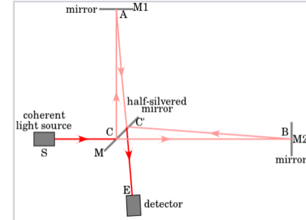
Michelson Interferometer

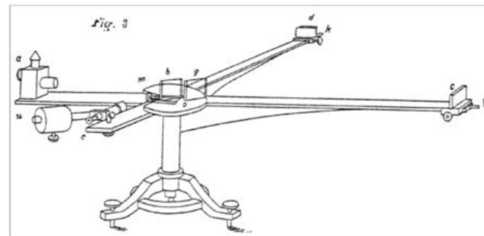


A. Importance of Michelson Interferometer (MI)

➢ Demonstration of a very basic physical optics phenomenon: light interference

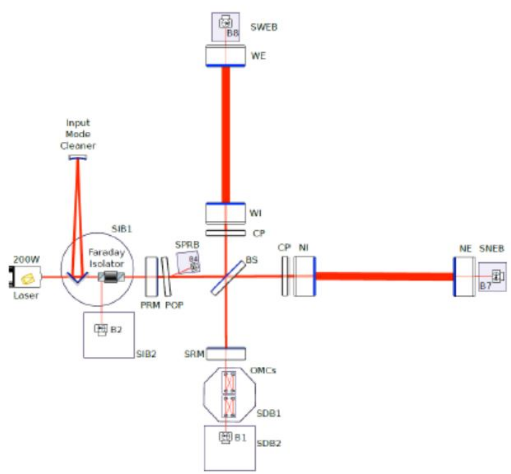
➢ Most famous scientific experiments based on MI

- Michelson-Morley (1887) experiment to verify the existence of *Aether* *(Nobel prize or Michelson in 1907)*



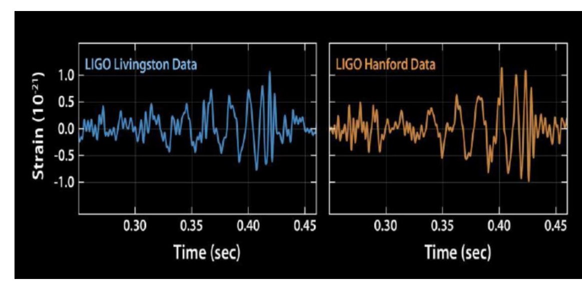
- Gravitational wave detection (LIGO,VIRGO-EGO,...) : extremely small effect on the distance between free masses :10^{-18} m on 1 km !!!

L1- Livingston – Louisiana state



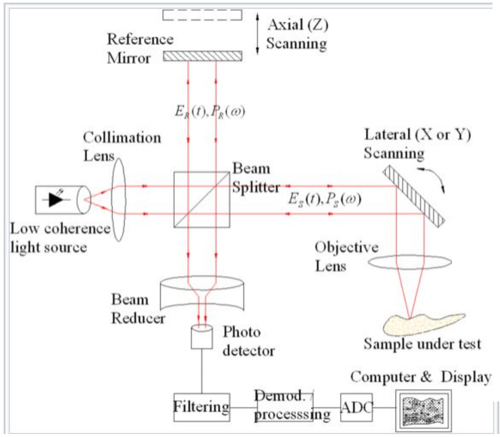
Advanced Virgo project baseline design

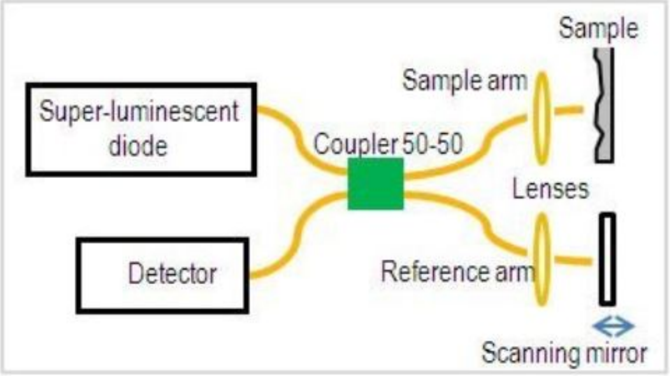
First LIGO signal observed Sept. 2015, probably generated by merging black holes; Nobel Prize in 2017

