Optica Applicata, Vol. XIV, No. 4, 1984

On possibility of surface deformation of the thin-film liquid with the He-Ne laser light beam

K. Rożniakowski, A. Dolny

Institute of Physics, Technical University of Łódź, ul. Wólczańska 219, 93-005 Łódź, Poland.

In works of Da Costa et al. [1–3] a phenomenon of laser-induced thermocapillarity in thin planar films of heavy hydrocarbons was studied. An existence of a liquid-surface tension gradient (e.g., due to laser heating) leads to hydrodynamic phenomena known as a capillary motion [4], the liquid free-surface deformation being the effect of this motion. That can be observed as an interference image for a beam reflected from the surface, since in the laser-induced thermocapillarity the laser is both a heat- and a light-source.

That phenomenon has been also observed by the authors of the present paper. The experimental set-up used is shown in Fig. 1. He-Ne laser light beam

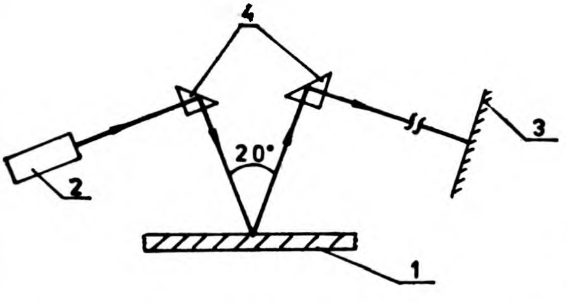

Fig. 1. An experimental set-up: 1 – liquid film, 2 – He-Ne laser, 3 – screen, 4 – prism

(spherical resonator, $\lambda = 6328$ Å, single-mode operation) irradiates directly surface of the horizontal sample (heavy hydrocarbon) highly absorbing light of this wavelength. The liquid film has been situated on the smooth surface reflecting weakly or strongly the incident light. The following incident power densities (changed with filters) have been employed: 0.12, 0.20 and 0.24 $\mathrm{mW/mm^2}$.

After some time from the moment the laser heating started, the liquid surface assumed a stable shape, and the interference image remained motionless. Exemplary reflected-light intensity distributions, recorded directly on a 27-DIN photographic film, are presented in Fig. 2. For each power density applied the time increase of angular divergence of the reflected-beam outer ring has been measured by measuring the ring diameter on a screen 7.5 m distant from the liquid surface (Fig. 3).

It results from the presented plots that the character of the obtained relations is identical with that in paper [1], although our applied power-density range was a few times lower. The reflected beam angular divergences obtained by us are also expected a few times lower than those observed in paper [1]. From our studies it also results that minimum power density necessary for

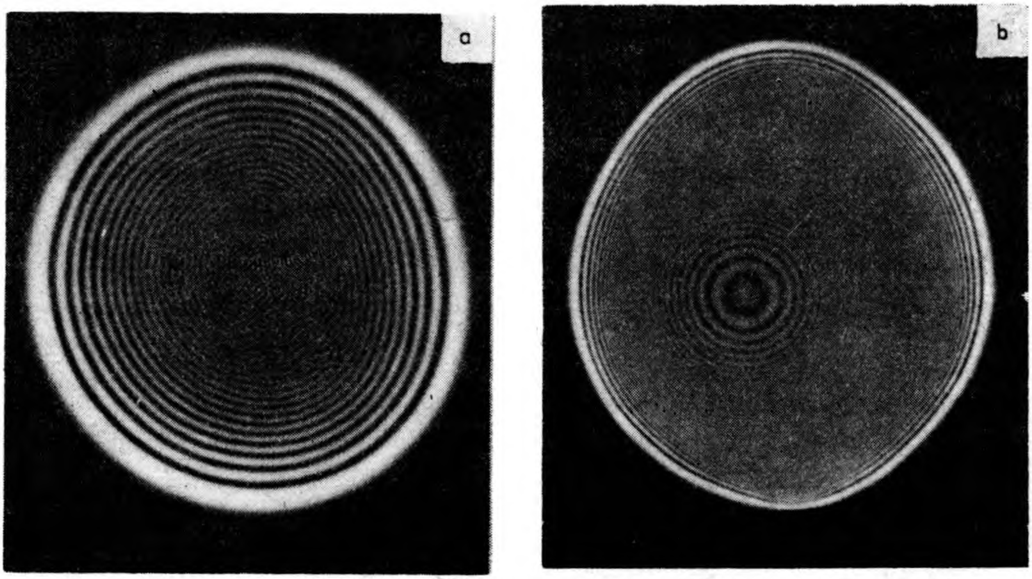

Fig. 2. A picture of the reflected-light intensity distribution. The liquid film situated on the smooth surface which can reflect the light (a) and which cannot reflect the light (b). Newton's rings are seen in the centre

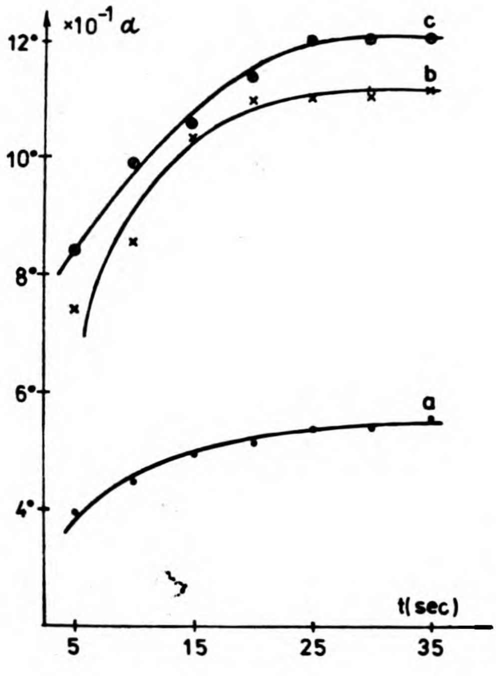

Fig. 3. Time increase of angular divergence of the outer ring for different laser-power densities. The liquid film situated on the non-reflecting surface: a – 0.12 mW/mm^2, b – 0.20 mW/mm^2, c – 0.24 mW/mm^2

the surface deformation, i.e. for observations of laser-induced thermocapillarity, for the hydrocarbons used (obtained from the Commercial Centre for Oil Industry CPN, Łódź, Poland) equals about 0.10 mW/mm^2 at the liquid temperature of 21°C.

Acknowledgements – The authors wish to thank Prof. A. Drobnik for the valuable and authoritative discussion.

References

[1] DA COSTA G., CALATRONI J., Appl. Opt. **17** (1978), 2381.
[2] DA COSTA G., CALATRONI J., Appl. Otp. **18** (1979), 233.
[3] DA COSTA G., BENTOLILA F., RUIZ E., GALÁN E., J. Opt. Soc. Am. **14** (1983), 179.
[4] LEVICH V.G., *Fiziko-khemicheskaya gidrodinamika*, Moskva 1959, 382.

Received May 20, 1984