Optical Excitation of Surface Waves in Transparent Condensed Media

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The striction mechanism of optical excitation of surface waves in condensed media is discussed. This mechanism is not related to absorption of radiation and is primarily suited for transparent media. Excitation of surface waves in a liquid (capillary waves) is considered in detail. Numerical estimates are given.

THE possibility of the effective optical excitation of surface waves (elastic or capillary) in condensed media through the action of a thermal mechanism, more precisely, the periodic (in space) surface heating of the sample, has been demonstrated recently in theoretical and experimental researches.[1-3] The heating itself is due in this case to absorption in the surface layer of two sufficiently short light pulses that are interfering with one another.[2,3] Such a method allows the excitation of a surface waves (SW) not only in absorbing media but also in transparent media, by depositing on the surface of the latter thin absorbing films with excellent thermal conductivity. In experiments[1,3], for the excitation of Rayleigh SW, thin metallic films are deposited on the surface of transparent solids. The thermal mechanism just described suffers, however, from the fact that it has a rather low limit on the maximum permissible intensity of the exciting light and consequently on the maximum amplitude of the excited SW. This limit is due to the dissipation of energy in the surface layer, which is consequently damaged. In[3] the maximum attained amplitude of the Rayleigh SW amounted to about 200 Å; further increase in the light intensity melted the metallic film.

In the present paper we want to discuss the striction mechanism of optical excitation of SW, which is not related to absorption of radiation and which is consequently well suited for transparent media. In this mechanism of excitation, the limit of increase of intensity of the exciting light (or of amplitude of the SW) is determined either by the limit in the mechanical stability of the surface of the sample[1)] or by optical breakdown in it. The estimates given below show that the proposed striction method of excitation allows us in principle to obtain much greater amplitudes of SW than the thermal method. On the other hand, the effect under consideration can in some cases determine the radiation surface strength of transparent materials used in laser technology.

The striction buildup of SW has been extensively discussed in the literature recently and is connected with the existence of a jump in the (normal to the surface) components of the ponderomotive force, that is produced when a transparent dielectric is placed in an electromagnetic field, and a voltage that is quadratically dependent on the field.[2)] In[4] (see also the latter works[5-9]), stimulated light scattering (of a plane monochromatic wave) by the surface of a liquid (or solid) has been investigated theoretically. This scattering is accompanied by parametric excitation of SW, which is due in turn to the interference between the incident light wave and waves scattered by the SW. Thanks to the presence of intrinsic damping (viscosity and thermal conductivity), the buildup of these SW has a threshold character in terms of the intensity I of the incident radiation. At $I > I_{th}$ the buildup condition, i.e., the condition of instability of the SW (a growth of amplitude exponential in time) is at once satisfied for the entire spectral range of the SW. For this reason, the characteristics of the surface waves excited in this fashion (their amplitude, length, frequency) cannot be controlled. If, moreover, we take it into consideration that the threshold intensity I_{th} is rather high (for liquids of low viscosity, for example, it is $\sim 10^6$ W/cm^2), it then becomes clear that the striction method of excitation of SW of a single light wave is of little practical interest, although the phenomenon of stimulated light scattering that arises here is, on the other hand, a very interesting physical effect, which can have practical value (for example, the disappearance of Fresnel reflection of light upon onset of instability of the SW is possible).

