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Results : The interpretation of these fringes to determine the deformation.

Conclusion : In this paper, we present experimental results of the variation of diffraction patterns for various displacements of paper.

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I. Materials and Method

The setup used for this purpose is very simple and is as follows:

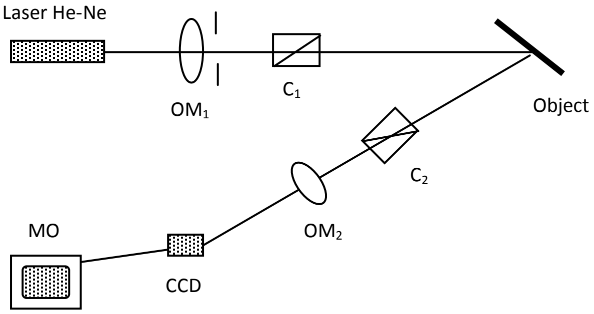

Figure 1 : Descriptif schema of optical assembly.

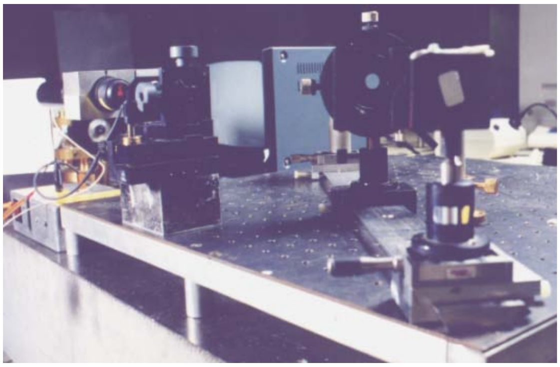

Figure 2 : Real schema.

A He-Ne laser illuminates the object through a microscope objective to expand the beam. An optical system (lens) creates an image of this object. A CCD camera connected to a "frame grabber", connected to a PC, save the image. The computer allows us to calculate the sum of the images and then calculate and display the Fourier transform of this sum. The objects used in this operation are pieces of sandpaper of different granularities. The optical system used in our installation is a simple lens of focal length f = 14 cm. For reasons of ease of handling, we took a magnification of 1. Therefore, as [1, 2, 3]:

$$\frac{1}{f}=\frac{1}{p}+\frac{1}{q} \quad \text{et} \quad M=\frac{q}{p}$$

There are :

$$q=M.p=p$$

$$\frac{1}{f}=\frac{2}{p}$$

$$q=2f \qquad (1)$$

Moreover, in order to vary the size of speckle grains, we have arranged a diaphragm (a pupil, ie a circular aperture) we can easily vary the diameter. This diaphragm is placed right up against the lens so that the system can be likened to a lens of variable diameter. Then we compute the Fourier transform of this sum, as explained in the theory, gives us a background radiation modulated by a term in cos ^{2}, in fringes.

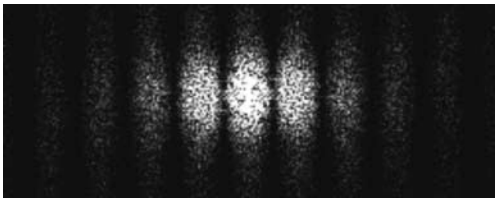

Figure 3 : The Fourier transform of the diffraction pattern.

Then we start all over for an equivalent movement of the camera (remember that a moving object D micron is equivalent to a displacement of the camera MD microns). Finally, we compare the results obtained in both cases. To make this comparison, we realize the profile of the fringes.

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In this graph, a maximum contrast (thus equal to one) is seen when the fringe back down each time down to zero. A loss of contrast will show up in fringes less marked, that is to say that the maxima and minima are vertically closer. But the loss of contrast is seen directly by elevated minima of this curve. So it is with this profile that we will quantify the loss of fringe contrast.

As mentioned in the introduction to this manipulation, we are interested in the loss of contrast as a function of surface roughness scattering. Initially, we used abrasive papers of different grain sizes and different luminous backgrounds.

But it appeared that this colored background has some significance. One can convince of it by looking at the profile below. These were obtained for papers of the same granularity but one had a yellow background, the other a brown background.

We see that the fringes are more distinct for the brown paper for paper yellow. This difference is marked especially at the edges of the profile. For the yellow paper, the modulation is visible only by the central peak. We then thought about taking sandpaper identical colors. But we quickly realized that this problem resurgissait, to a lesser extent it is true. We then seemed difficult to draw an effect of roughness on decorrelation in this way.

We then had another idea: instead of taking the papers of different granularities, we decided to take only one and varying the diameter of the diaphragm.

Indeed, if we assume it constant, take different granularities papers like having average sizes of different structures. Moreover, in this case, the speckle size is constant. So this means varying the ratio between the size of structures and size of speckle grains.

Now consider the case where the diaphragm is varied. This variation influences the size of speckle grains but not structures. So this also amounts to varying the ratio between the size of structures and size of speckle grains.

That is why these experiments are almost equivalent. We chose the latter so as not to encounter the problems described above.

