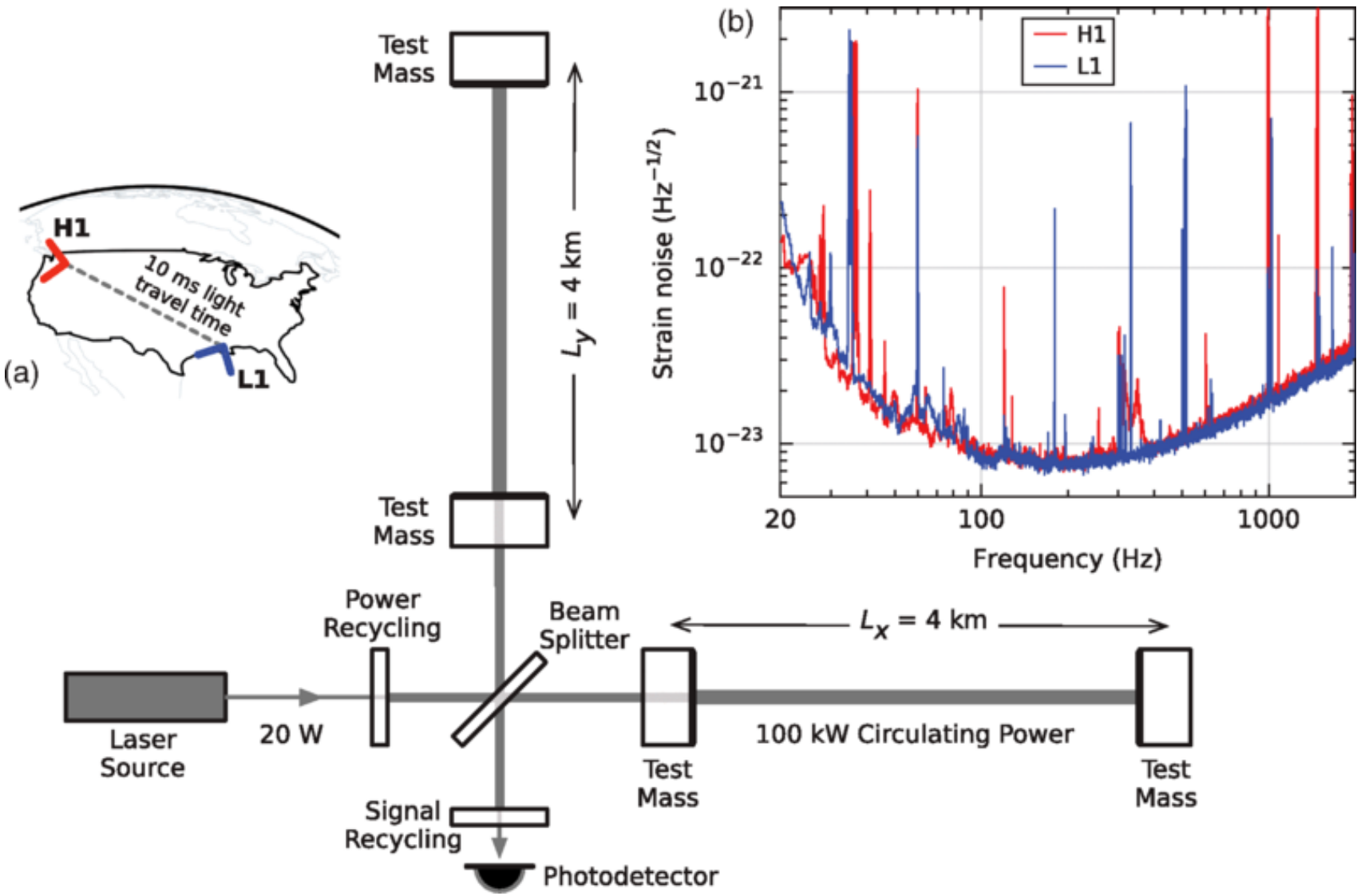




- Optical coherence tomography
- Phase contrast
- Differential interference contrast
- Angle-resolved low-coherence interferometry



Gravity wave detection



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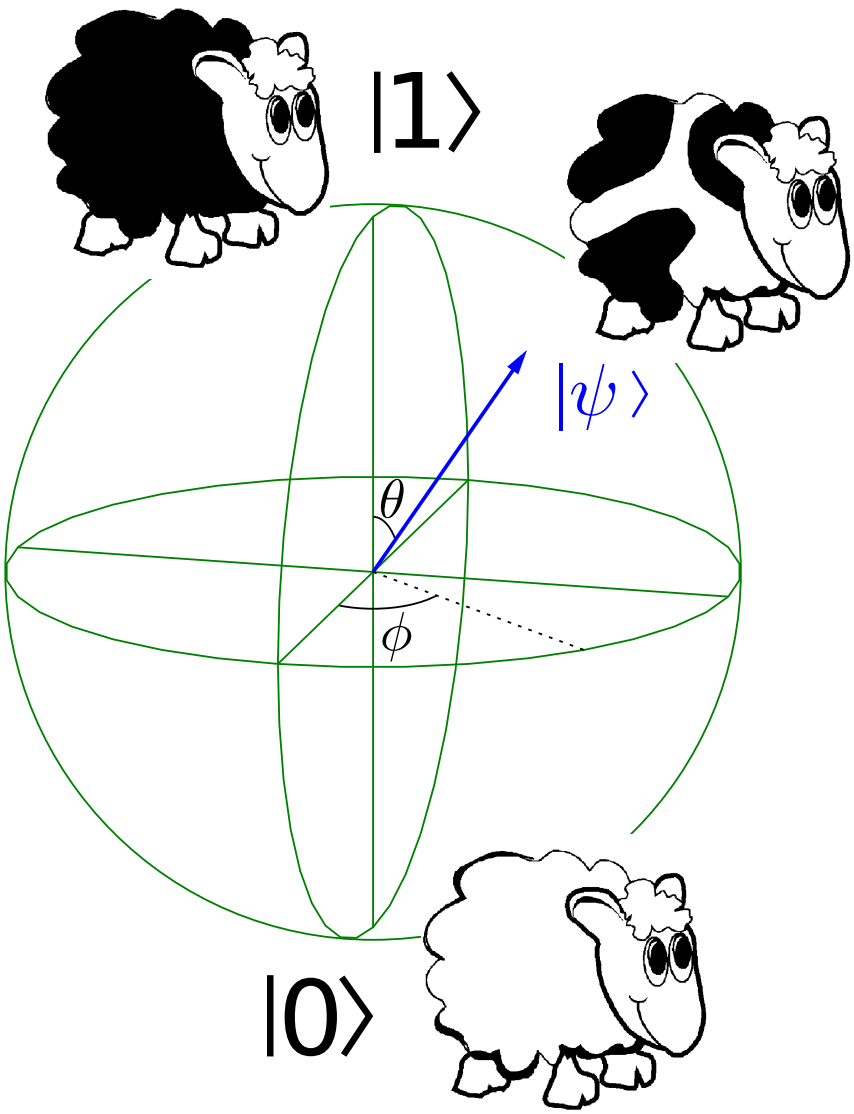
Quantum information



