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Examination of gas-liquid diffusion by holographic interferometry method of enhanced sensitivity*

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1. Introduction

Of the optical methods used for phase object examinations the holographic interferometry is especially suitable for investigation of diffusion in gases and liquids since it is insensitive to the wavefront perturbation by the vessel wall and the optical element of the experimental setup.

The results of examinations of liquid-liquid diffusion reported in papers [1, 2] showed the succesful applicability of holographic interferometry to determination of the diffusion coefficient. However, the data reported in [3] indicated that the method of holographic interferometry in its standard form may be not sensitive enough in the case of free flow of gas over the liquid surface. In the paper presented the sensitivity of holographic interferometry has been increased by letting the object wave to pass three times through the diffusion region. This way of sensitivity enhancement for the diffusion examination proved to be useful since at each horizontal plane of the diffusion region the light refractive index was constant.

2. Experimental data

In this paper the PI-München holographic camera was used (fig. 1). The light beam from a helium-neon laser L is split with the help of beam splitter into object and reference waves. The

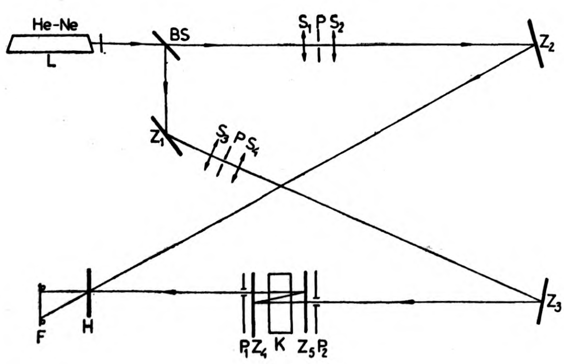

Fig. 1. Scheme of the optical system for examination of the gas-liquid diffusion effect: L – laser, S_1, S_2, S_3, S_4 – lenses, P – pinhole, P_1, P_2 – screens with slits, Z_4, Z_5 – semitransparent mirrors, Z_1, Z_2, Z_3 – totally reflecting mirrors, K – vessel with liquid, F – photographic camera without objective, H – hologram

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reference wave after being formed in a parallel beam by a system lenses S_1 and S_2 and reflected from the mirror Z_2 falls onto hologram H. The object wave being reflected from the mirror Z_1 is formed in a parallel beam by the system of lenses S_3 and S_4, and directed with the help of the mirror Z_3 onto the cuvette with the liquid (fig. 2). The vertical slits in the screens

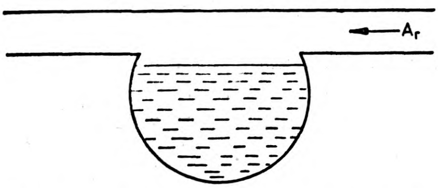

Fig. 2. Vessel with liquid

P_1 and P_2 and the mirrors Z_4 and Z_5 are positioned with respect to one another in such a way that the light entering the cuvette could pass it three times. The object wave passing through the slit in the screen P_1 falls onto holographic plate H. In the experiment both the double-exposure hologram and real time technique were used.

3. Experimental results

Holographic interferograms obtained by wavefront reconstruction from double-exposure or by real-time holograms present the interference pattern which illustrates the refractive index distribution in the diffusion region. The holographic interferogram shown in fig. 3 a was obtained by wavefront reconstruction from a double-exposure hologram. A holographic interferogram obtained by using the real time technique in the case of threefold enhancement of sensitivity is shown in fig. 3 b.

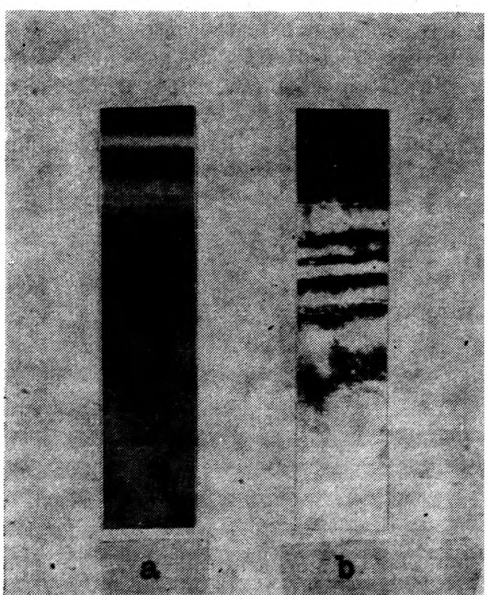

Fig. 3. Holographic interferograms obtained by the methods of double exposure (a), and real-time (b)

4. Conluding remarks

Holographic interferograms allow to obtain some information about the refractive index distribution in the diffusion region. The diffusion coefficient has been calculated by fitting the theoretical distribution of the refractive index to its experimental distribution. The theoretical distribution of the refractive index was calculated for diffusion coefficient for

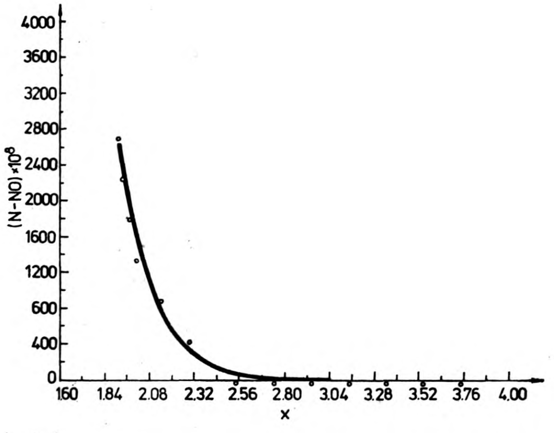

Fig. 4. Refractive index distribution in the diffusion region:
○ – experimental distribution,
▬ – theoretical distribution
N – refractive index in the region of diffusion,
$N0$ – refractive index of water before diffusion ($N = N(x)$),
x – depth of the diffusion region

which the experimental and theoretical distributions were fitted by the method of least squares (fig. 4). The value of the diffusion coefficient for argon-water system at the temperature 293 K was $D = 5 \times 10^{-3}$ cm²/s.

References

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[3] Budziak A., Kędzierski S., Mrowiec S., Piwowarczyk L., Acta Phys. Pol. **A45** (1974), 919.

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