$$K_1(\omega) \sim \mathrm{Re}\,[\hbar\omega - \Delta E - \Sigma_1(\omega + \omega_0 - \omega^*)]^{-1/2}. \qquad (2)$$

Allowance for the higher-order approximations in Σ shows that the approximation cannot be used in a "forbidden" interval of order of $\alpha\omega_0$ near ω^*. This expression is meaningful, however, since the characteristic interval of ω near ω^*, where $dK_1/d\omega$ differs noticeably from $dK_0/d\omega$, is $\alpha^{2/3}\omega_0$, which is larger than the "forbidden" interval. The most significant among the higher-order diagrams are those without intersection of the phonon lines. The summation of these diagrams leads to a renormalization of ω^* by an amount on the order of $\alpha\omega_0$ and to a narrowing of the "forbidden" interval to $\alpha^2\omega_0$.

In the foregoing calculation, just as in [2], no account was taken of the Coulomb interaction between the electron and the hole; this interaction can lead to exciton effects near the singularity in question. If this interaction is appreciable, then the character of the singularity near ω^* may change. But even in the latter case, no singularity of the absorption occurs near ω^*.

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EXCITATION OF STIMULATED LIGHT SCATTERING BY BROAD-SPECTRUM PUMPING

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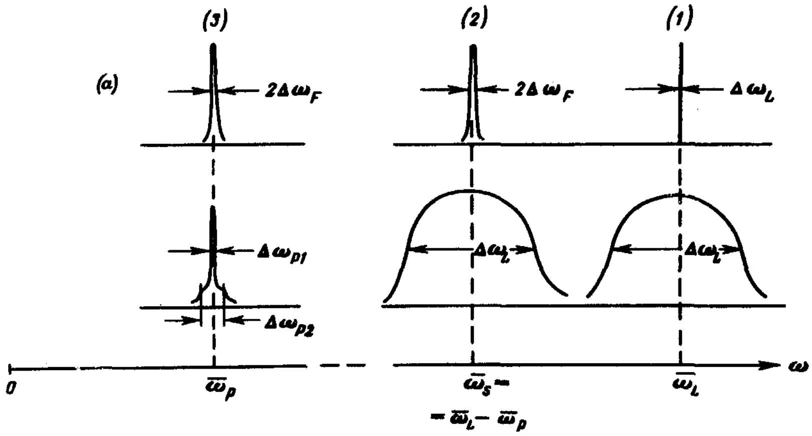
1. To observe stimulated Mandel'shtam-Brillouin scattering (SMBS) and stimulated Roman scattering (SRS) in the stationary regime, the pump laser is chosen to have a bandwidth $\Delta\omega_L$ narrower than the bandwidth $\Delta\omega_0$ of the spontaneous scattering.



Theoretical spectra of pump (1), the scattered light (2), and the hypersound in the case of narrow-band (a) and broadband (b) exciting radiation.

We have made estimates that show that it is possible to use just as effectively (without a decrease in the scattering efficiency at a given average pump intensity $\bar{I}_L$) stationary pumping with a broad spectrum ($\Delta\omega_L \gg \Delta\omega_0$). The smearing of the pump spectrum, connected with the finite duration T of its p pulse, is assumed to be negligible: $\Delta\omega_L T \gg 1$, and also $\Delta\omega_0 T \gg 1$.

When $\Delta\omega_L >> \Delta\omega_0$, the scattering spectra acquire a number of singularities. In particular, the linewidth of the Stokes component is close to $\Delta\omega_L$ (together with the independence of the efficiency of $\Delta\omega_L$, this agrees qualitatively with the experimental data [1]). The spectrum of the acoustic component, however, remains narrow, making it possible, in the case of SMBS, to measure by spectral methods the velocity of hypersound with practically the same accuracy as when $\Delta\omega_L << \Delta\omega_0$.

2. The amplitude A_S of the Stokes comp nent of the SMBS[1)] scattered backwards by the region $0 \leq x \leq \ell$ is equal to [2] $A_S(t) = A_L(t)F(t)$, where

$$F(t) = \int_0^\infty d\theta \int_0^\ell dz\, e^{-\alpha v \theta} N(t-\theta,\ \ell - z)\, I_0\{\sqrt{2\alpha v g z \bar{I}_L \theta[1 + \xi(t,\ \theta)]}\}, \tag{1}$$

$$\xi(t,\ \theta) = \frac{1}{\theta \bar{I}_L} \int_0^\theta \tilde{I}_L(t - \theta_1)\, d\theta_1,$$

$A_L(t)$ is the fluctuating complex amplitude of the pump; the intensity of the exciting radiation is a sum of the dc and ac components, $|A_L^2(t)| = \bar{I}_L + \tilde{I}_L(t)$; α and v are the attenuation coefficient and the velocity of the hypersound at the frequency $\omega_P = 2(v/u)\,\bar{\omega}_L$ $(\Delta\omega_0 = 2\alpha v)$, $\bar{\omega}_L$ is the average laser frequency, u is the velocity of light in the medium, $N(t,z)$ the noise field, g a constant coefficient equal to the specific gain (per unit of pump intensity and unit length) in the case of monochromatic excitation, and I_0 a modified Bessel function

When $\Delta\omega_L >> \Delta\omega_0$, owing to the averaging during the course of integration in (2), the value of ξ in (1) is small, and the function $F(t)$ has the same characteristics as in the case when $\xi = 0$ or $\tilde{I}(t) = 0$, when the variance of F is equal to $\sigma_F^2 \sim \exp J$ and the width of the spectrum is $\Delta\omega_F = \alpha v\sqrt{(\ln 2)/J}$, where $J - g\bar{I}_L\ell >> 1$ [4, 5]. It follows therefore that the exponential dependence of the intensity of the SMBS Stokes component on J remains the same in the case of broadband pumping, namely $I_S = \bar{I}_L\sigma_F^2 \sim \exp J$.