As will be seen from the following, the striction mechanism of SW excitation becomes much more effective and controllable if not one light beam but two mutually interfering beams are used as the exciting radiation. Here the frequencies ω_1 and ω_2 of these beams can either be identical (as in the thermal method of SW excitation) or different. In the first case, excitation of static (immobile) SW takes place: $\zeta_0 \cos(\mathbf{q}\cdot\mathbf{r})$ ($\mathbf{q} = \mathbf{k}_{t_1} - \mathbf{k}_{t_2}$, $\mathbf{k}_{t_1}$ and $\mathbf{k}_{t_2}$ are the projections of the wave vectors of the two beams $\mathbf{k}_1$ and $\mathbf{k}_2$ on the surface of the medium, $|\mathbf{k}_1| = |\mathbf{k}_2|$, $|\zeta_0|$ is the amplitude of the SW), which, after shutting off of the light pulse, transforms into two "characteristic" traveling waves $\frac{1}{2}\zeta_0 \cos(\mathbf{q}\cdot\mathbf{r} \pm \Omega_0 t)$, where the frequency $\Omega_0 = \Omega_0(q)$ is determined by the dispersion equation of the SW. The external picture of SW excitation in this case is similar to that observed in the thermal method of excitation.[2,3] In the second case, excitation of the traveling wave $\zeta_0 \cos(\mathbf{q}\cdot\mathbf{r} - \Omega t)$ occurs at the beat frequency $\Omega = \omega_1 - \omega_2$, which does not generally satisfy the dispersion equation for SW (i.e., $\Omega \neq \Omega_0$). After cessation of the light pulse, a transformation of this "improper" SW into the "proper" SW should take place. In such a method of optical excitation of SW, their buildup takes place as the result of forced vibrations of the surface of the medium under the action

[1)]In the case of a liquid, it is a matter of the turbulence of the surface motion for large oscillation amplitudes.

[2)]The existence of such a jump at the surface is one of the manifestations of the striction effect; the medium itself can even be incompressible in this case.

of an external force due to the interference of the two incident light waves. For this reason, even in the presence of "proper" damping of the SW, their excitation does not have a threshold character in the light intensity I (as is the case in the parametric excitation of a single light wave); further, the exciting SW always remains stable (if, of course, it does not begin to show the parametric instability mentioned above).

We present below a quantitative study of the suggested method of SW excitation. We limit ourselves here to the case of a liquid medium and we shall therefore be interested in the excitation of capillary waves. The viscosity of the liquid (SW damping) is assumed to be arbitrary, and the liquid itself incompressible. The electrodynamic part of the statement of the problem presupposes the incidence of two coherent, plane monochromatic waves on the surface of the liquid.

2. The equations of motion of the liquid on the interface with the atmosphere, with account of ponderomotive forces, are[10,11]

$$\partial \mathbf{V}/\partial t = \nu\Delta\mathbf{V} - \nabla p/\rho, \quad \operatorname{div}\mathbf{V} = 0 \tag{1}$$

and the boundary conditions

$$(p - p_{\text{atm}} + \alpha\Delta_\perp\zeta + f)n_i - \eta\left(\frac{\partial V_i}{\partial x_k} + \frac{\partial V_k}{\partial x_i}\right)n_k = 0. \tag{1a}$$

Here $\Delta_\perp = \partial^2/\partial x^2 + \partial^2/\partial y^2$, $\zeta = \zeta(x, y, t)$ is a function describing the deviation of the surface of the liquid from the plane $z = 0$ (the region of liquid corresponds to $z < \zeta$), $n_i = \{-\partial\zeta/\partial x, -\partial\zeta/\partial y, 1\}$ is the normal to the surface,

$$p = p' - \rho\frac{\partial\varepsilon}{\partial\rho}\frac{E^2}{8\pi},$$

p', ρ, $\mathbf{V}$, ν, α, ϵ are respectively the pressure, density, velocity, kinematic viscosity ($\nu = \eta/\rho$), surface tension, and dielectric constant of the liquid, p_{atm} is the atmospheric pressure.

The quantity f determines the striction pressure jump at the surface of the medium and can be expressed in terms of the field intensity in the liquid:

$$f = \frac{\varepsilon - 1}{8\pi}[(\varepsilon - 1)(\mathbf{E}\mathbf{n})^2 + E^2],$$

where, of course, the rapidly oscillating components (averaged over the period of the field) are omitted. In our case of two plane electromagnetic waves incident on the interface $\zeta(x, y, t)$, the quantity f can be represented as the sum $f_0 + f_1$, where f_0 is a constant component which is combined in what follows with the constant quantity $p_0 - p_{\text{atm}}$, and f_1 is the periodic component, which has the form

$$f_1 = \operatorname{Re}\left(\frac{\varepsilon - 1}{8\pi}[\mathbf{E}_{t1}\mathbf{E}_{t2}^* + \varepsilon\mathbf{E}_{n1}\mathbf{E}_{n2}^*]\exp\{i[(\mathbf{k}_{t1} - \mathbf{k}_{t2})\mathbf{r} - (\omega_1 - \omega_2)t]\}\right). \tag{2}$$

