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Recording of thermal changes of light refraction coefficient with holographic interferometry method *

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Axi-symmetric changes of light refraction coefficient in liquids irradiated with laser beams were observed and interpreted. Real-time holographic interferometry method was applied in the experiment. The magnitude of these changes was determined on the basis of the obtained results.

1. Introduction

Interferograms of axi-symmetric changes of light refraction coefficient n are interpreted basing on the equation [1–5]

$$N(x)\lambda = 2\int\limits_{x}^{R}\frac{\Delta n(r)\,r\,dr}{(r^2-x^2)^{1/2}} \tag{1}$$

where: $N(x)$ – deviation of interference fringes from their linear direction,
λ – recording wavelength,
$\Delta n(r)$ – function of the axi-symmetric changes of n,
r – radial distance from the axis,
R – radius of the phase object.

Equation (1) is one form of Abel's integral equation. If $\Delta n(r)$ is zero for all $r > R$, then Eq. (1) inverts analytically into

$$\Delta n(r) = -\frac{\lambda}{\pi}\int\limits_{r}^{R}\frac{(dN/dx)\,dx}{(x^2-r^2)^{1/2}}. \tag{2}$$

BOCKASTEN [1] obtained a simple form of Eq. (2)

$$\Delta n_j = \frac{\lambda}{R}\sum_k a_{jk} N_k \tag{3}$$

where: Δn_j – values of n-changes,
a_{jk} – coefficients evaluated numerically,
N_k – deviation values of interference fringes.

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2. Experimental

In the first part of the experiment, the axi-symmetric changes of n were obtained by changing the temperature of the examined object. The straight line conductor with radius of 0.06 mm was dipped in water. The direct current flowing along the conductor stimulated the axi-symmetric changes of temperature. The distribution of n-changes was recorded by applying real-time holographic interferometry method. The classical holographic set-up for real-time interferometry [3] was equipped with the camera, monitor and the videorecorder. Hologram was recorded on Agfa–Gevaert 10 E 75 plate, using 8 mW He-Ne laser. The exposure time was 10^{-3} s.

During real-time holographic observation of the examined liquid there appeared parallel interference fringes. After stimulating the axi-symmetric n-changes in liquid, a deviation of interference fringes from their linear direction has been observed.

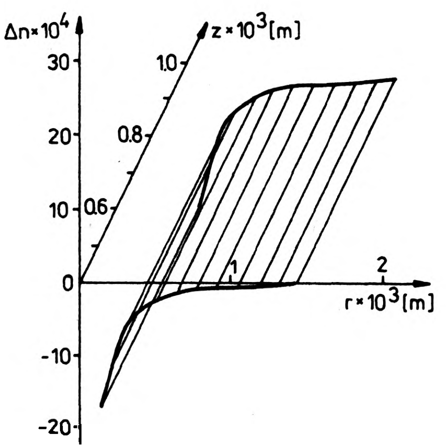

Fig. 1. Distribution of the changes of n in water near straight line conductor $I_1 =$ 3.6 A

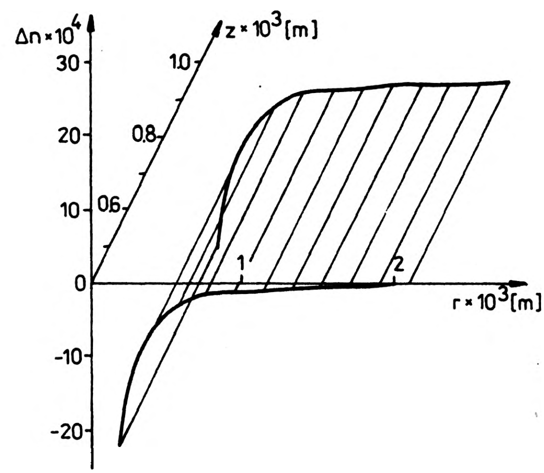

Fig. 2. Distribution of the changes of n in water near straight line conductor $I_2 = 5$ A

Figures 1 and 2 show a graphic interpretation of interferograms for the conductor supplying 3.6 A and 5 A, respectively. The conductor was dipped along the z-axis. Then, the hologram of axi-symmetric changes of n in apiezon C, irradiated with CO_2 (10.6 μm) laser beam perpendicular to the liquid surface, was recorded.

The continuous laser beam of 1 W optical power was focused on the liquid surface. The experimental arrangement with CO_2 laser was similar to that with straight-line conductor.

Figure 3 shows a graphic interpretation of one of the obtained interferograms.

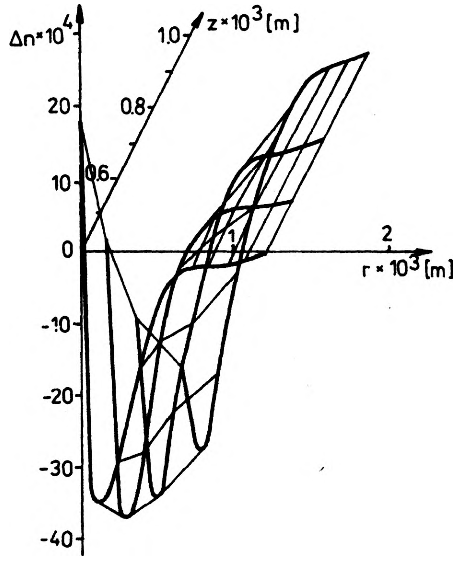

Fig. 3. Distribution of the changes of n in apiezon C irradiated with CO_4 laser beam

The CO_2 laser beam propagates along the z-axis. The changes of n in apiezon C were calculated for the 0.56×10^{-3} m thick liquid layer lying on the depth of 0.96×10^{-3} m.

3. Conclusions

Real-time holographic interferometry method enables the monitoring and continuous control of small changes of n ($\Delta n = 10^{-4}$) in liquids. The distribution of these changes defined the distribution of the temperature changes. Microscopic holographical interferograms were recorded for circularly symmetric phase objects with radii of about 2×10^{-3} m.

The experiment proved the applicability of holographic interferometry method in studies of small changes on n in transparent object irradiated with circularly symmetric laser beams.

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Определение термических изменений коэффициента рефракции света методом голографической интерференции

В работе зарегистрированы и интерпретированы аксиально-симметрические изменения коэффициента рефракции света в жидкости. Для регистрации применен метод голографической интерферометрии в реальное время. Полученные результаты позволяют определить значение изменения коэффициента рефракции света, возникшего во время воздействия лазерного излучения на жидкость.