Base states

$$|0\rangle \qquad |1\rangle$$

Superposition principle

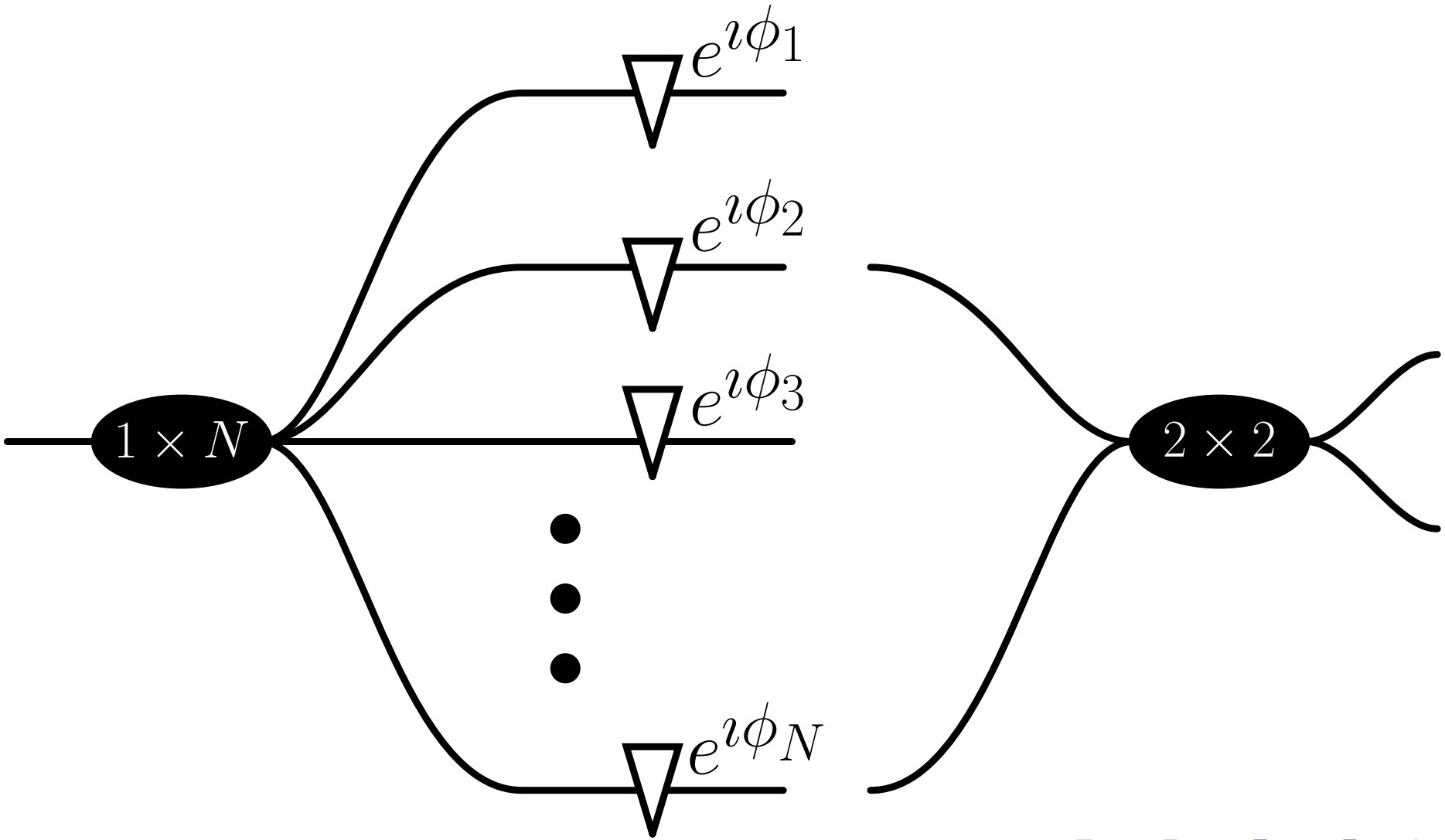
$$|\psi\rangle = \sin\theta\,|0\rangle + e^{i\phi}\cos\theta\,|1\rangle$$

- 1 qubit $= \infty$ classical bits
- projective measurement $\rightarrow$ probabilistic outcome
- entanglement