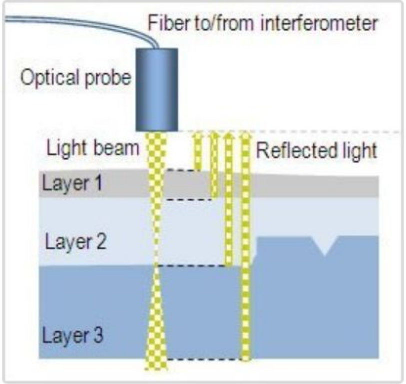


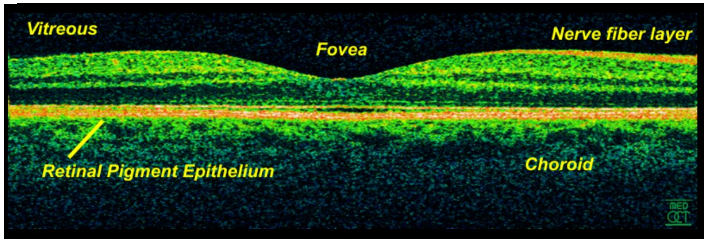
Michelson Interferometer

- ➢ Important practical applications: high accuracy length and shape measurements
- High-coherence-laser based interferometry , measurement accuracy is a small fraction of the laser wavelength
- Low-coherence laser or LED based interferometry (so called OCT), accuracy on the sub-micron scale, however allows to work in non-stabilized environment and has versatile fibre-optic based versions









Michelson Interferometer

Basics to be refreshed in preparation for the laboratory session

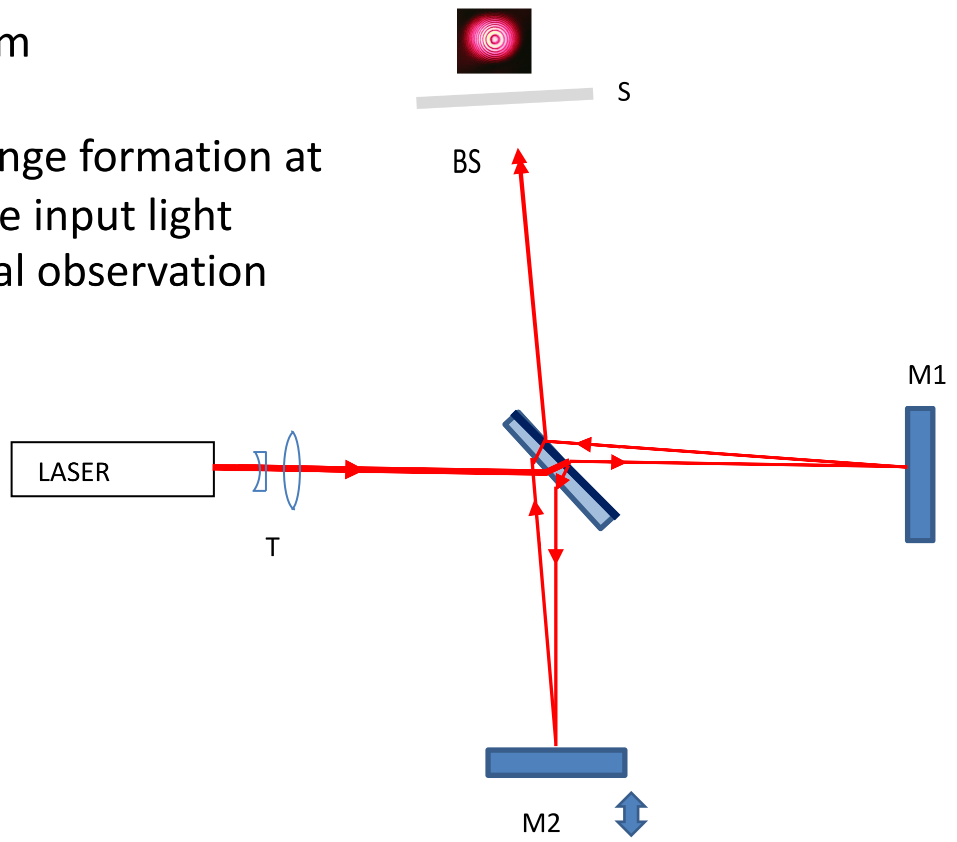
- Basic theory of light and interference
- Electric field amplitude, phase , wavelength, carrier frequency and intensity of monochromatic light
- Derivation of the expression for the interference of two monochromatic plane waves with equal frequency (intensity as a function of phase difference): $\mathbf{I=I_1+I_2+2(I_1I_2)^{0.5}\cos(fi_1-fi_2)}$
- Fringe visibility as a function of the ratio I_1/I_2 and of the phase difference
- Coherence length/coherence time , formula for the relation coherence length-light bandwidth ($\Delta\lambda$) : $\mathbf{Lcoh \sim \lambda^2/\Delta\lambda}$; $\mathbf{Tcoh=Lcoh/c \sim 1/\Delta\nu}$

