EFFECT OF LIQUID SURFACE LAYERS ON THE HEAT RELEASE AND HEATING OF WATER DROPLETS UNDER THE ACTION OF RADIATION

A. P. Prishivalko and S. T. Leiko

The optical properties of water droplets can be substantially altered by formation on them of liquid foreign films whose condensation is due to commerical waste or artificial atomization of various liquids such as surface-active media (SAM). One usually considers cases when the thickness of such films is very small (see, e.g., [1]). In the present paper is considered the influence exerted on the heat release and on the heating of water drops by films up to $(1.5\text{–}1.7)\lambda$ thick, where $\lambda = 2.36$ μm and the drop radius is $R_1 = 100$ μm. Since there are practically no data on the optical properties of SAM, the analysis is carried out for a wide interval of variation of the refractive index of the films, $n_2 = 1.15\text{–}1.6$, and of absorption coefficient, $\varkappa_2 = 0\text{–}0.01$. For water at $\lambda = 2.36$ μm we have $n_i = 1{,}274, \varkappa_i = 7.6 \cdot 10^{-4}$.

It can be seen from Fig. 1 that when the radius of the water drop is increased from 100 to 104 μm, the absorption effectiveness factor k_n increases almost linearly. In most cases when a film of a nonabsorbing liquid is produced on the droplet surface, the absorption effectiveness factor is decreased. The scattering effectiveness factor is increased. At small film thicknesses (up to 0.75λ) the function $k_n(R_2)$ at $n_2 > n_i$ is oscillatory. The position of the first minimum of $k_n(R_2)$ is determined quite accurately by the interference condition $R_2 - R_1 = \lambda/4n_2$. When the surface-layer thickness increases above 0.75λ the $k_n(R_2)$ function becomes disordered. The absorption-effectiveness factor increases rapidly at $\varkappa_2 \neq 0$.

The increase of the film thickness influences much more strongly the distribution of the radiation intensity (and accordingly the heat release) inside the drop. With increasing n_2, the height of the maxima B increases. For $n_2 = 1.5$, the change of the highest maximum as a function of the film thickness is shown in Fig. 2. As the film thickness is increased from zero to $R_2 - R_1 = \lambda/4n_2$ the highest maximum B increases by 4 times, and then decreases by a factor 3.25 at $R_2 - R_1 = 2.35(\lambda/4n_2)$. It is noteworthy that the very highest value $B_{\text{макс}}$ is reached at a film thickness corresponding to the first minimum of the function $k_n(R_2)$, while the second minimum of the function $B_{\text{макс}}(R_2)$ occurs at a film thickness corresponding to the second maximum of $k_n(R_2)$. With further increase of the film thickness, the distances between the neighboring maxima (and minima) of the function $B_{\text{макс}}(R_2)$ remain approximately constant at $2.1(\lambda/4n_2)$. The difference between the extremal values of this function decreases gradually. It can be easily noted that the highest values of the function $B_{\text{макс}}(R_2)$ lie on the single straight line $B_{\text{макс}} = 450.3 - 2.76 R_2$ (with a spread not larger than ±1%). In turn, the lowest values of $B_{\text{макс}}(R_2)$ lie near the line

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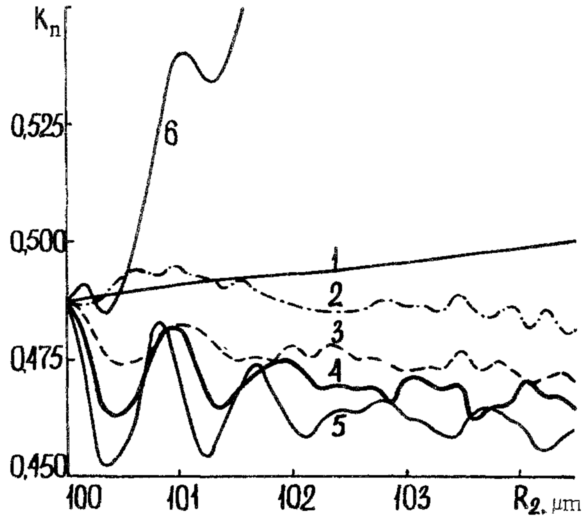

Fig. 1. Dependences of the absorption effectiveness factors on the surface-layer thickness for a homogeneous water droplet (1) and at various n_2 = I.I5(2); I.4(3); I.5(4); I.6(5) , as well as at n_2= I.5, $\varkappa_2$ = 0.0I(6).