In this formula, it is assumed that the displacements of the boundary surface from the equilibrium position $z = 0$ are small in comparison with the wavelengths of the incident radiation, i.e., $|k_i\zeta| \ll 1$ $(i = 1, 2)$, E_{ti} and E_{ni} are the tangential and normal (to the surface $z = 0$) Fresnel components of the field intensity of the refracted waves, corresponding to two light waves incident on the surface with wave vectors $\mathbf{k}_i$ and frequencies ω_i, $\mathbf{k}_{ti} = \{k_{xi}, k_{yi}\}$, and $\mathbf{r} = \{x, y\}$ are two-dimensional vectors in the plane $z = 0$.

In the following, only linear surface waves will be considered with $|\nabla\zeta| \ll 1$. The boundary conditions (1a) should obviously be satisfied individually in the zeroth and first orders in ζ. Here we shall assume the stimulating "force" f_1 to be $\lesssim p_\zeta$, where p_ζ is the linear-in-ζ term in the expansion of p in powers of the displacement of the boundary surface, and the "force" f_1 itself is determined by Eq. (2). In first order, with account of the zeroth order, they take the form

$$\begin{gathered} 2\eta\frac{\partial V_z}{\partial z} - (p_\zeta + \alpha\Delta_\perp\zeta) = f_1, \\ \frac{\partial V_y}{\partial z} + \frac{\partial V_z}{\partial y} = 0, \quad \frac{\partial V_x}{\partial z} + \frac{\partial V_z}{\partial x} = 0. \end{gathered} \tag{3}$$

The z dependence of the Fourier transforms of the velocity and the pressure

$$\tilde{\mathbf{V}}(z) = (2\pi)^{-3}\int d\mathbf{r}\,dt e^{-i(\mathbf{q}\mathbf{r}-\Omega t)}\mathbf{V}(\mathbf{R}, t),$$

$$\tilde{p}_\zeta(z) = (2\pi)^{-3}\int d\mathbf{r}\,dt\, e^{-i(\mathbf{q}\mathbf{r}-\Omega t)}p_\zeta(\mathbf{R}, t),$$

$$\frac{\partial\zeta}{\partial t} = V_z|_{z=0}, \quad \mathbf{q} = \{q_x, q_y\}, \quad \mathbf{R} = \{x, y, z\}$$

is determined from the bulk equations (1) under the assumption of a solution damped in z:

$$\begin{gathered} \tilde{V}_{x,y} = A_{x,y}e^{mz} + \frac{q_{x,y}}{q}A_p e^{qz}, \\ \tilde{V}_z = -\frac{i}{m}(q_x A_x + q_y A_y)e^{mz} - iA_p e^{qz}, \\ \tilde{p}_\zeta = \frac{\rho\Omega}{q}A_p e^{qz}, \end{gathered} \tag{4}$$

where

$$m = \sqrt{q^2 - i\Omega/\nu}, \quad \operatorname{Re}(m) > 0, \quad q = |\mathbf{q}|,$$

$$\tilde{V}_z|_{z=0} = -i\Omega\zeta(\mathbf{q}, \Omega), \quad \zeta(\mathbf{q}, \Omega) = (2\pi)^{-3}\int d\mathbf{r}\,dt e^{-i(\mathbf{q}\mathbf{r}-\Omega t)}\zeta(\mathbf{r}, t).$$