Description of Laboratory tasks

A.MICHELSON INTERFEROMETER

1. Alignment of the interferometer
2. Fringe observation and explanation of the change of the pattern when:
   - mirror angle is changed
   - the distance of one arm is changed
   - fringe shape change at nearly equal arm lengths (i.e. single bright or dark fringe)

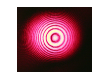
3. Assume a plane wave and a single dark fringe formation at the interferometer output: explain where the input light energy ends up? Try to make an experimental observation confirming your answer

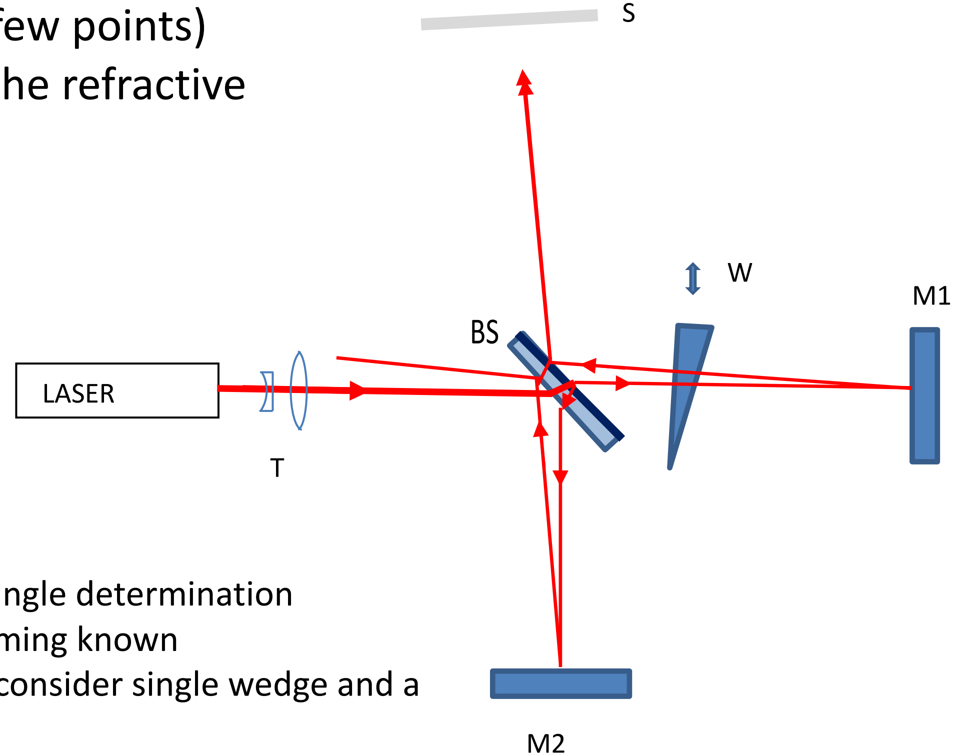


LASER: He-Ne laser, wavelength 632 nm
T: magnifying telescope or negative lens
BS: Beam splitter (semitransparent mirror)
M1,M2: High-reflectivity mirrors,
M2 mounted on a precision translation stage
S- white screen

Description of Laboratory tasks

4. Insertion of a wedge (or wedge pair) in one arm and realignment of the interferometer
5. Measurement of fringe change vs wedge insertion dependence (count number of central fringe transitions caused by a wedge Insertion measured by the micrometer. Take a few points)
6. Calculate the wedge angle (use n=1.457 for the refractive Index)





LASER: He-Ne, wavelength 632.8 nm
T: magnifying telescope or negative lens
BS: Beam splitter (semitransparent mirror)
M1,M2: High-reflectivity mirrors
W : fused silica wedge
S- white screen

Prepare in advance: derive the expression allowing wedge angle determination from the measured fringe changes vs wedge insertion (assuming known laser wavelength and glass refractive index) . For simplicity, consider single wedge and a small angle approximation

Description of Laboratory tasks

B. Simple Light Polarization Experiments

7. Waveplates: determination of waveplate type of the
The 2 available waveplates and determine their optical axes
using the polariser
8. Can we use the interferometer to determine with
high accuracy the optical axis of $\lambda/4$ plate?
9. Construct an optical isolator based on polarizer
and a $\lambda/4$ plate
10. Measure the Brewster angle of the glass wedge and
calculate its refractive index