École Polytechnique Fédérale
de Lausanne

Optical Engineering: Interferometer

Group	C-8
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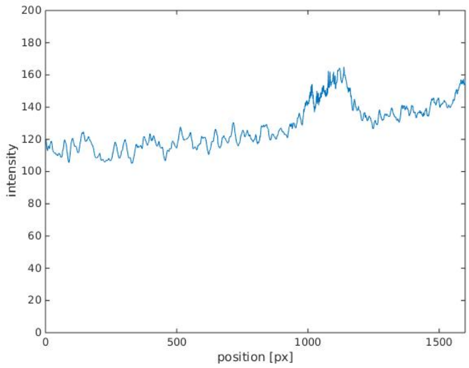
Abstract

In this work, we analyze the properties of the Michelson interferometer. Separating the ray in two and recombining it we obtain an interference figure which yields information about the position of two virtual sources. When they are both on the same optical axis, there is *zero optical paht difference*. The contrast between low and high at the ZOPD point is $C = 0.39$. Then we determinate the laser source spectral width observing the beat phenomenon in the contrast measure ($\Delta\lambda = 0.22\,\text{nm}$). Finally we determinate the incline angle corresponding to 180° phase shifting performing a pressure on the optical support ($0.06 \times 10^{-3\circ}$).

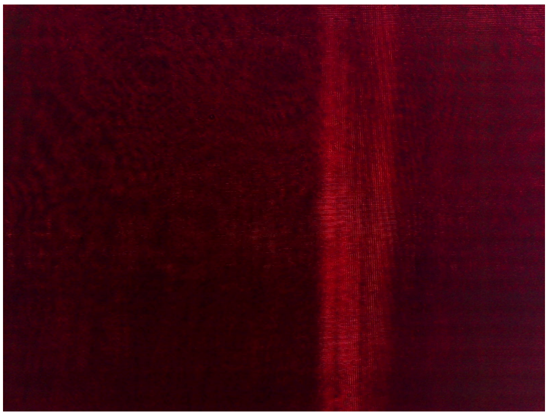
1 Procedures and results

1.1 Zero optical path difference

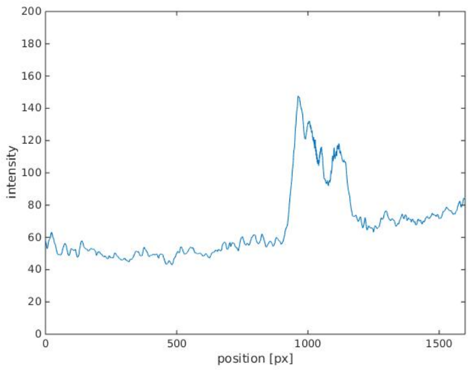
(a) High intensity.



(b) High intensity line graph.



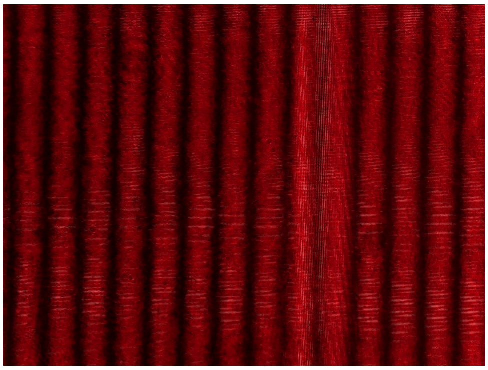
(c) Low intensity.



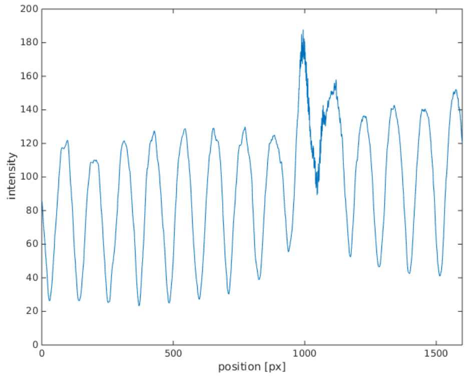
(d) Low intensity line graph.