Substituting (4) in the boundary condition (3), we get a linear inhomogeneous set of equations relative to the quantities A_x, A_y, A_p, on the right hand side of which we have

$$\tilde{f}_1 = A\delta(\mathbf{q} - \mathbf{k}_{t1} + \mathbf{k}_{t2})\delta(\Omega - \omega_1 + \omega_2) + A^*\delta(\mathbf{q} + \mathbf{k}_{t1} - \mathbf{k}_{t2}) \times \delta(\Omega + \omega_1 - \omega_2),$$

$$A = \frac{\varepsilon - 1}{16\pi}[\mathbf{E}_{t1}\mathbf{E}_{t2}^* + \varepsilon\mathbf{E}_{n1}\mathbf{E}_{n2}^*]. \tag{5}$$

The solution of this set can be written down in the form

$$A_{x,y} = \frac{2\nu q^2\sqrt{1 - i\Omega/\nu q^2}}{\rho\Omega\Delta}\xi q_{x,y},$$

$$A_p = \frac{(i\Omega - 2\nu q^2)}{\rho\Omega\Delta}\xi q, \tag{6}$$

where

$$\xi = -i(\omega_1 - \omega_2)A\delta(\mathbf{q} - \mathbf{k}_{t1} + \mathbf{k}_{t2})\delta(\Omega - \omega_1 + \omega_2) + i(\omega_1 - \omega_2)A^*\delta(\mathbf{q} + \mathbf{k}_{t1} - \mathbf{k}_{t2})\delta(\Omega + \omega_1 - \omega_2),$$

$$\Delta = \Omega_0^2 + (2\nu q^2 - i\Omega)^2 - (2\nu q^2)^2\sqrt{1 - i\Omega/\nu q^2}, \quad \Omega_0^2 = \alpha q^3/\rho.$$

We note that the equation $\Delta(\Omega, q) = 0$ represents the dispersion equation for capillary waves on the surface of a liquid with arbitrary viscosity.[12] In our case, Ω and q are real quantities and therefore $\Delta(\Omega, q)$ does not vanish. It is not difficult to obtain expressions for the velocity and pressure from (4)–(6) by carrying out the inverse Fourier transformation. Thus, we get for the velocity component V_z

$$V_z(\mathbf{R}, t) = \operatorname{Re}\left\{\frac{2q}{\rho\Delta}[(2\nu q^2 - i\Omega)e^{qz} - 2\nu q^2 e^{mz}]Ae^{i(\mathbf{r}\mathbf{q}-\Omega t)}\right\},$$

where $q = k_{t_1} - k_{t_2}$ and $\Omega = \omega_1 - \omega_2$ here and in what follows. For the displacements of the boundary surface, we have

$$\zeta(\mathbf{r},t) = \mathrm{Re}\left\{\frac{q}{\rho\Delta}\frac{\varepsilon-1}{8\pi}[\mathbf{E}_{t1}\mathbf{E}_{t2}^* + \varepsilon\mathbf{E}_{n1}\mathbf{E}_{n2}^*]e^{i(\mathbf{qr}-\Omega t)}\right\}. \quad (7)$$

Thus, under the action of two plane electromagnetic waves, the surface of the liquid should undergo stimulated oscillations with amplitude $|\zeta_0| = 2q/\rho|A/\Delta|$ and wave vector $\mathbf{q} = \mathbf{k}_{t_1} - \mathbf{k}_{t_2}$ at the beat frequency $\Omega = \omega_1 - \omega_2$.

3. We now consider the dependence of the square of the amplitude $|\zeta_0|^2$ on q and Ω in certain special cases. For simplicity, we shall assume below that both plane electromagnetic waves lie in a single plane of incidence and are polarized perpendicular to the plane of incidence (x, z). Here,

$$|\zeta_0|^2 = I_1I_2\frac{(\varepsilon-1)^2}{c^2}\frac{q^2}{\rho^2|\Delta|^2}|T_{\perp 1}|^2|T_{\perp 2}|^2, \quad (8)$$