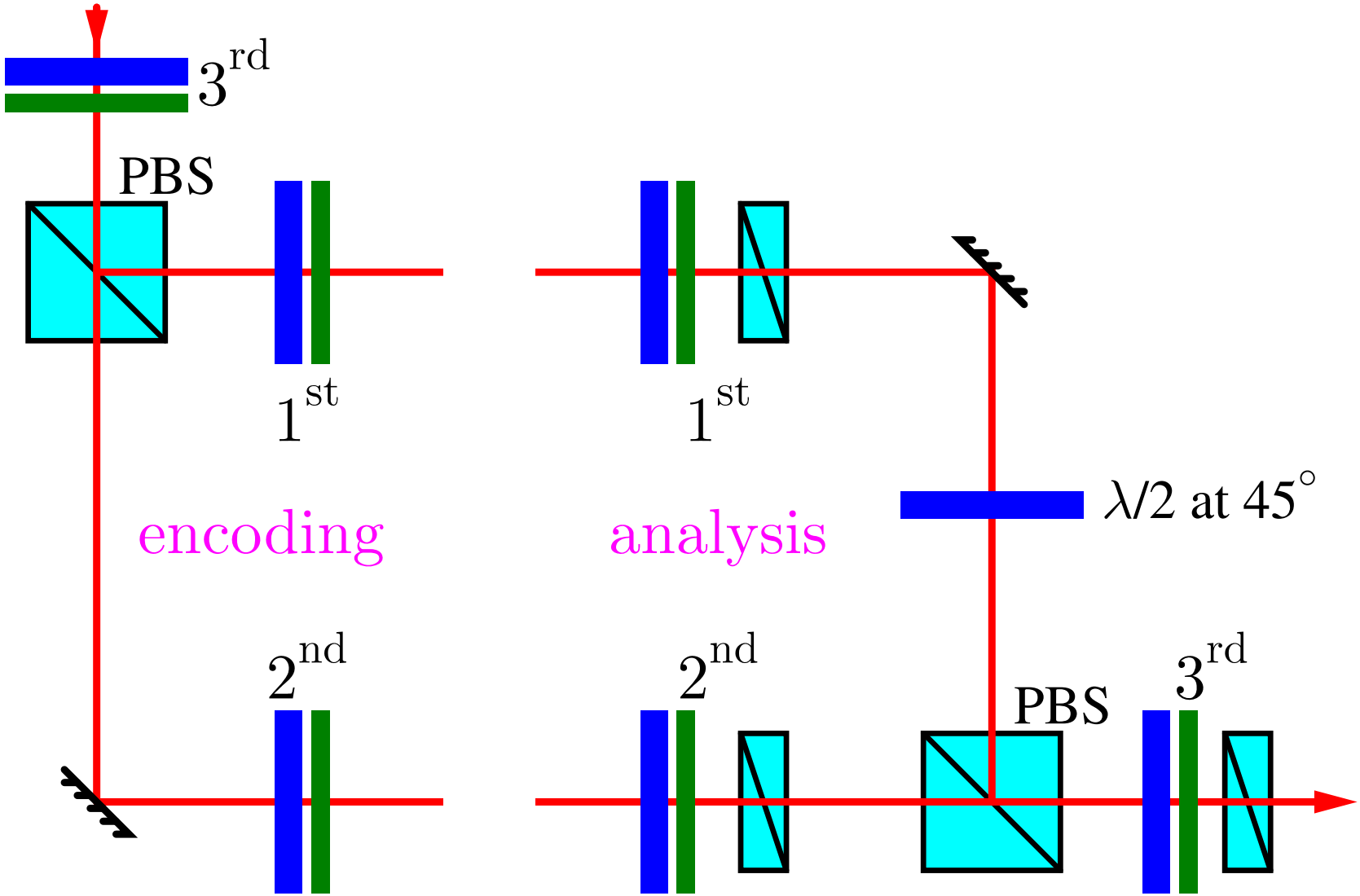
Path encoding

preparation of *N*-dimensional state

measurement



Dense coding – 3 qubits by 1 photon



Content

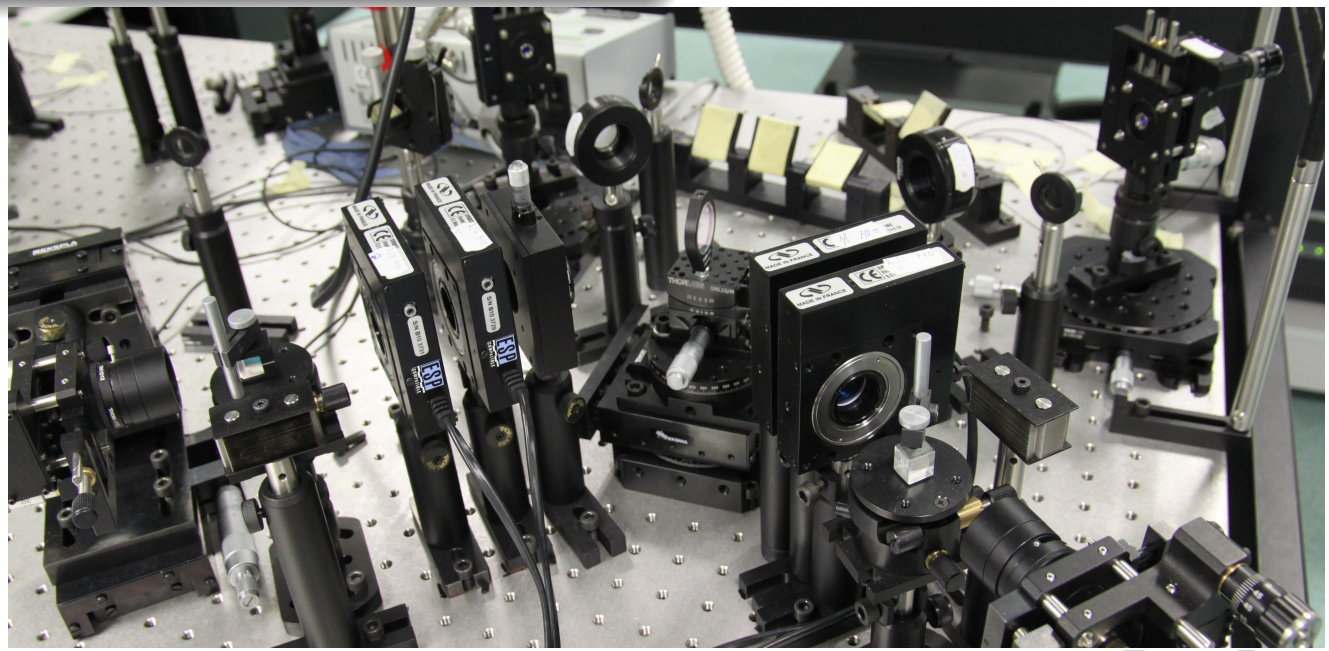
Bulk optics

Positives

- optical components from broad range of applications
- complex setups can be designed
- recycling of setups

Negatives

- large space
- beware of dust
- less stable



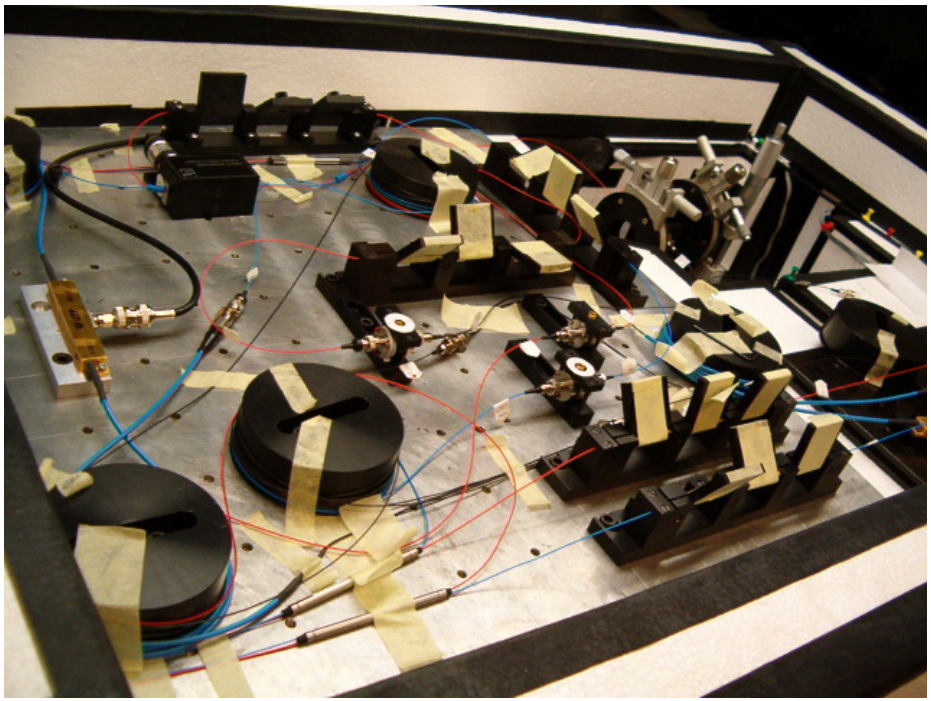
Fiber optics

Positives

- special components (VRC)
- perfect overlap of spatial modes

Negatives

- bigger losses (phase shift)
- polarization not under control
- fixed length of fibers, AG needed
- more sensitive to temperature fluctuations
- new components optimized for 1 550 nm



