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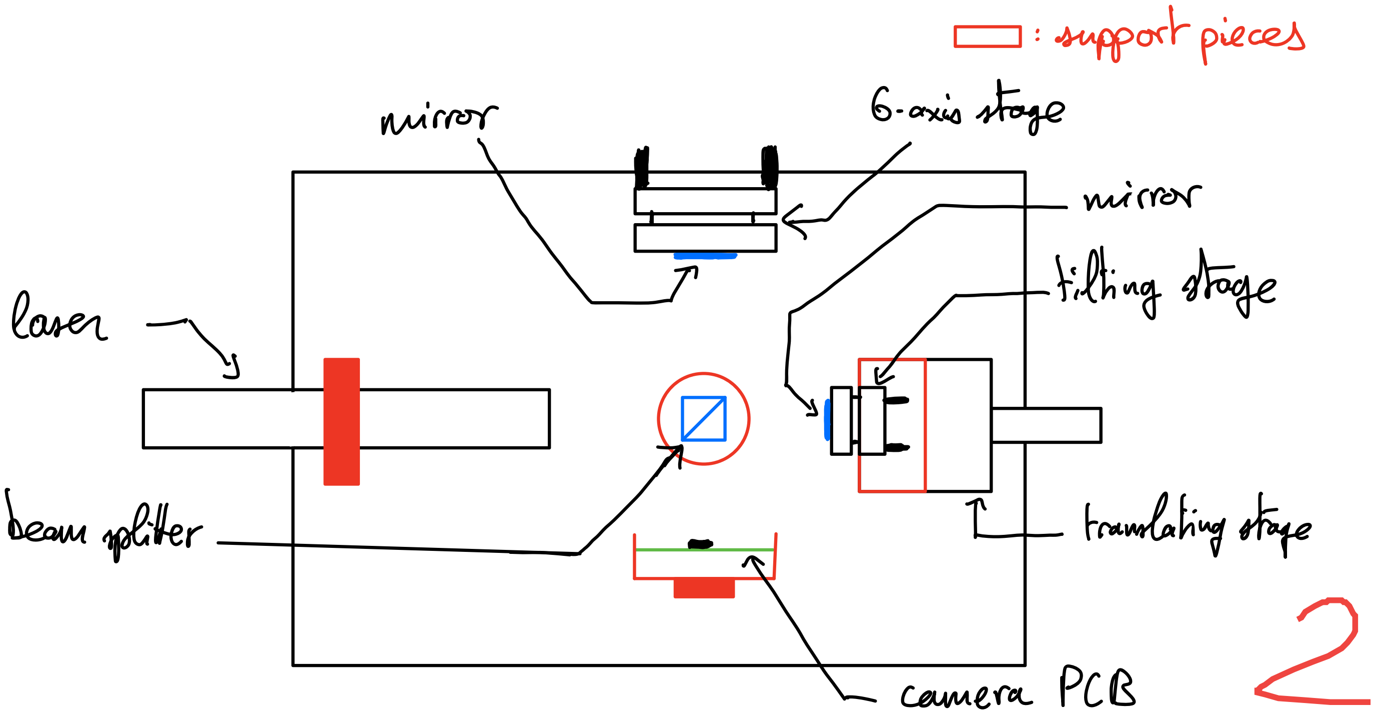
Advance report – Interferometer

1. Schematics

Draw simple schematics of the (different) experiment(s) you will perform in this TP, indicate the source(s) and optical element(s):



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2. Goal of the experiment(s)

Describe the objective(s) of the experiment(s) you will perform today:

The first experiment will try to find the zero optical path difference
In the second experiment, starting from the zero OPD, we will move the translation stage by step of 0,1 mm, thus adding 0,2 mm in the optical path at each step. We then measure the contrast in the fringes and plot them in relation to the relative optical path difference.

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3. Theoretical background

Explain briefly the theoretical background for this TP, indicate the main formulas.

* Interference and coherence:

The interference fringes are an intensity modulation resulting from the addition of coherent light beams. There are two aspects:

(1) The spatial coherence is linked to the physical size of the source. To be able to see interferences, the light has to be superposed with path differences within the coherence length. Thus, the superposition of coherent areas in the spatial domain has to be assured if a spatially extended source is used.

(2) The temporal coherence is linked to the spectral properties of the light. It is possible to quantify the coherence by its length l_c:

$l_c = \frac{1}{n}\frac{c}{\Delta\nu} = \frac{1}{n}\frac{\lambda^2}{\Delta\lambda}$ where n is the refractive index of the surrounding medium.

* Interference and contrast:

Interference appears when coherent waves are superposed. The result of interference phenomena are interference fringes in space. For the one-dimensional case, the following equations are used to define the fringe contrast and the fringe period:

(a) amplitude of the electric field: $E = E_1 + E_2$ (b) irradiance: $I = I_1 + I_2 + 2\sqrt{I_1 \cdot I_2} \cdot \cos\delta$

where the phase difference is given by: $\delta = (\vec{k_1}\cdot\vec{r} - \vec{k_2}\cdot\vec{r} + \varepsilon_1 - \varepsilon_2)$

So, for a given problem, the maximum and the minimum values of intensity can be calculated.

The contrast of the interference fringes is an important parameter which is defined as:

$$C = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$$ for I: the intensity max or min.

By using the previous equations, we can reformulate the contrast as: $C = \frac{2\sqrt{I_1 I_2}}{I_1 + I_2}$

If the intensities are equal, we obtain a contrast of 1. If they differ, the contrast will be less than 1.

* Interference with several frequencies (beating).

This case is due to the wave vectors $\vec{k_i}$ having different values because the wavelength are not equal. By considering two wavelengths, we are interested in the contrast of fringes indues by this effect. We reformulate the phase delay and get:

$\cos\delta = \cos(k_1 - k_2)\cdot z$ where $k_1 = \frac{2\pi}{\lambda_1}$ and $k_2 = \frac{2\pi}{\lambda_2}$ $\Rightarrow \cos\delta = \cos\left(2\pi\frac{\Delta\lambda}{\lambda^2}\cdot z\right)$

The intensity will change with the change of z and will lead to a full modulation over a distance that is given by the periodicity of the cosine function as a multiple of its periode which is $\lambda^2/\Delta\lambda$. 2.1

It is possible to show that this "beating" behaviour of varying contrast is not only found for the intensity but also for the contrast of fringes in an interferometer

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2.1 for n = 1!