where $I_i = c|\mathbf{E}_{0i}|^2/8\pi$ is the intensity of the incident plane waves (i = 1, 2), $T_{\perp i} = 2k_{zi}/[k_{zi} + \sqrt{\epsilon\omega_i^2/c^2 - k_{xi}^2}]$ are the Fresnel amplitude coefficients of the refracted waves, k_{xi} and k_{zi} are the components of the wave vectors $\mathbf{k}_i$ of the incident waves. One can show that Eq. (8) is valid even in the case of total Fresnel reflection, when the two plane electromagnetic waves are incident on the interface between the liquid and the free space from the side of the medium, i.e., the liquid occupies the space $z > \zeta(x, y, t)$. In such a case, the z components of the wave vectors of the refracted waves become imaginary and (8) can be written in the form

$$|\zeta_0|^2 = \frac{16\varepsilon}{c^2}\frac{q^2}{\rho^2|\Delta|^2}I_1I_2\cos^2\theta_1\cos^2\theta_2, \quad (9)$$

where it is assumed that the angles of incidence θ_1 and θ_2 are greater than critical, i.e., $\sin^2\theta_i > 1/\epsilon$, and $I_i = c\sqrt{\epsilon}|\mathbf{E}_{0i}|^2/8\pi$.

We shall analyze the behavior of the "frequency characteristic" $|\Delta|^{-2}$ as a function of Ω for a given value of q.

a) Region of low frequencies Ω. At $\Omega = 0$ we have $|\Delta|^{-2} = 1/\Omega_0^4 = \rho^2/\alpha^2q^6$ for a liquid with an arbitrary viscosity. We now consider the case when $\delta = (\Omega/\nu q^2) \ll 1$. Here it is easy to obtain

$$|\Delta|^{-2} = (\nu q^2)^{-4}[\mu^4 + (4-3\mu^2)\delta^2 + (13 + {}^5/_4\mu^2)\delta^4/4]^{-1}, \quad (10)$$

for the quantity $|\Delta|^{-2}$, where $\mu = \Omega_0/\nu q^2$. It then follows that, for $\mu^2 < 4/3$, the frequency characteristic in the low frequency region is described by a Lorentz curve with width $\Delta\Omega = \Omega_0^2/\nu q^2\sqrt{4-3\mu^2}$:

$$|\Delta|^{-2} = \frac{[(4-3\mu^2)(\nu q^2)^2]^{-1}}{\Omega_0^4/[(\nu q^2)^2(4-3\mu^2)] + \Omega^2}. \quad (10a)$$

For $\mu^2 = 4/3$, the curve $|\Delta|^{-2}$ differs from Lorentzian and has the width $\Delta\Omega = (3/11)^{1/4}\Omega_0 = (2/\sqrt{3})(3/11)^{1/4}\nu q^2$,

$$|\Delta|^{-2} = 3/11\,({}^3/_{11}\Omega_0^4 + \Omega^4). \quad (10b)$$

The two cases considered, $\mu^2 \leq 4/3$, pertain to viscous liquids, for which, as we have seen, the frequency characteristic $|\Delta|^{-2}$ has a maximum at zero frequency ($\Omega = \omega_1 - \omega_2 = 0$). Conversely, for liquids of low viscosity, when $\mu^2 > 4/3$, the point $\Omega = 0$ is the point of minimum $|\Delta|^{-2}$. From (10) we have for $\mu^2 > 4/3$ in the region of low frequencies,

$$|\Delta|^{-2} = \frac{[(3\mu^2-4)(\nu q^2)^2]^{-1}}{\Omega_0^4/[(\nu q^2)^2(3\mu^2-4)] - \Omega^2}. \quad (10c)$$

b) Region of high frequencies Ω. In this region, $\delta = (\Omega/\nu q^2) \gg 1$, and we get for $|\Delta|^{-2}$

$$|\Delta|^{-2} = (\nu q^2)^{-4}[(\mu^2-\delta^2)^2 + 4\sqrt{2}\sqrt{\delta}(\delta^2-\mu^2) + 8(\delta^2+\mu^2)]^{-1}. \quad (11)$$

It is then seen that $|\Delta|^{-2} \approx 1/\Omega^4$ for all liquids, in the limit of large Ω. For viscous liquids ($\mu \leq 4/3$) this representation is valid if $\delta \gg 1$ ($\Omega \gg \nu q^2$); for low-viscosity liquids ($\mu \gg 1$) it is valid for $\delta \gtrsim \mu^2$ ($\Omega \gtrsim \Omega_0^2/\nu q^2$).