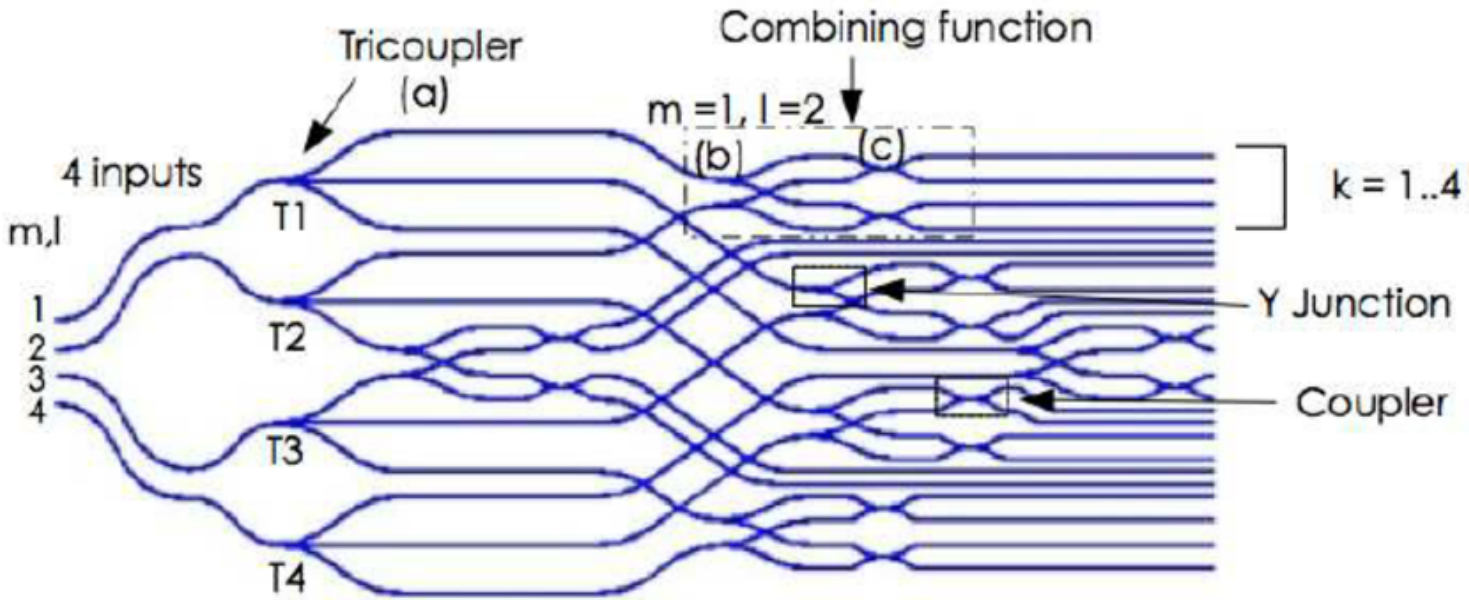
Integrated optics

Positives

- compact stable construction
- complex setup can be designed

Negatives

- coupling losses
- fixed components
- expensive fabrication



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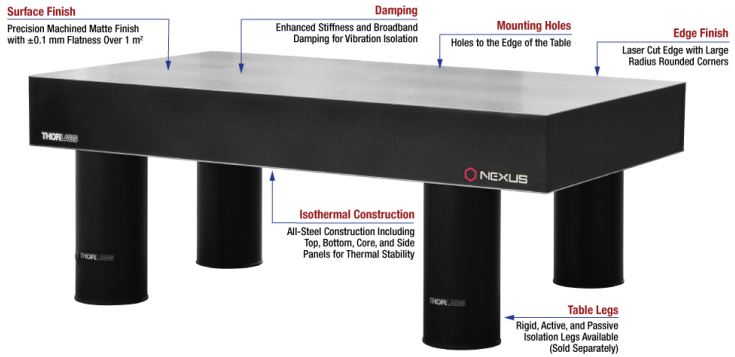
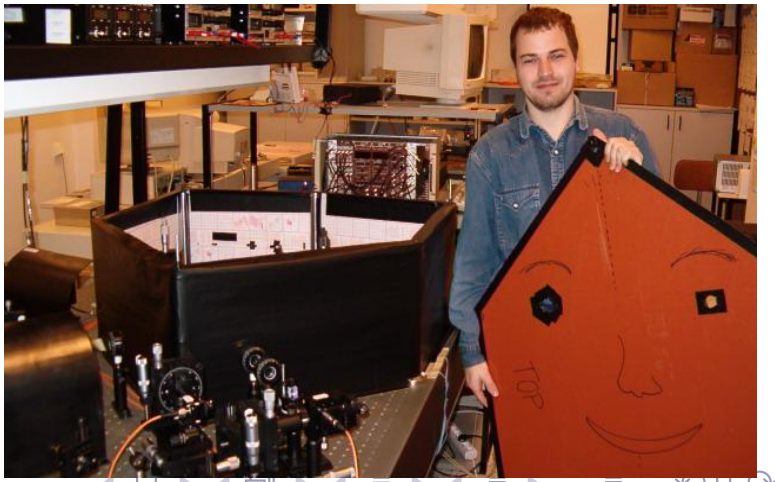
Content

Passive stabilization

- building far from any roads
- laboratory in basement, isolated floor
- air condition with temperature stability and homogeneous air flow
- optical table with vibration damping
- enclosure box, polystyrene, paper or prefabricated
- isolate all possible source of vibrations and temperature gradients
- computer control of the experiment