Fig. 1: Zero optical path difference. The intensity is a result of either positive or negative interfence and can be manipulated by pressing slightly on base plate of the system. The contrast is $C = 0.39$.

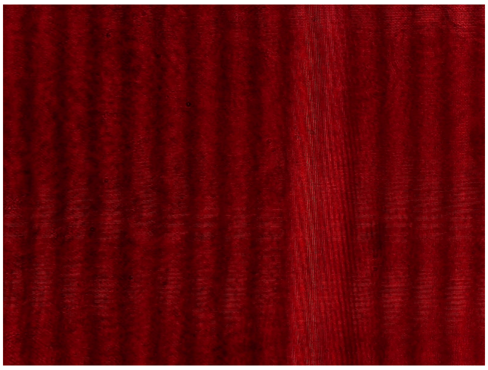
1.2 Measurement of laser fringe contrast



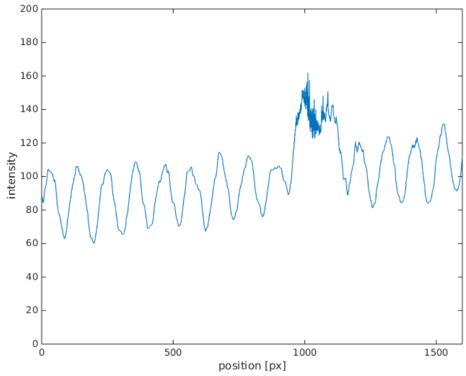
(a) High contrast.



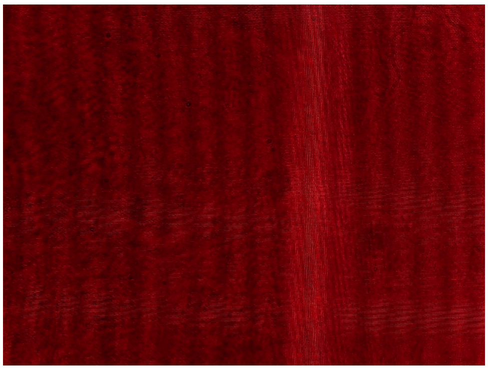
(b) High contrast line plot.



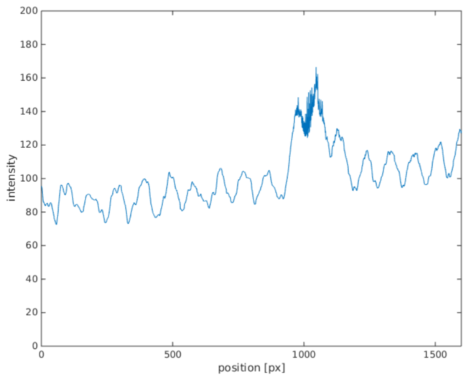
(c) Medium contrast.



(d) Medium contrast line plot.



(e) Low contrast.



(f) Low contrast line plot.

Fig. 2: Fringes with different contrasts and their corresponding line plots. Tha change of contrast is due to a change of the optical path difference.

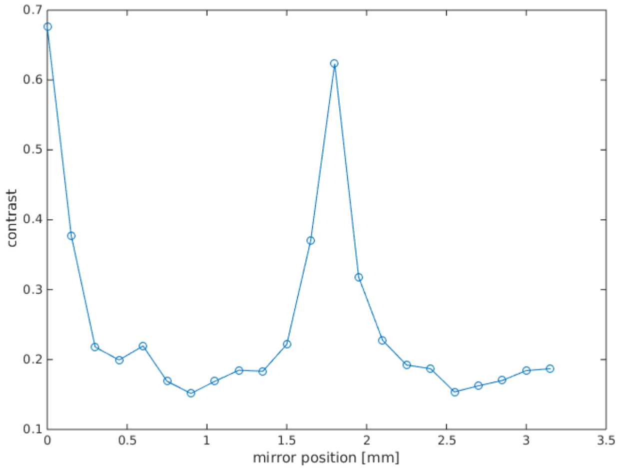


Fig. 3: The contrast as a function of the measurement position. We deduce $\Delta z = 1.8\,\mathrm{mm}$ as the period of the variation.

