Calibrating a point diffraction interferometer using aspherical wavefront reference.

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Abstract. This work presents a method to calibrate the reference wavefront generated by an IDP. This wavefront is considered for quantitative evaluation of a plano-convex aspheric surface. Preliminary experimental results are presented.

1. Introducción.

The point-diffraction interferometer (PDI) divided the light in two components to produce a test and reference beams, after passing through the system under test. The PDI generates a spherical reference wave by diffraction at a point discontinuity placed in the path of a beam [1, 2]. The configuration illustrated in Fig.1.

![Fig. 1. The configuration of PDI.](image)

The PDI operation consists in impinging a converging wave on a semi-transparent plate. The plate has a micro hole, which functions as a point source which generates spherical waves. After the plate an interference unlocated pattern is generated by the sum of the transmitted wave and the spherical reference wave. The PDI has several advantages such as not requiring a reference surface, like other interferometers, the PDI can measure phase variations from variations of the interference pattern and one of the most important characteristics is a that it is a common paths interferometer, therefore is insensitivity to mechanical vibrations.
2. PDI manufacturing.

The construction of the PDI begins with cleaning coverglass, between two of them a drop of mercury is placed and pressed to form tiny droplets. With the aid of a stereomicroscope (Fig. 2), the right sizes are chosen and others are removed with compressed air, in this case the orifice size is a 12µm (Fig. 3).

![Fig. 2. Stereomicroscope used in the construction process of the PDI.](image1)

![Fig. 3. Mercury chosen seen through a Stereomicroscope.](image2)

Then an aluminum coating is made by evaporation with certain percentage of a defined thickness, the evaporator with glass slides is illustrated in Fig. 4. The thickness obtained with evaporation are shown in Table 1. Finally, the sphere of mercury is separated from glass coverslips. Mercury hole seen through a stereomicroscope is show in Fig. 5.

![Fig. 4. The evaporator with slides.](image3)

![Fig. 5. The hole of 12µm seen through a stereomicroscope.](image4)
| Disseminator (Torr) | Cold Cathode (Torr) | VariaC (C) | Rate (Å/s) | Thickness (kÅ) | Time (Min) |
|---------------------|--------------------|------------|------------|----------------|------------|
| 1                   | 1.1x10^{-2}        | 4.5x10^{-5}| 4.5        | 0.000          | 0:00       |
| 2                   | 1.7x10^{-2}        | 2.1x10^{-4}| 4.5        | 1.0            | 2:00       |
| 3                   | 1.2x10^{-2}        | 1.6x10^{-4}| 4.75       | 0.231          | 4:00       |
| 4                   | 1.1x10^{-2}        | 1.5x10^{-4}| 6.0        | 0.310          | 7:00       |

3. Calibration of the PDI.
Before taking the test with an aspherical lens, the PDI was calibrated with a spherical wavefront coming from a reference spherical lens of a commercial interferometer Zygo®, the characteristics of the lens are shown in Table 2.

Table 2. Parameters of the espherical lens [λ/20] of Zygo®.

| Parameter | Value |
|-----------|-------|
| R [mm]    | 298.03|
| D [mm]    | 101.6 |
| f [mm]    | 338.08|

The PDI was placed at the focus of the lens, as shown in Fig. 6, and the observed interferogram is shown in Fig. 7.

Fig. 6. The set up to calibration of the PDI.

Fig. 7. Experimental interferogram obtained of PDI with 12µm hole, placed at the focus.
4. Experimental Development.
The experimental arrangement, shown in Fig. 8, for testing an aspherical lens (the parameters are shown in Table 3) was placed at a distance of 52.3 cm from the spherical lens. The PDI is placed at a distance of 111 cm from the aspheric lens. A camera was used to obtain interferograms produced by the PDI was placed at a distance of 4 cm from the PDI.

Table 3. Parameters of the aspherical lens A100-200LPX-U-S of Asphericon®, $A_j$ are the three coefficients.

| Parameter | Value |
|-----------|-------|
| $R$ [mm] | 102.24 |
| $D$ [mm] | 100 |
| $K$      | -1    |
| $N$      | 1.5168 |
| $A_4$    | $4.9646003 \times 10^{-008}$ |
| $A_6$    | $7.4017872 \times 10^{-013}$ |
| $A_8$    | $9.4141703 \times 10^{-018}$ |

Fig. 8. The set up with the aspherical lens under test and the PDI.

5. Preliminary results.
The interferogram obtained with the PDI, with a hole of 12 µm is shown in Fig. 9, where seven visible fringes and a good contrast between them. A qualitative evaluation is shown in Fig. 10 and Fig. 11, were made using the commercial program Apex®. In Fig. 12, we can see the contrast between the strips for two wavelengths along the interferogram and qualitative evaluation data by the analysis program Apex® shown in Table 4.
Table 4. Data by an analysis program Apex®.

| Data            | Value |
|-----------------|-------|
| λ[µm]           | 0.6328|
| Irregularity[µm]| 6.97  |
| RMS[µm]         | 1.88  |
| Peak-to-Valley[µm]| 6.99  |
| Points          | 3297  |

Fig. 9. Experimental interferogram obtained of PDI with 12µm hole, placed at the focus.

Fig. 10. Processed contour of the interferogram obtained with PDI.

Fig. 11. Processed curves of the interferogram obtained with PDI, where red is lowest and blue is highest.
6. Conclusions.
Since in the PDI is used a micropinhole to produce the reference wavefront, it is not necessary to use optical reference surface; some intrinsic errors can be eliminated. On the other hand, the results show that although IDPs are not perfect, they are suitable for evaluating aspherical surfaces. It is noteworthy that the process for evaluating the aspheric surface will be carried out as future work.

7. References.
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