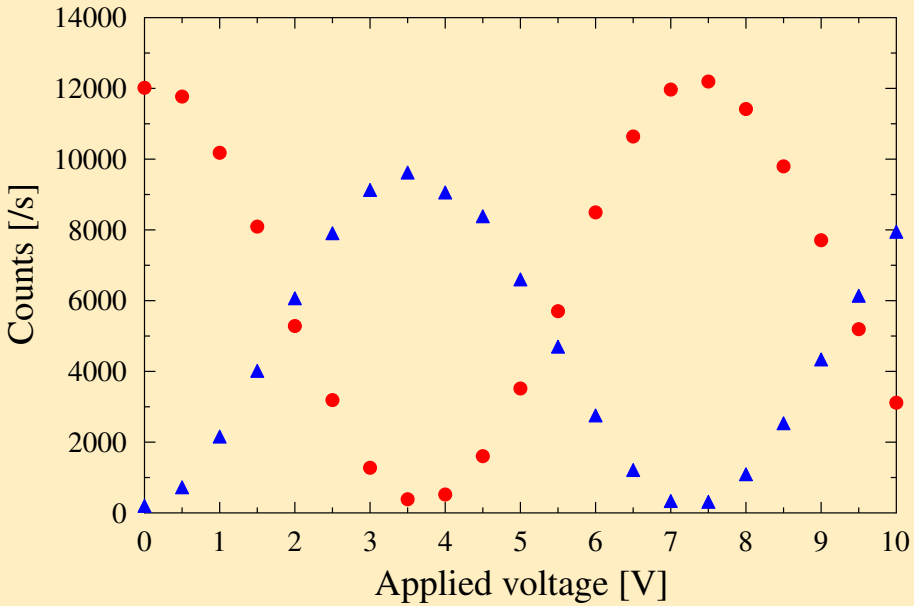




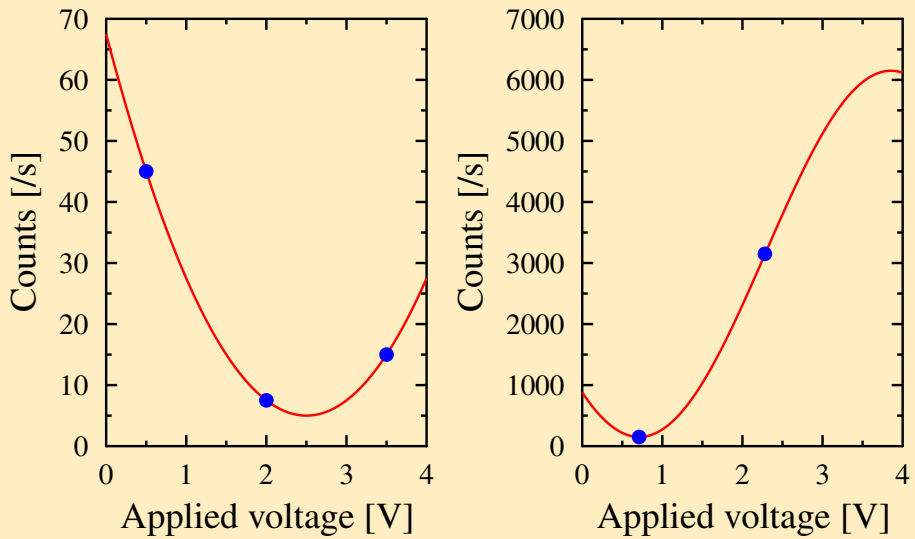
Active stabilization

- perform measurement of phase shift in time
- find the time interval, for which the phase is stable
- perform procedure for active stabilization periodically