We used a black-grained sandpaper 180, which corresponds to a mean grain diameter of 82 μ m. We want to vary the diaphragm so that the size of the speckle grains obtained either:

- half the size of the structures
- twice that of structures

Therefore, for the first case, we seek to have the radius $\frac{82}{2}\frac{1}{2} = 20,5\mu m$ and in the second, a radius of $\frac{82}{2}2 = 82\mu m$.

The size of speckle grains is given by [4-8]:

$$\Delta r = 1,22\frac{f}{\phi}(1+M)\lambda$$

It is important to note that Δr represents the radius of the speckle spot.

The above relation, we deduce:

$$\phi = 1,22\frac{f(1+M)\lambda}{\Delta r}$$

Where :

$$f = 14cm = 14.10^{-2}m$$

$$\lambda = 632,8nm = 632,8.10^{-9}m$$

$$M = 1$$

$$\Delta r = 20,5\mu m = 20,5.10^{-6}m$$

$$\Rightarrow \phi_1 = \frac{1,22.14.2.328}{20,5}10^{-5m} = 1054,46.10^{-5}m$$

$$\phi_1 = 1,054cm \qquad (2)$$

To calculate found identical to the second aperture:

$$\phi_2 = 0,263cm \qquad (3)$$

II. RESULTS

But to get a clearer picture of this decorrelation and also to take account of the aperture, it is necessary to go to the profile of these Fourier transforms.

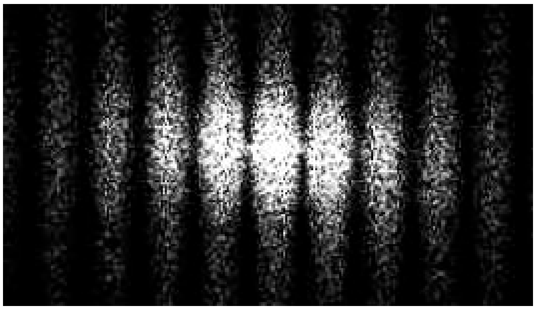


Figure 4 : Profile of the Fourier transform.

We have seen that the Fourier transform of the double exposure as a result gives a modulated spectrum :

$$I \cong 4\left|\overset{\square}{T}\right|^2\cos^2(\pi k_x\chi)$$

Where χ represents the translation.

For some trigonometric considerations, we can rewrite:

$$\cos^2\alpha = \frac{1+\cos 2\alpha}{2}$$

We will then approximate the profile fringes with Easyplot with an equation like

$$y = \frac{1}{2}\left(1 + \gamma \cos\left(fx + g\right)\right)T$$

- T is the form of non-modulated profile, it is obtained by the Fourier transform to a zero displacement.
- f is the frequency of the fringes.
- g is their phase.

But the point that interests us above all is γ. This is the fringe contrast.

Below we can see the result of approximation by Easyplot for two diaphragms. The curves correspond to a displacement of the object of 0.8 millimeters. One can see that this approximation is good.

We have summarized the results of these approximations in the following tables, where we have only postponed the values of contrast.

a) Diaphragm 10,54 mm

Displacement (1/10mm)	Paper	Camera	Report	Difference
2	0,814	0,843	0,96559905	0,029
4	0,686	0,723	0,94882434	0,037
6	0,593	0,618	0,95954693	0,025
8	0,464	0,465	0,99784946	0,001
10	0,394	0,465	0,84731183	0,071

Tableau 1: Displacement for the diaphragm of 10.54 mm.

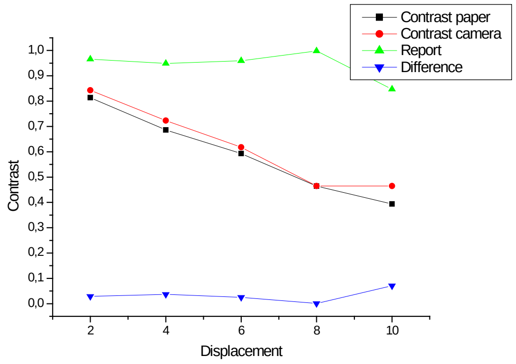
b) Diaphragm 2,63 mm

Displacement (1/10mm)	Paper	Camera	Report	Difference
2	0,814	0,892	0,91255605	0,078
4	0,613	0,717	0,85495119	0,104
6	0,562	0,732	0,76775956	0,170
8	0,470	0,610	0,7704918	0,140
10	0,307	0,535	0,57383178	0,228

Tableau 2 : Displacement for the diaphragm of 2.63 mm.

III. DISCUSSION

Below, we have plotted the contrast. For each aperture, we find a curve for the contrast when moving the object (sandpaper), another curve for the contrast related to the movement of the camera and finally, a curve for the ratio of these two contrasts (paper/camera).