With the period of the variation Δz deduced in figure 3, we can calculate the spectral width $\Delta\lambda$ (equation 1).

$$\Delta\lambda = \frac{\lambda^2}{\Delta z} = \frac{(635\,\mathrm{nm})^2}{1.8\,\mathrm{mm}} = 0.22\,\mathrm{nm} \tag{1}$$

1.3 Phase shifting interferometry

Performing finger pressure on the support, we search to observe 180° phase shifting.

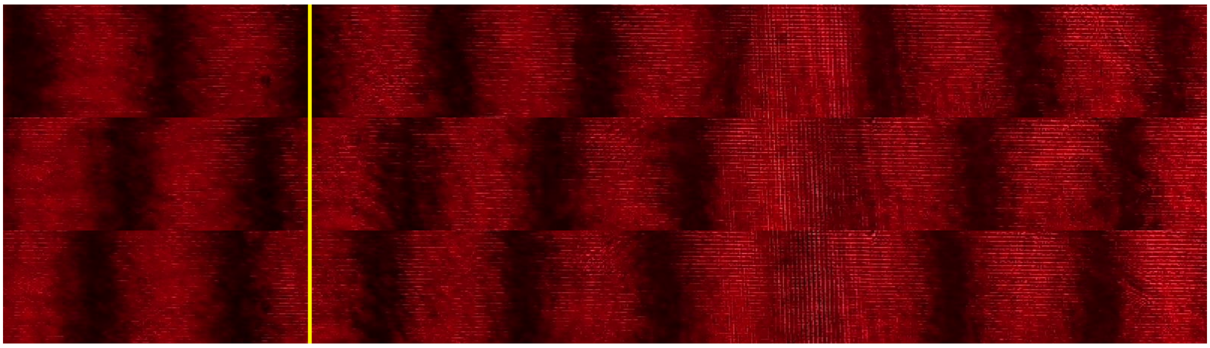
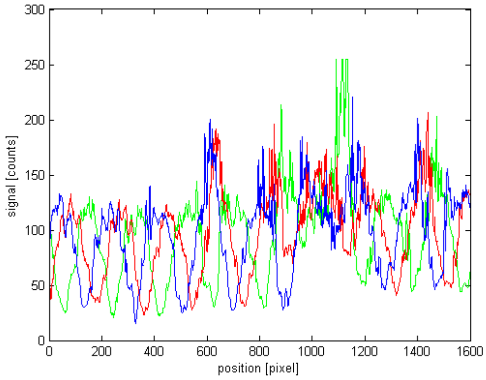
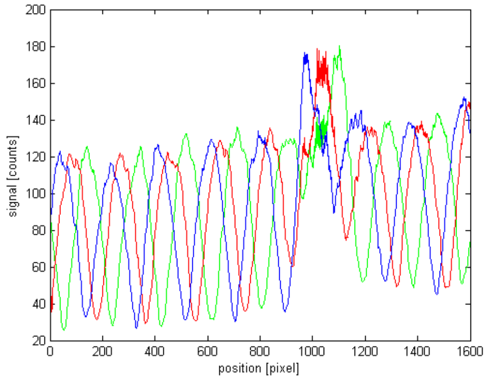


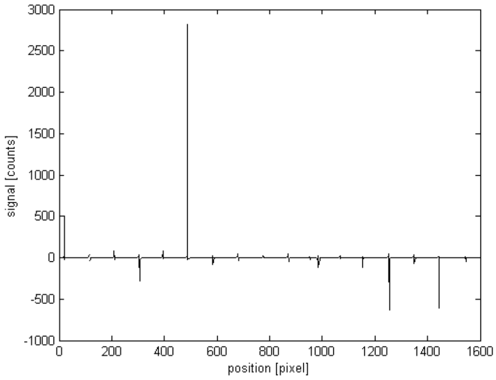
Fig. 4: Different phase shifts.