However, inasmuch as $F(t)$ changes much more slowly with time than $A_L(t)$ $(\Delta\omega_F < \Delta\omega_0 << \Delta\omega_L)$, the scattered-light spectrum will have the same form as the pump spectrum (Fig. b).

In estimating ξ, we note that when $\xi = 0$ in (1) only a small region near $\theta = \theta_0 = J/\Delta\omega_0$ is of importance for the integration with respect to θ. This means that the averaging time in (2) is large compared with the pump correlation time $(\Delta\omega_L\theta_0 = \Delta\omega_L J/\Delta\omega_0 >> 1)$, and for estimating purposes the process $I_L(t)$ can be regarded as δ-correlated, while the process $\xi(t)$ can be regarded as Gaussian. According to (2), we have $< \xi^2 > = \Delta\omega_0/J\Delta\omega_L << 1$, in agreement with the initial assumption that ξ is small. ξ can be taken out of the argument of I_0 in (1) in the form of a factor $\lesssim B(t) - \exp[J\xi(t)/2]$, the mean-squared value and spectral width of which are estimated at $\sigma_B^2 = \exp(J\Delta\omega_0/\Delta\omega_L)$ and $\Delta\omega_B = \Delta\omega_0/J$

[1)]The dynamic similarity of the linear regimes of SRS and SMBS (cf., e.g., the expressions for the Stokes amplitudes in [2] and [3]) allows us to apply the subsequent estimates to SRS.

(if $J\Delta\omega_0/\Delta\omega_L \ll 1$) or $(\Delta\omega_0)^2/\Delta\omega_L$ (if $J\Delta\omega_0/\Delta\omega_L \gg 1$). Comparison with the previously obtained characteristics of F yields $\sigma_B^2 \ll \sigma_F^2$ and $\Delta\omega_B < \Delta\omega_F$, so that the influence of ξ on the gain and on the spectral characteristics is negligible.

3. A hypersonic wave is produced in the SMBS process. Let us examine its amplitude A_P at the start of the scattering region ($z \simeq \ell$), where the sound intensity $I_P = \langle|A_P^2|\rangle$ is maximal. For $A_P = P/2v\rho$ (P - pressure amplitude, ρ - density), we can write the equation

$$\sqrt{\frac{2\bar{\omega}_L}{g\omega_P a v^2}}\left(\frac{dA_P}{dt} + avA_P\right) = A_L^* A_S = [\bar{I}_L + \tilde{I}_L(t)]F(t), \tag{3}$$

from which we see that in the case of broadband pumping there appear in the hypersound spectrum wings connected with the rapidly varying components $\tilde{I}_L(t)$ in the right part of (3) and occupying a frequency band $\Delta\omega_{P2} = \Delta\omega_0$ (Fig. b). The central (and principal from the point of view of intensity) part of the spectrum, however, has the same form as in the case of narrow-band pumping, being characterized by a bandwidth $\Delta\omega_{P1} \simeq \Delta\omega_0 \sqrt{(\ln 2)/J}$ (see Figs. a and b), and its summary intensity I_{P1} greatly exceeds the in-ensity I_{P2} contained in the wings of the spectrum (by approximately $\Delta\omega_L/\Delta\omega_0 \gg 1$ times).

4. It should be noted that in the derivation of (1) in [2] we used the conditions

$$\frac{1}{u}\frac{\partial A_S}{\partial t} \ll \frac{\partial A_S}{\partial z}, \qquad A_L(t + z/u) \approx A_L(t), \tag{4}$$

which obviously no longer hold in the case of sufficiently large bandwidth $\Delta\omega_L$. Replacement of t by $t + z/u$ in (1) reduces (4) to a single inequality, $(2/u)\partial A_S/\partial t \ll \partial A_S/\partial z$. Substituting in it (see Sec. 2) $\partial A_S/\partial t \simeq (1/2)\Delta\omega_L A_S$ and $\partial A_S/\partial z \simeq A_S g\bar{I}_L/2$, we find that our results are valid if the following condition is satisfied

$$\Delta\nu_L \ll \frac{1}{4\pi} g\bar{I}_L,$$

where $\Delta\nu_L$ is the width of the pump spectrum in cm^{-1}. In the case of SRS, analogous conditions, which limit the pump bandwidth from above, take the form

$$\Delta\nu_L \ll \frac{1}{4\pi} g\bar{I}_L \qquad \text{(forward SRS)}$$

$$\Delta\nu_L \ll \frac{1}{4\pi} g\bar{I}_L \frac{u}{\delta u} \qquad \text{(backward SRS)}$$

where $\delta u/u$ is the relative dispersion of the group velocities of the SRS Stokes component and of the exciting radiation.

The pump bandwidth must likewise not exceed double the shift value

$$\Delta\omega_L < 2\bar{\omega}_p,$$

for otherwise certain scattering frequencies will be anti-Stokes relative to part of the pump spectrum, and they can be suppressed, thereby reducing the pump efficiency. It is easy to verify that in this case hypersonic waves of frequency $\sim\bar{\omega}_p$, traveling in both directions, and not only in the direction of the laser beam, as assumed above, will take place in the interaction. This case cannot be described, in principle, by the same system of abbreviated equations for which the solution (1) was obtained.

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