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Analysis of refracting objects by speckle holographic interferometry

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Abstract The authors present an optical method based on digital holographic interferometry to visualize and measure the refractive index variations occurring inside a transparent and refracting object. The aim is, in future, to reconstruct the evolution in time of the 3D convection currents or the thermal gradients inside a lighting bulb. Some convincing results have been already obtained for analyzing the variations of the refractive index occurring inside transparent object but not strongly refracting. For that, a tomographic optical bench having six different sights of view has been built and convincing results of 3D gas density reconstruction have been obtained in helium jets and small supersonic jets issuing from 3D shape nozzles. In this paper, the authors expose the advantages and disadvantages of speckle holographic bench, the aim being to reconstruct the 3D flow of a spherical field of 100mm in diameter. The authors also propose an optical solution to bring closer the sensor from the object. The limits of this optical technique and the effect on the resolution are discussed.

Keywords: Digital holography, Inverse method, 3D reconstruction

1 Introduction

The analysis and the measurement of variations in the refractive index of transparent objects is very well known and a lot of researchers have been proposed different optical benches for analyzing 2D and 3D unsteady flows [1,2]. But, when the analyzed objects are transparent and also strongly refracting, classical Michelson or Mach-Zehnder setups are not operating. The authors propose here to define in one direction of sight of view an optical setup based on speckle holographic interferometry, the aim being to reproduce several times this bench for analyzing the 3D transparent and refracting objects. A lighting bulb is used as test case.

2 Definition of the optical bench and first results

Firstly, a coherent pulsed laser @532 nm is used as luminous source of the interferometer and we know that the dimension of the experimental setup is directly proportional to the size of the object under analysis. In these conditions, the bulb is located at 600mm for the ground plate and to maintain an acceptable illumination, the authors use a method proposed by Schnars et al. [3] where a negative lens is introduced just in the front of the beam splitter cube located near the camera in order to provide a virtual image of the object at the closest distance from the sensor. Figure 1 shows photography and a drawing of the bench.

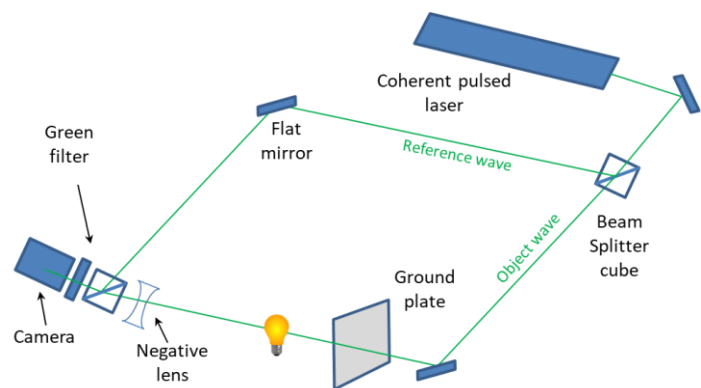
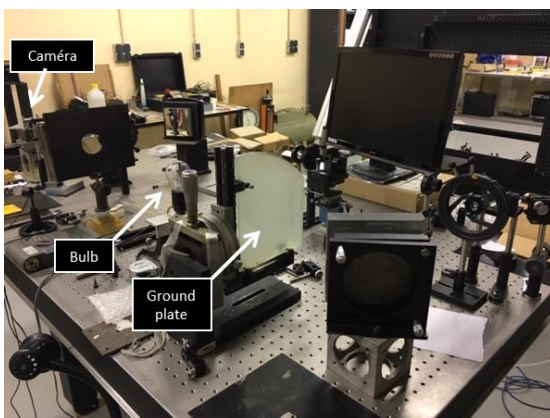


Fig. 1 Photography and scheme of the optical setup

As the optimization of the off-axis setup has to satisfy the Shannon conditions, the focal length of the lens has to be judiciously calculated (-150mm). First, an interferogram is recorded without the light and then the interferograms are recorded at the framing rate of the pulsed laser (10HZ) when the bulb is lightening. A discrete Fresnel transform is applied from the reference interferogram and for each measurement interferogram. In this experiment, the diffuser size is 15cmx20cm and the virtual distance taken for reconstructing the phe amplitude and the phase is fixed at 245 mm. The optical magnification provided by the negative lens is 0.158. Note that to avoid that the lightening of the lamp dazzle the sensor, a green filter is introduced just in the front of the sensor.