Thus, for viscous liquids, the frequency characteristic $|\Delta|^{-2}$ falls off monotonically with increasing frequency, in the entire range of frequencies Ω from the value Ω_0^{-4} at $\Omega = 0$.

For low-viscosity liquids, in the range of high frequencies that satisfy the condition $|\delta^2 - \mu^2| \lesssim \mu$, we have resonance. In this range, the expression

$$|\Delta|^{-2} = [(\Omega^2 - \Omega_0^2)^2 + 16\Omega_0^2(\nu q^2)^2]^{-1} \quad (12)$$

is valid for $|\Delta|^{-2}$. The half-width of this resonance is equal to $2\nu q^2$.

We now write down formulas that are suitable for calculation of the amplitudes $|\zeta_0|$ of the SW for three cases: $\Omega = 0$, $\Omega = \Omega_0$ and $\Omega \gtrsim \Omega_0^2/\nu q^2$ (the latter two, of course, refer to liquids of low viscosity). We shall make use here of the general formula (9), which is convenient for the case of total Fresnel reflection of the light. Furthermore, we shall assume that $I_1 = I_2 = I$, $|\Delta\theta| \equiv |\theta_1 - \theta_2| \ll \cot\theta_1 \equiv \cot\theta$, $q = |k_{x1} - k_{x2}| \approx |\Delta\theta|\,k\cos\theta$, and $k = |k_1| \approx |k_2| = \omega\sqrt{\epsilon}/c$.

1) $\Omega \equiv \omega_1 - \omega_2 = 0$. The steady-state response is the static surface wave $\zeta = \zeta_0\cos(\mathbf{q}\cdot\mathbf{r})$ with amplitude

$$|\zeta_0| = \frac{4\sqrt{\varepsilon}I\cos^2\theta}{c\alpha q^2} = \frac{4\sqrt{\varepsilon}I}{c\alpha k^2|\Delta\theta|^2}. \quad (13)$$

We note that the amplitude $|\zeta_0|$ does not depend on the viscosity of the liquid. However, the SW buildup time τ does depend on it. For a strongly viscous liquid ($\mu \ll 1$) the time $\tau \approx 2\nu q^2/\Omega_0^2$ (see (10a)), while for a weakly viscous liquid, $\tau \approx 1/2\nu q^2$.

2) $\Omega \equiv \omega_1 - \omega_2 = \Omega_0(q)$. The steady-state response here is the traveling surface wave $\zeta = \zeta_0\cos(\mathbf{q}\cdot\mathbf{r} - \Omega_0 t)$ with amplitude

$$|\zeta_0| = \frac{\sqrt{\varepsilon}I\cos^2\theta}{c\rho\Omega_0\nu q} = \frac{\sqrt{\varepsilon}I\cos^2\theta}{c\nu(\alpha\rho q^3)^{1/2}}. \quad (14)$$

The buildup time is $\tau \approx 1/2\nu q^2$.

3) $\Omega \equiv \omega_1 - \omega_2 \gtrsim \Omega_0^2/\nu q^2$. The steady-state response is the traveling surface wave $\zeta = \zeta_0\cos(\mathbf{q}\cdot\mathbf{r} - \Omega t)$ with amplitude

$$|\zeta_0| = \frac{4\sqrt{\varepsilon}Iq\cos^2\theta}{c\rho\Omega^2} = \frac{4\sqrt{\varepsilon}kI\cos^3\theta}{c\rho\Omega^2}|\Delta\theta|; \quad (15)$$

the buildup time is $\tau \approx 1/2\nu q^2$.

In this case, the amplitude $|\zeta_0|$ depends neither on the viscosity nor the surface tension of the liquid.

