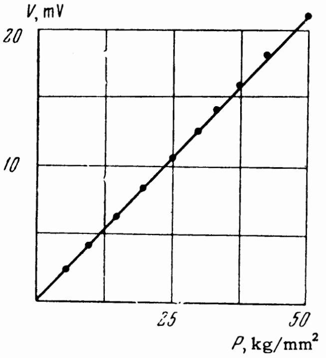

dicates that quite moderate compressions and relatively low illuminations of the sample produced a potential difference of 20 mV varying, within the experimental error, linearly with the load. On repeated tests, the effect was found to be fully reproducible. The PPE potential difference under a constant load varied linearly with the illumination intensity. The dependence shown in the figure was obtained by illuminating that sample surface which was oriented along the crystallographic plane (111), with the direction of the applied stress coinciding with the projection of the [100] axis on this plane.

The effect described here is obviously due to the anisotropy of the diffusion coefficient of carriers, caused by the unidirectional deformation of the crystal.1) The carrier diffusion is due to the difference between the carrier densities at the illuminated and unilluminated surfaces of the sample. The following tests support this explanation.

A. On rotation of the test sample by 180° about an axis coinciding with the direction of the applied deforming force (keeping the direction of illumination and the measuring electrode positions fixed), the sign of the potential difference changed.

B. On rotation of the sample by 90° about the same axis and under the same experimental conditions, the potential difference decreased by more than one order of magnitude.

C. The effect was negligibly small in a sample cut in such a way that the illuminated surface coincided with the crystallographic plane (100).

The same tests may be regarded as a proof that the effect described here cannot be ascribed to phenomena of the photovoltaic type which appear in inhomogeneous semiconductors. At present, we are continuing detailed studies of the PPE in germanium and other semiconductors. The PPE may obviously find practical application in those cases where the normal piezoelectric effect in dielectrics is used.

---

1) We have recently learned that such an effect has already been considered theoretically by van Roosbroeck and Pfann.[1].

---

[1] W. van Roosbroeck and W. G. Pfann, J. Appl. Phys. 33, 2304 (1962).

Translated by A. Tubulewicz
113

SECOND HARMONIC RADIATION FROM INHOMOGENEITIES IN AN INTENSE LIGHT FIELD

G. A. ASKAR'YAN

P. N. Lebedev Institute, Academy of Sciences, U.S.S.R.

Submitted to JETP editor June 16, 1964

J. Exptl. Theoret. Phys. (U.S.S.R.) 47, 782 (August, 1964)

LET us consider the effects of radiation of double-frequency waves when small inhomogeneities of an isotropic medium are placed in an intense electromagnetic field $\mathbf{E}(t) = \mathbf{E}_0 \sin \omega t$. These effects are connected with the quadratic transverse polarization of particles under the effect of the Lorentz force due to the interaction between the variable dipole moment of the inhomogeneity and the magnetic field of the wave, and are not connected with the nonlinear properties of the medium.

If the dimension a of the inhomogeneity is much smaller than the wavelength λ, then the dipole moment is

$$\mathbf{P}(t) \approx \frac{\varepsilon - 1}{\varepsilon + 2} a^3 \mathbf{E}(t)$$

For simplicity we shall assume the inhomogeneities to be quasispherical). This dipole moment is acted upon by a Lorentz force $\mathbf{F} = \mathbf{P} \times \mathbf{H}/c$ in a direction transverse to the electric field. This force is equivalent to the field intensity acting on the electrons $\mathbf{E}_{eq} \approx \mathbf{E}/qN_a$ (where N_a —total number of atoms in the inhomogeneity, q —charge of the atom electrons responsible for the polarization), and equivalent to an external field*

$$\mathbf{E}_{\text{eq}}(t) = \frac{1}{qN_A} \frac{(\varepsilon - 1) a^3}{(\varepsilon + 2) c} [\dot{\mathbf{E}}\mathbf{H}] = \frac{\varkappa_1}{2\bar{\lambda} q} [\mathbf{E}_0 \mathbf{H}_0] \sin 2\omega t,$$

---

*$[\mathbf{E}_0\mathbf{H}_0] = [\mathbf{E}_0 \times \mathbf{H}_0]$.