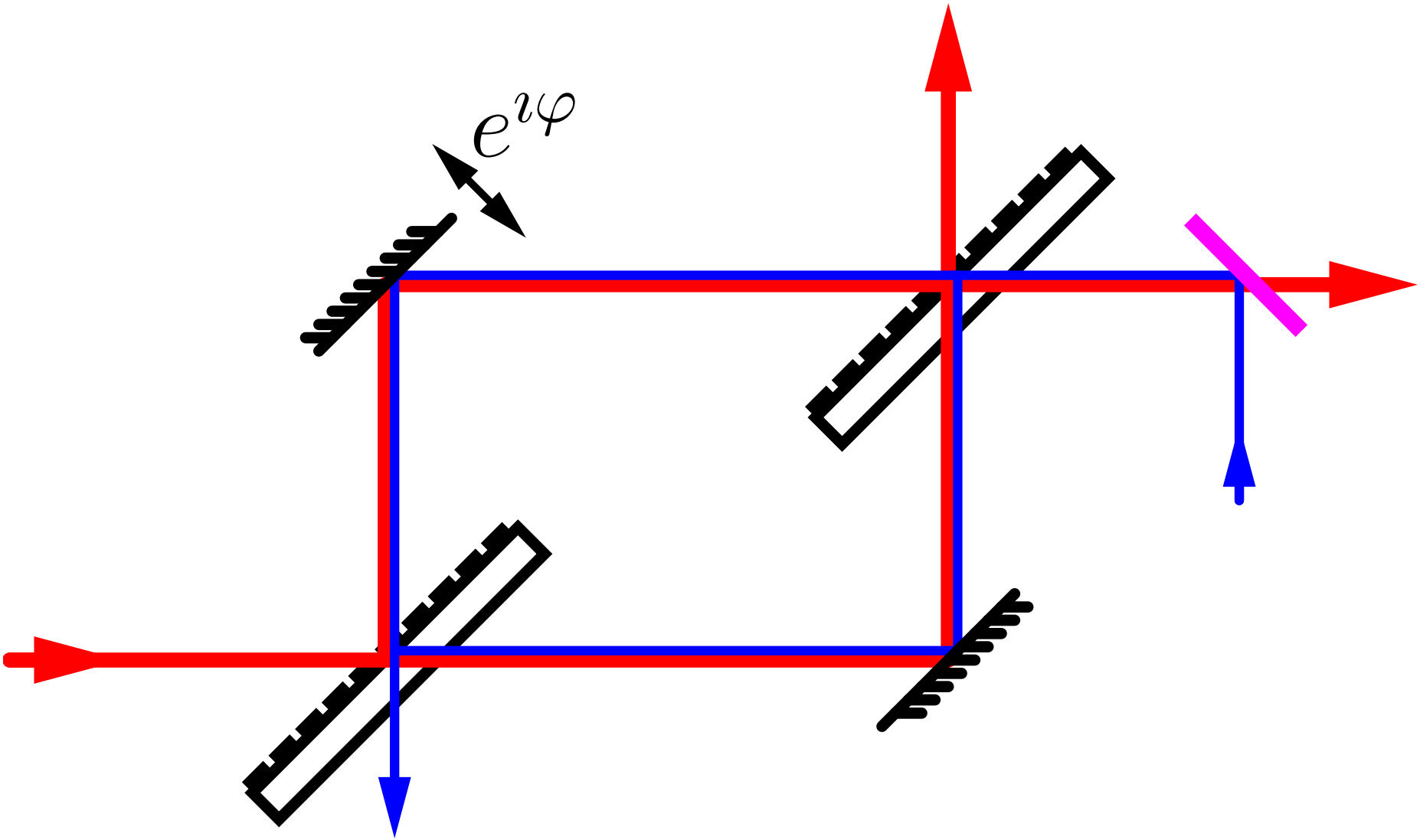
Raw (long) stabilization



Fine (short) stabilization

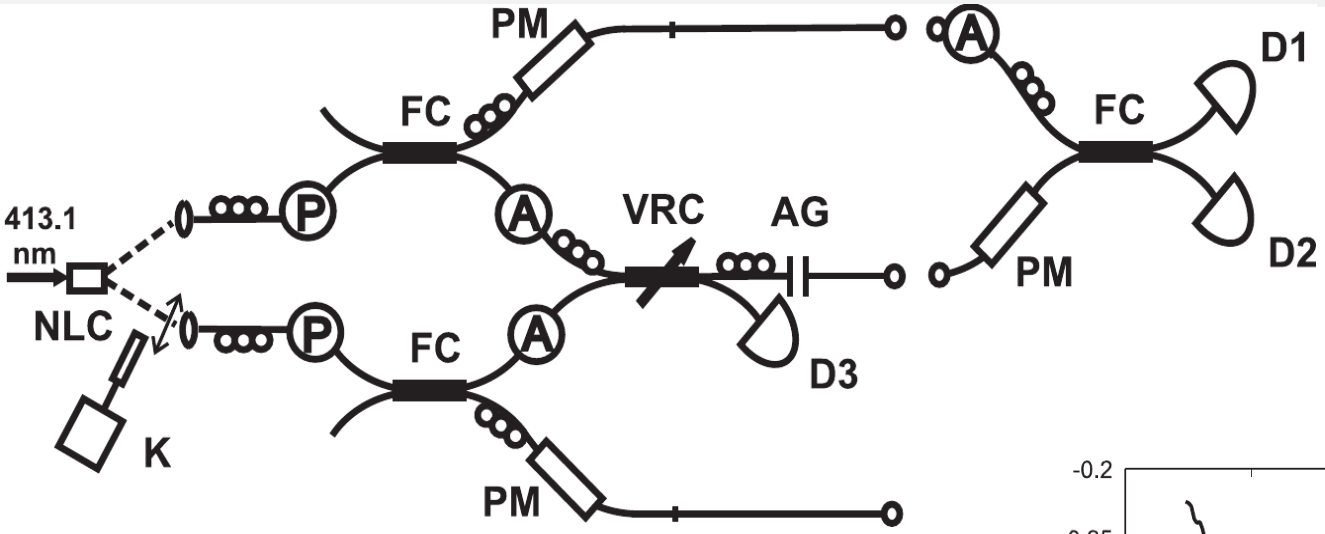


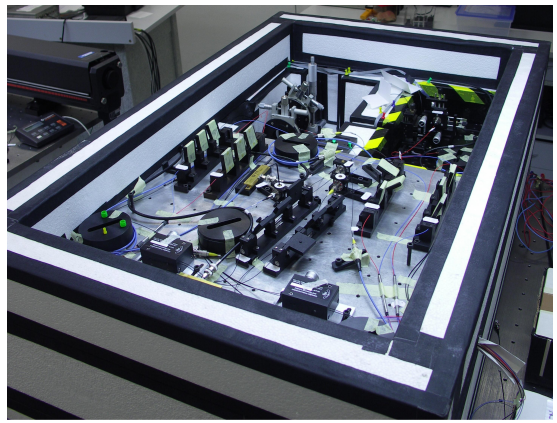
Instant active stabilization



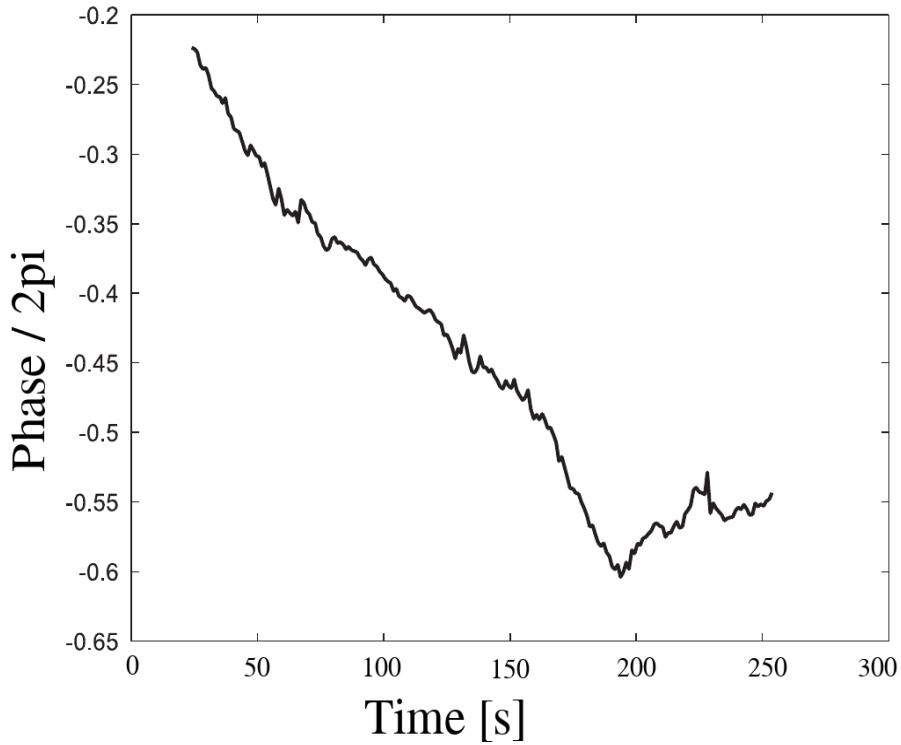
Content

Fiber interferometer for qutrit encoding



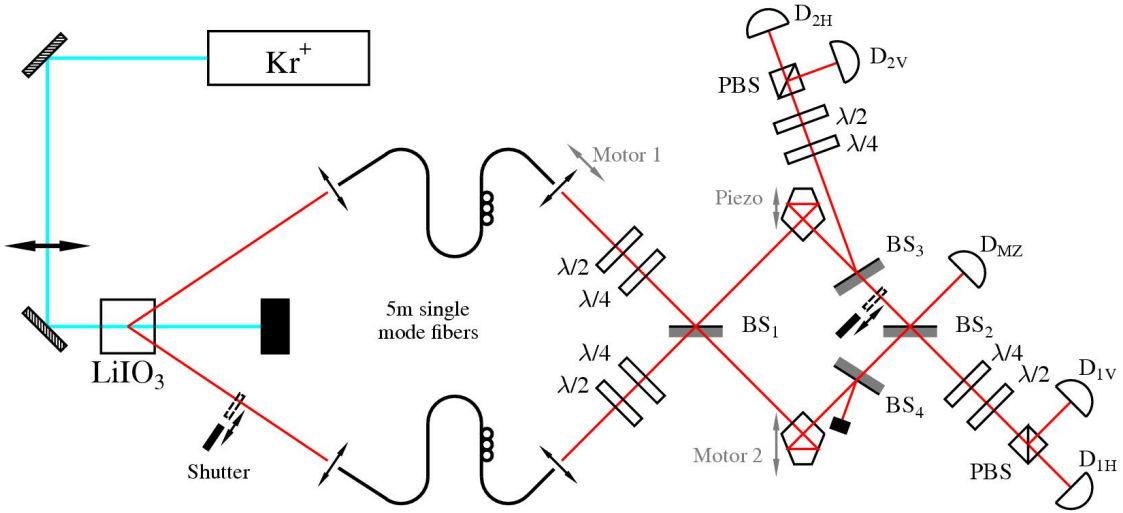


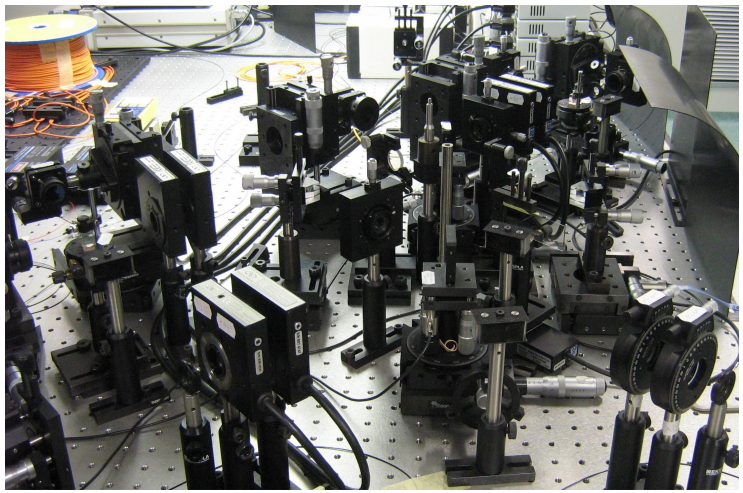
- passive stabilization in polystyrene box
- active stabilization each 5 s



