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SCATTERING OF LIGHT BY ELASTIC SURFACE WAVES

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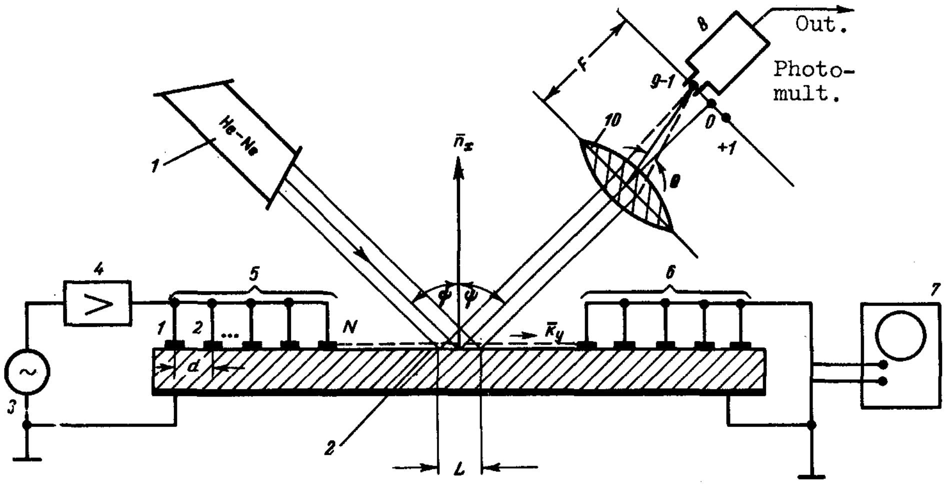
In this paper we present the results of experiments on the scattering of light by elastic surface (Rayleigh) waves (ESW). We use as the light-scattering medium a crystal with trigonal synagony, α-quartz, in which direct piezoelectric excitation of ESW is possible by producing a spatial electromagnetic field in a periodic (offset-post) array consisting of metallic (silver) electrodes deposited on a polished surface of a crystal with a spatial pitch $d = \Lambda = v_R/f_0$. Here Λ is the length of the ESW, v_R the ESW velocity on the free surface of the crystal in a given direction, and f_0 the frequency of the excited ESW. The use of this method of exciting the ESW has enabled us to obtain relatively simply a large ESW amplitude by using an array with a large number of electrodes. The experimental setup is shown in the figure.

Polarized light from an He-Ne laser (type LG-36), designated 1 in the figure, with radiation power ∿ 30 MW, was directed to the surface of the crystal (2), along which the ESW propagated in the direction $\vec{k}_y$. An electric signal of frequency f_0 = 10 MHz and amplitude 20 V (effective) was applied to the exciting array (5) from a GCh-44 generator (3) through a UZ-5A amplifier (4). The presence of the ESW was monitored with the aid of a similar array (6) and an S1-20 oscilloscope (7).

The scattered light was registered with an FEU-27 photomultiplier (8) located at the focus of a spherical lens. A diaphragm (9) with inside diameter 1 mm was used to reduce the



parasitic scattered light incident on the photomultiplier.

The ESW were excited by means of photochemically prepared multi-electrode ($N \sim 100$) reticular converter with pitch $d = 0.32$ mm and with electrode width and length along the z axis 0.1 and 20 mm respectively.

The length of the piezoelectric quartz plate along which the ESW propagated was 200 mm, its width was $\ell_z = 20$ mm, and its thickness $\ell_x = 5$ mm.

The theoretical calculations have shown that in the case of a traveling ESW the expressions obtained for the scattered light are similar to those obtained for the case of interaction between elastic volume waves and light [1, 2].

In our experiments, unlike in the experimental setup of [3], we used light reflected from the ESW, making it possible to observe scattering from both metalized surfaces and surfaces of optically opaque materials. To observe the scattered light, the photomultiplier was placed at first-order maximum, corresponding to a diffraction angle $\theta = \Lambda \cos \psi$. Since the amplitude Δa of the ESW was much smaller than λ, the index of phase modulation of the scattered light was $W = 4\pi\Delta a \cos \psi/\lambda << 1$, and the ratio of the light intensities in the first and zeroth diffraction orders is expressed with sufficient accuracy by the formula

$$I_1/I_0 = I_1^2(W)/I_0^2(W) \cong (W/2)^2 = 4\pi^2\Delta a^2\cos^2\psi/\lambda^2 .$$

Here I_1 and I_0 are the light intensities in the first and zeroth diffraction orders, and $I_1(W)$ and $I_0(W)$ are Bessel functions of first and zeroth orders.

We measured the ratios I_1/I_0 for several values of the angle and found that the intensity of the light in the first diffraction order increases at large angles of incidence ($\psi = 70 - 80°$), owing to the increase of the reflection coefficient. The main experimental results were obtained at $\psi = 80°$. The intensity of the diffracted light was measured by comparison with zeroth-order light attenuated by means of calibrated absorbers. From the obtained ratios $I_1/I_0 = 5 \times 10^{-4}$ and from the angle of inclination of the first diffraction maximum of the scattered light, we determined the amplitude $\Delta a = 150$ Å and the ESW velocity $v_R = 3.18 \times 10^5$ cm/sec. It is important to note that in all cases the useful signal level was not less than 30 dB higher than the noise at the photomultiplier output.

This indicates that the parasitic light scattering due to the non-ideal reflectance of the surface was small.

Thus, a study of the scattering of light by ESW makes it possible to determine the pattern of the field and the structure of the ESW itself on surfaces of all materials (including optically opaque ones), and also to use this phenomenon to develop new types of opto-acoustic light modulators.

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