4. To simplify the theoretical consideration, we have discussed above only the case in which the SW excitation comes about by the interference of two plane monochromatic light waves. In a possible experiment with the use of laser sources of excitation, the irradiated region of the surface will have finite dimensions and the interfering light beams themselves will generally

have multimode structure and a frequency spectrum of finite width. Moreover, the radiation can be pulsed, and, consequently the SW excitation should have a nonstationary character. However, it is easy to demonstrate the conditions under which Eqs. (8), (9), (13)—(15) (obtained above for the amplitudes $|\zeta_0|$ of the steady-state SW) are valid and applicable to a real experiment. So far as the temporal and spatial limitations of the light beams are concerned, it is obviously necessary to require that the conditions $\tau_L \gg \tau$ and $a \gg 2\pi/q = \Lambda$ be satisfied, where τ_L is the length of the laser pulse, τ the time of buildup of the SW, which is estimated above, a the linear dimension of the irradiated region of the surface, and Λ the wavelength of the excited SW. The spatial limitation of the light beams can appear, however, in a static bending of the whole radiated portion of the liquid surface. Such a bending effect was discussed in[13] as a possible reason for the self-focusing of the light beam in its entry into the linear medium.

The estimate of the effect on SW excitation of the multimode structure and the finite width of the frequency spectrum of the laser radiation in the general case is rather complicated. However, in a laser operating in a regime of longitudinal modes only the picture is greatly simplified and in fact does not differ from that described above. Actually, the frequency of intermode beats ($\Delta\omega = c/2nL \sim 10^9-10^8$ sec^{-1}) can always be assumed in this case to be large in comparison with the characteristic frequencies Ω ($\sim 10^6-10^5$ sec^{-1}) of the excited SW and consequently one can neglect the excitation of the liquid surface at the frequencies $\Delta\omega$ and their multiples. In this approximation, the variable part of the external force (the pressure jump) f_1, which develops as the result of the interference of two multimode light beams, which are in turn produced by the splitting of a single laser beam, turns out to be identical with the force that appears in this same interferometer in the case of single mode and multifrequency beams with the same integrated intensity. The effect of the finite width of the frequency spectrum of each mode here is eliminated in the usual fashion by having a zero time delay between the interfering beams. To obtain different frequencies ω_1 and ω_2 a Doppler shift of the frequency can be produced in one of the branches of the interferometer. The effect of the finiteness of the spectral width of the individual mode here is eliminated by satisfaction of the condition $(\Omega/\omega_{1,2})\langle(\Delta\tau_L\varphi)^2\rangle^{1/2} \ll 1$, where $\langle(\Delta\tau_L\varphi)^2\rangle \equiv \langle(\varphi(t+\tau_L)-\varphi(t))^2\rangle$ is the mean square of the phase increment of the individual model in the time τ_L.

In conclusion, we present numerical estimates of the necessary intensities of light radiation. The values given below for the intensities $I = I_1 + I_2$ correspond to stationary stimulated SW with amplitude $|\zeta_0| = 2 \times 10^{-6}$ cm. The SW wave number q is assumed to be 10^3 cm^{-1} in all the estimates, which, for $k = 10^5$ cm^{-1}, corresponds to a difference in angle of incidence $\Delta\theta \approx 1°$ (the angles of incidence themselves $\approx 60°$).

For a high-viscosity liquid $\eta = 14.95$ poise (glycerine), resonance corresponds to $\Omega = 0$, the characteristic time $\tau = 2\nu q^2/\Omega_0^2 = 4.6 \times 10^{-4}$ sec, $I = 8.7 \times 10^5$ W/cm^2.

For a low-viscosity liquid, $\eta = 2.4 \times 10^{-3}$ poise (ethyl ether), the resonance corresponds to $\Omega = \Omega_0 = 1.5 \times 10^5$ Hz, the characteristic time $\tau = 1.4 \times 10^{-4}$ sec, $I = 2.5 \times 10^4$ W/cm^2.

Under conditions of total internal reflection (9) the corresponding intensities are smaller by a factor of 4—5. Thus, for glycerine, $I \approx 1.2 \times 10^5$ W/cm^2, and for ethyl ether, $I \approx 6.4 \times 10^3$ W/cm^2.

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