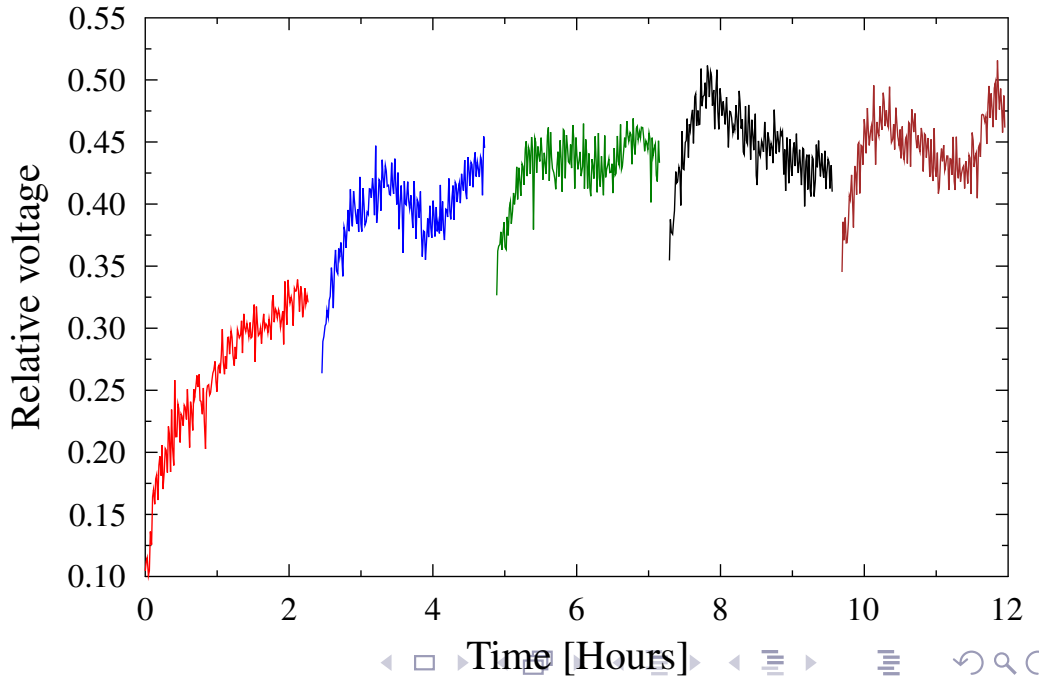
Bartůšková *et al.*, Phys. Rev. A **74**, 022325 (2006)

Bigger bulk interferometer for SWAP gate



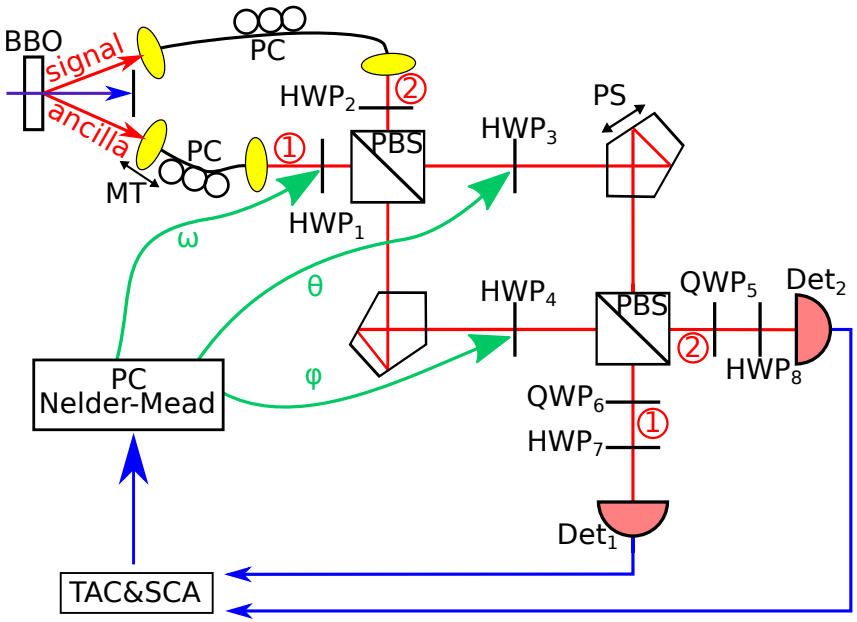


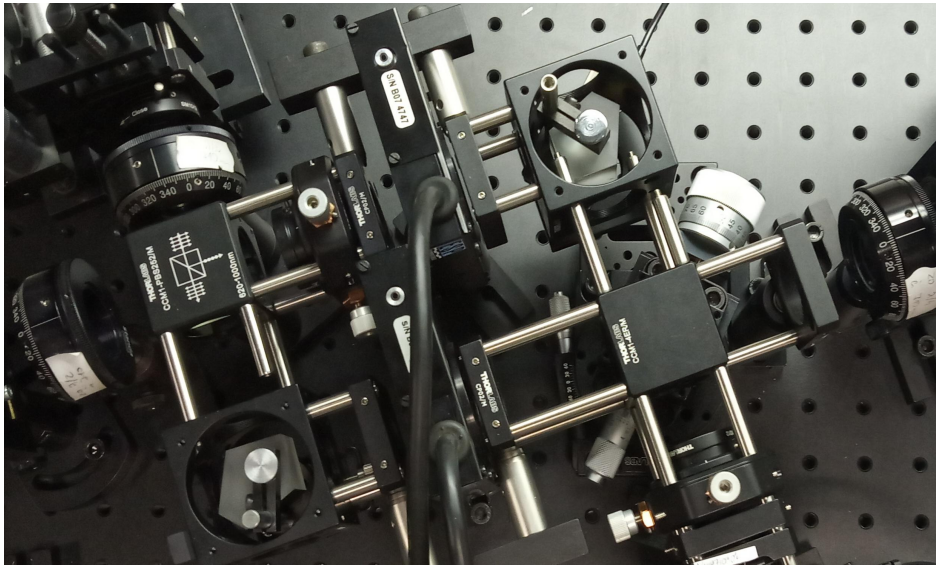
- no extra passive stabilization
- active stabilization after each three 15 s measurements



Phys. Rev. Lett. **100**, 180501 (2008)

