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Refraction mapping of translucent objects with Shack-Hartmann sensor

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ABSTRACT

Possibility is experimentally demonstrated of measuring refraction distribution in non-homogeneous translucent objects using Shack-Hartmann sensors. Holographic micro-lens matrix of 13×19 lenses with diameter 0.5 mm and focal length 80 mm operating with simple market available CCD array resulted in the sensitivity to wave front measurements corresponding to 0.01 λ .

Key words: refraction distribution, wave front aberrations, wave front sensing, Shack-Hartmann sensor.

1. INTRODUCTION

In many applications, wave front distortions in investigated media play the major role. Ophthalmology is one of them, where media non-homogeneities result in low visual acuity. Their compensation by special microsurgical procedures or special contact or intraocular lenses^{1,2} needs high precision measurements of wave front aberrations in the eye. One more application is biology with its translucent objects like amphibian embryos, on early stages having no intensity contrast^{3,4}. Their study can be provided using the information on wave front aberrations. Chemistry is another field where processes in solutions can be effectively visualized with imaging refraction distribution.

To compensate for highly dynamic turbulence processes in atmosphere, adaptive optics technique was developed⁵. It supposes measuring the wave front distribution after light propagation in the atmosphere and following wave front correction. In our studies, we use the sensor part of this technique based on Shack-Hartmann sensors.

2. EXPERIMENTS AND RESULTS

Experimental setup was described in earlier publication⁶. Single-pass part of it was used for investigations. Shack-Hartmann sensor was composed of a holographic lenslet array and CCD module *Mintron* MTV-261.

Lenslet array consists of 13×19 micro-lenses with apertures 0.5 mm. Distance between the centres of neighbouring lenses equals to 0.5 mm. Focal length of each lens is 80 mm. The source of irradiation is He-Ne laser.

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As an object for investigation, water solutions were used filling the cell, its thickness being 18 mm. Refraction non-homogeneity causes transverse displacement of the corresponding spots of light formed by multi-lens array (fig. 1). From these displacements, wave front aberrations are calculated.

In figures 2, 3 and 4, 5, examples are shown of wave front aberrations in the solutions of sugar (figs. 2, 3) and alcohol (figs. 4, 5) in water. Coordinate X coincides with horizon, Y is directed into the depth of the cell. In the first case, a crystal of sugar was dipped into water. Chaotic wave front distribution resulted in the process of its solving. In the second case, a drop of alcohol was put on the surface of water. Fair transition is seen in figs 4, 5 from alcohol solution to water. In topograms of figs. 2, 4, contour lines are shown in 0.02λ steps for sugar, and 0.2λ - for alcohol.

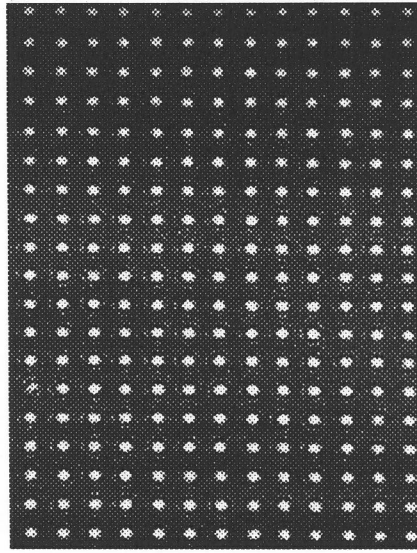


Fig. 1. Typical picture of light spots projected on CCD matrix by holographic lenslet array after light having passed through the object with non-homogeneous refraction distribution