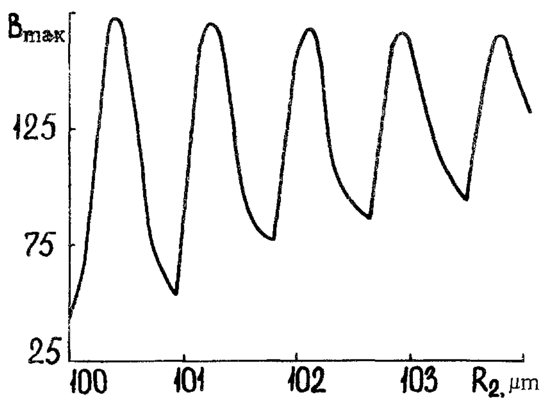

Fig. 2. Dependence of the highest maximum of B on the film thickness at n_2= I.5 .

$B_{макс}$ = I5.3R_2 - I488 (with a spread not larger than 10%).

The agreement noted above between the first maximum of $B_{макс}(R_2)$ and the first minimum of $K_n(R_2)$, and between corresponding second extrema of these functions, is evidence, on the one hand, that interference phenomena in the surface film exert in this region a substantial influence on the energy distribution inside the drop. On the other hand, this shows quite obviously that the increase of the maximum values of B inside the drop is due not to an increase of the integral absorption of the radiation by the drop, but to the substantial redistribution of the energy inside the drop and the concentration of this energy within the confines of a decreasing part of the drop volume. This redistribution influences quite noticeably the dynamics of the drop heating and the conditions under which complete destruction of the drop is achieved.

A substantial increase of the maximum values of B at a film thickness $\sim\lambda/4n_2$ occurs also at values of its refractive index other than n_2= I.5 . This regularity can be used to increase the effectiveness of the action of the radiation on the water drop.

LITERATURE CITED

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INVESTIGATION OF INTERNAL ELECTROMAGNETIC FIELD IN WEAKLY ABSORBING PARTICLES UNDER RESONANCE CONDITIONS

A. P. Prishivalko, L. G. Astaf'eva,
and M. S. Veremchuk

This paper deals with the structure of electromagnetic fields and with heat release inside a dielectric sphere under resonance conditions. The distributions of the electromagnetic energy inside the particles were calculated using the formulas and procedure described in [1, 2]. The energy density of the electromagnetic field and the heat release inside the particles are characterized by a quantity B, calculated in terms of the component of the electric field strength $\vec{E}$, viz. $B = \vec{E} \cdot \vec{E}^* / E_0^2$.

A typical picture of the energy distribution inside the particle under resonance conditions is shown Fig. 1, which presents two regions of equal-energy curves in the plane of the particle's great circle. The radiation flux is from left to right. The light incident on the particle is polarized. It can be seen from Fig. 1 that the largest inhomogeneity of the distribution of the electromagnetic energy is observed for this resonance in the direction $\theta = 0^0$-180^0, which coincides with the propagation direction of the incident radiation. With increasing distance from this direction, the values of B decrease rapidly (by three orders of magnitude). At $\theta > 20^0$, the $B(\theta)$ dependence has an oscillating character with small oscillation amplitudes. It must be noted that the bulk of the electromagnetic energy is released in the regions adjacent to the particle surface.

The investigations have shown that for a particle with $\rho = 44.409$ the predominant contribution to the resonance is made by a magnetic partial wave of the order of $\ell = 53$. The maximum value of B is then on the diameter that coincides with the direction of the incident radiation. The character of the energy distribution inside the water droplets under conditions of resonances of the magnetic type of other orders does not differ from the energy distribution at the given value of ρ, and all that changes is the maximum value of B and its radial coordinate.

If the main contribution to the resonance is made by electric partial waves, the maximum value of B may turn out to be shifted by a certain angle $\pm\theta$ relative to the particle

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