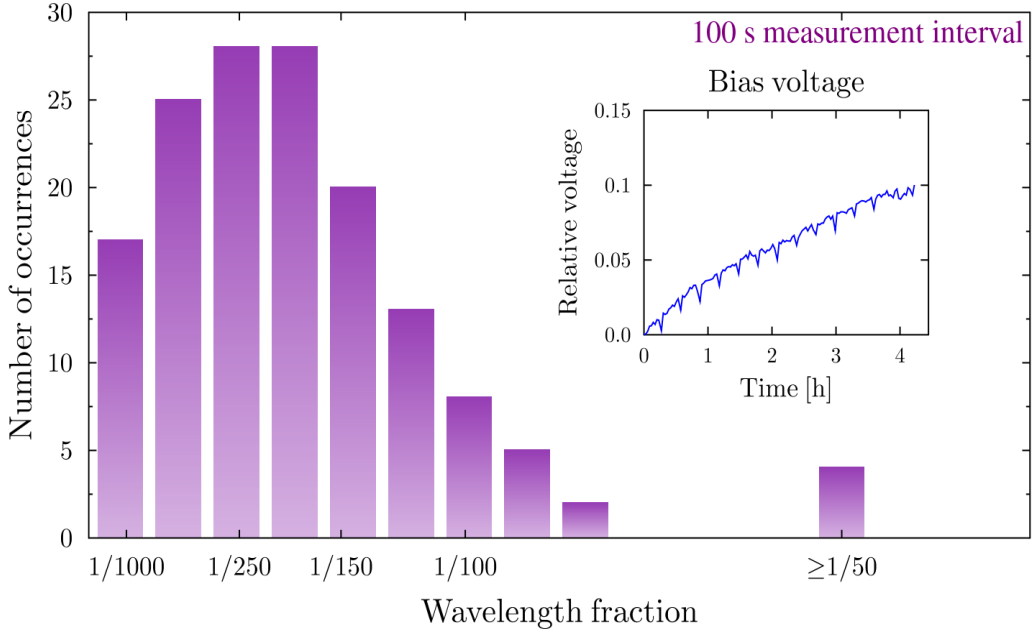
Compact bulk interferometer for MLC



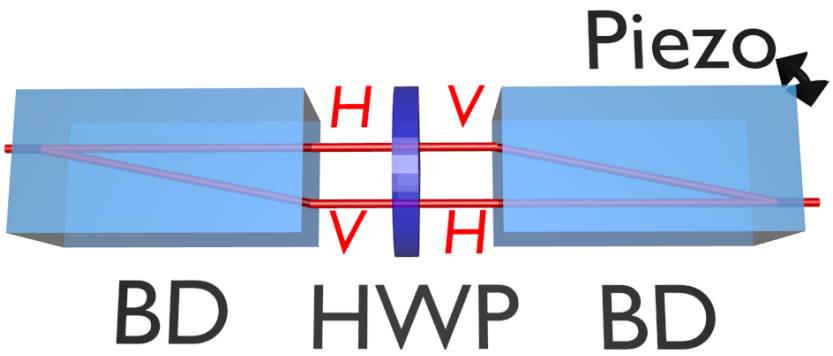


- passive stabilization by paper box
- measurement of phase shift in 100 s intervals

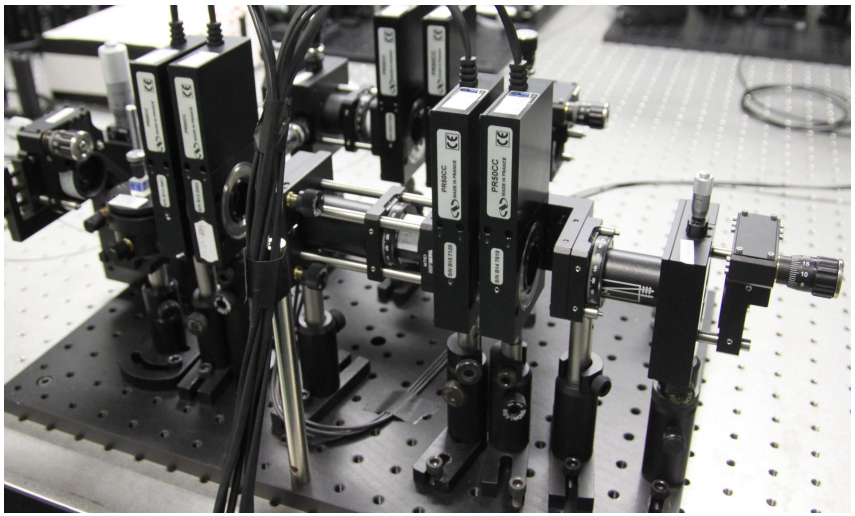
Jašek *et al.*, Optics Express, in print

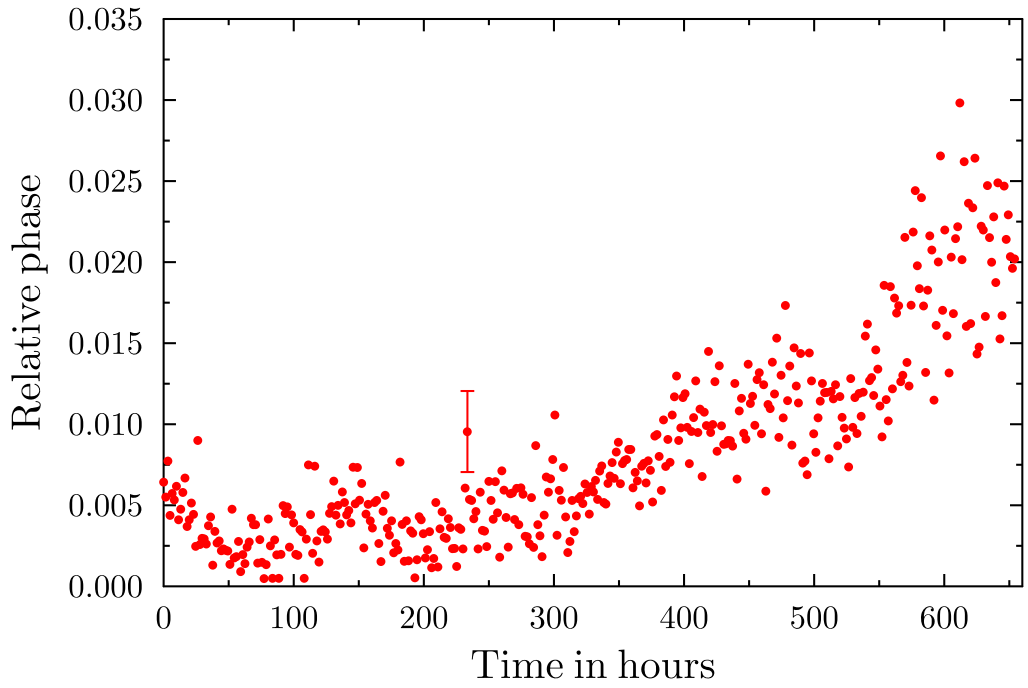


Tiny bulk interferometer



- no stabilization





Phys. Rev. A **98**, 032307 (2018)
Scientific Reports **8**, 13480 (2018)
Phys. Rev. A **99**, 042123 (2019)

Thanks for your attention