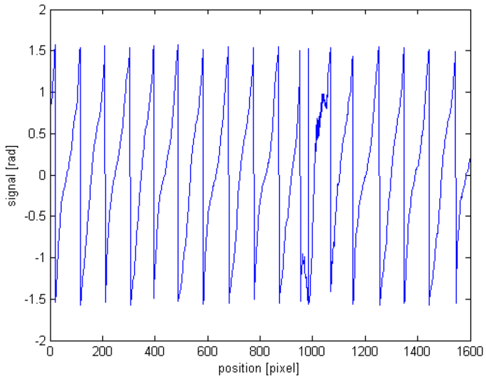
(a) Intensity of the center line of three different phases.



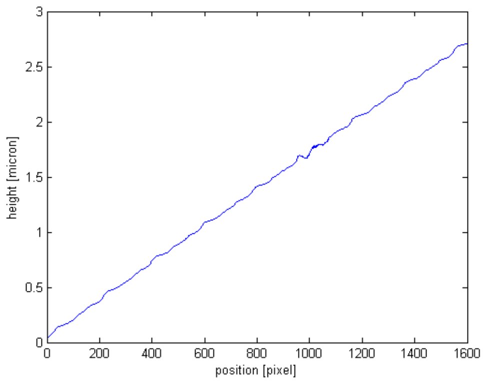
(b) Intensity averaged over 200 lines.



(c) Tangent plot.



(d) Phase between $-\frac{\pi}{2}$ and $\frac{\pi}{2}$.



(e) Height difference as a funciton of the position (unwinded phase).

We can observe phase shifting spotting destructive and constructive interferences. Observing the destructive and constructive fringes we feel there haven't the same width. It's wrong, there are exactly identical. The error can result by overexposure or eyes sensibility or brain color treatment. Significant irregularities on the intensity diagrams result by a blurred column appearing on all our pictures. On the last picture we determinate the slope (1.65×10^{-3}). So the angle which generate a 180° shift is $\alpha = 0.06 \times 10^{-3\circ}$. This angle represent a 635/2 nm distance variation ($\frac{1}{2}$ coefficient because the ray cover the distance at back and forth). These values correspond to the interferometer resolution.

1.4 Web-Example

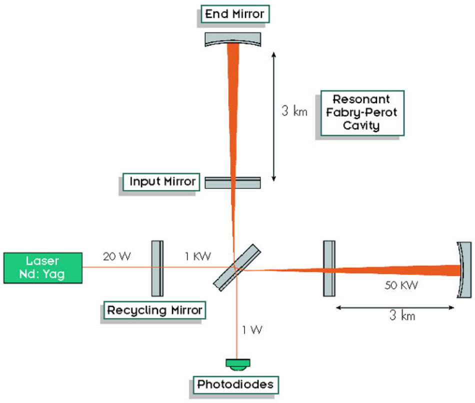


Fig. 6: Sources: Laboratoire d'Annecy-le-Vieux de Physique des Particules and EGO (European Gravitational Observatory)

The Virgo is a gravitational wave detector built in Italy in the site of EGO. It's a Michelson laser interferometer which has two arms 3 km length. The effective optical length of each arm is extended by the mirrors up to 100 kilometers. His frequency range sensibility extends from 10 Hz to 10 kHz. This range should allow detection of gravitational radiation produced by supernovae and the coalescence of systems in the Milky Way and in outer galaxies.

2 Discussion

It was interesting to experiment with a interferometer and to see the incredibly small distances and angles that can be resolved using this technology, as well as the difficulties that come along with setting up such a system.