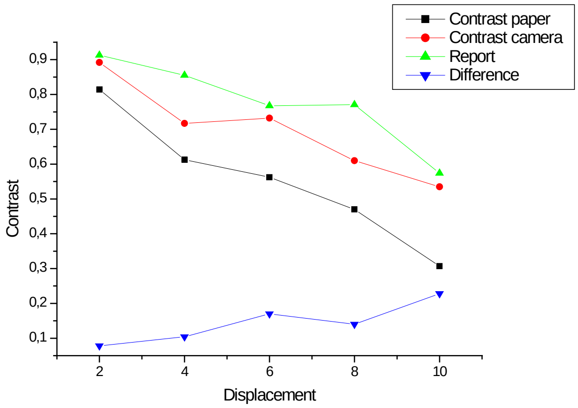


Figure 5 : Contrast of an opening.

a- 10.54 mm

b- 2.63 mm

Carry on the same graph the contrast ratio (paper / camera) for the two f-stops. Do the same with the difference contrasts (camera-paper). We see that the ratio decreases more rapidly for the smallest opening, as well as the difference increases faster in this case.

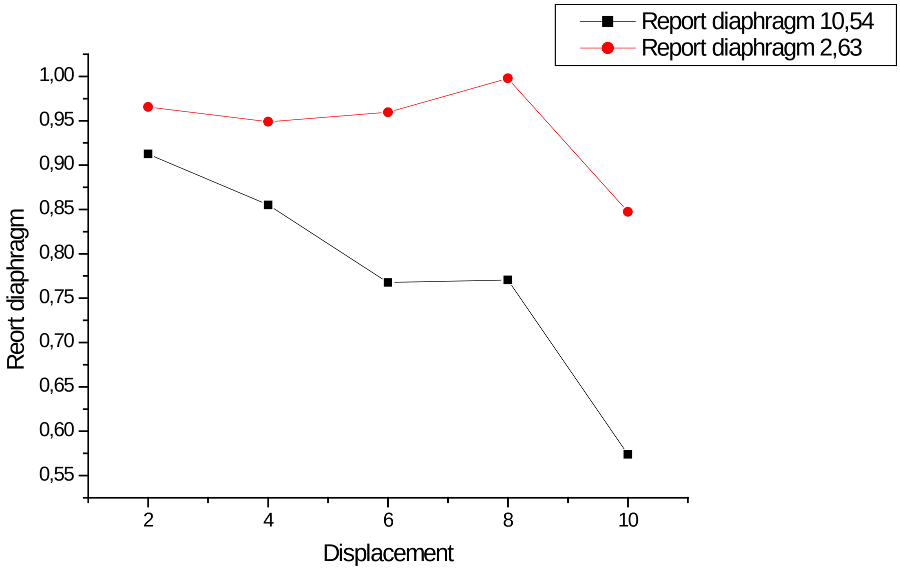


Figure 6 : Contrast ratio for the two openings.

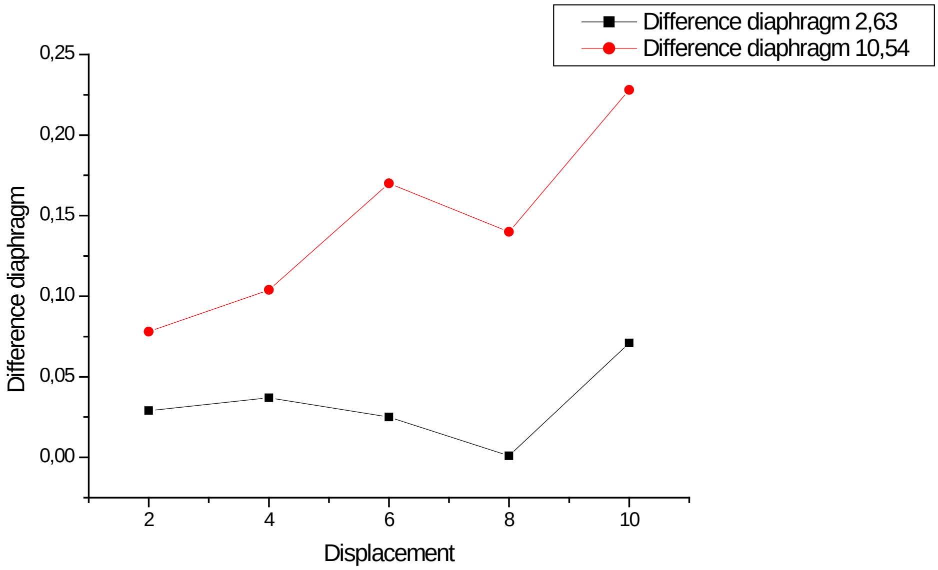


Figure 7 : Difference in contrast to the two openings.

IV. Conclusion

Using the charts above, we can notice that the decorrelation of the speckle is more pronounced when the diaphragm is closed. In other words, we can say that the speckle decorrelation is greatest when, at the image plane, the speckle is predominant in relation to structures of the object studied.

Conversely, we can conclude that we will see a decorrelation faster when the structures of the object are a minority compared to the holography, ie when the roughness of the object studied is low. Schematically: roughness decorrelation.

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