Figure 2 show the evolution in time of the modulo 2π difference phase maps between the measurement interferogram and the reference interferogram. At this stage, our work is focused on the unwrapping of these maps because we can observe a lot of singularities and phase shifts resulting of the phase unwrapping.

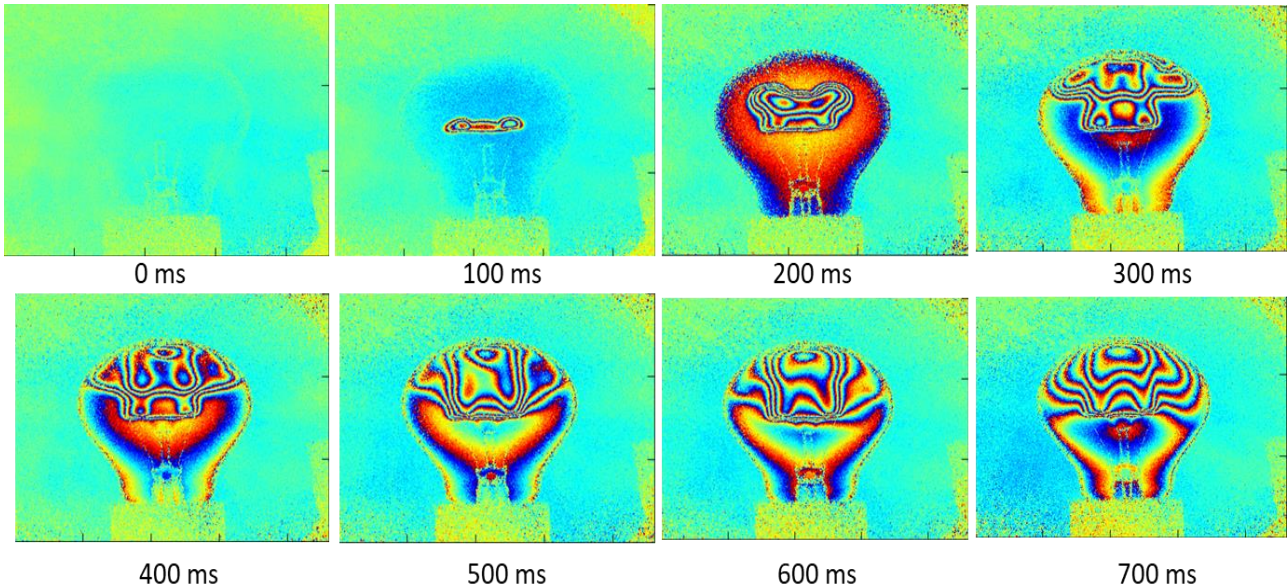


Fig. 2 Modulo 2π difference phase maps for the bulb lightening

4 Conclusion

An optical bench based on speckle holographic interferometry has been implemented for analyzing transparent and strongly refractive objects along one direction of view. A negative lens has been inserted in the front of the camera in order to decrease the distance between the bulb and the sensor. With the optical setup proposed, the spatial resolution is a little bit weak because phase shifts appears for the phase unwrapping. To avoid this problem, the observed field has to be reduced or a camera with more pixels has to be used.

Nevertheless, convincing results have been obtained to visualize and measure the variations of the refractive index inside transparent and refractive objects and future work will be oriented on the phase unwrapping.

3 Reference

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