where $\kappa_1(\omega)$ —coefficient of polarizability of the atom and $ƛ = c/\omega$. Since $E_0 \approx H_0$ in a plane wave, the amplitude ratio is $K = E_{eq}/E_0 \approx \kappa_1 E_0 / 2ƛq$; for example, when

$$\varkappa_1 \approx qe / m\omega_a^2 \approx 10^{-24}\,\mathrm{cm}^3,$$

$$ƛ \approx 10^{-5}\,\mathrm{cm}, \quad E_0 \approx 10^6 \ \mathrm{V/cm}$$

we have $K \sim 10^{-6}$. The ratio of the intensity of radiation of the second harmonic to the intensity of light scattering is equal to

$$\frac{I_{2\omega}}{I_\omega} = \frac{P_{2\omega}^2 (2\omega)^4}{P^2 \omega^4} = 16 \left(\frac{\varkappa_1 (2\omega)}{\varkappa_1 (\omega)} \frac{E_{\mathrm{eq}}}{E_0} \right)^2 \sim \left(\frac{E_0}{ƛ} \right)^2$$

and does not depend on the dimension of the small inhomogeneities.

In the presence of many inhomogeneities (drops, fog, clouds, bubbles in liquids, fluctuations, dust) a noticeable radiation at double the frequency should be observed, and should be readily separable from the intense scattered light. This separation is especially easy if the fundamental frequency lies in the invisible infrared band while the second harmonic falls in the visible part of the spectrum.

For small inhomogeneities ($a < ƛ$) the second-harmonic radiation intensity depends very strongly on the dimension of the inhomogeneities $I_{2\omega} \sim a^6$, but for $a \gg ƛ$ this radiation is weakened by interference and is not observed in the case of a homogeneous isotropic nonlinear medium, in which, as is well known, the second harmonic is not generated. The angular distribution of the second-harmonic radiation over the inhomogeneities differs from the scattered light, since the dipole of the harmonic has a direction perpendicular to the direction of the dipole that gives the scattered light.

The phenomenon under consideration may turn out to be useful not only for a study of dispersion media, phase nuclei, or fluctuations, but also to disclose inhomogeneities produced by an ionizing particle in a bubble chamber or a cloud chamber.

In conclusion I thank corresponding member A. M. Prokhorov and Professor M. S. Rabinovich for useful discussions.

Translated by J. G. Adashko
114

INVESTIGATION OF ATTENUATION OF HYPERSOUND IN LIQUIDS BY AN OPTICAL METHOD

D. I. MASH, V. S. STARUNOV, and I. L. FABELINSKIĬ

P. N. Lebedev Physics Institute, Academy of Sciences, U.S.S.R.

Submitted to JETP editor May 23, 1964

J. Exptl. Theoret. Phys. (U.S.S.R.) **47**, 783-784 (August, 1964)

UNTIL most recently experimental investigations of the propagation of hypersound at $\sim 10^{10}$ cps in liquids were carried out almost exclusively by an optical method whereby the fine structure components of the Rayleigh scattering line were measured[1)]. These measurements have made it possible to determine the velocity of the hypersound and to observe the sound velocity dispersion in liquids[3,4].

The hypersound attenuation could be estimated only by using these data and relaxation theory[5]. The width of the Mandel'shtam-Brillouin components (shifted fine-structure components of the Rayleigh light-scattering line) is determined by the absorption coefficient of the corresponding hypersound wave[3]. Therefore a direct measurement of the width of the shifted fine-structure components makes it possible to obtain the coefficient of hypersound amplitude attenuation. However, such measurements were hitherto impossible for lack of a sufficiently narrow spectral line to excite the scattered light.

Such a narrow exciting line is now available, and measurement of the half width of the Mandel'shtam–Brillouin components, and consequently also the absorption coefficient of hypersound, became possible. In this brief note we report on first measurements of this type.

The investigated liquid was illuminated with a beam of the narrow spectral line $\lambda = 6328\,\mathrm{Å}$. The light scattered by the liquid in a direction perpendicular to that of the exciting light was guided to a Fabry-Perot interferometer, back of which was a camera to photograph the fine structure. Photographic photometry of the fine structure photographs yielded the intensity distribution in the fine structure components and their half-widths. The half-width found for benzene is $\delta\nu = 0.01\,\mathrm{cm}^{-1}$ and for carbon tetrachloride $\delta\nu = 0.02\,\mathrm{cm}^{-1}$ (the apparatus half-width is excluded). It is easy to find from these results that the coefficient of hypersound amplitude attenuation of benzene at