Reprinted from

Volume 5, Number 12 APPLIED PHYSICS LETTERS 15 December 1964

OPTICAL HETERODYNE DETECTION OF THE FORWARD-STIMULATED BRILLOUIN SCATTERING

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(Received 21 October 1964)

(CS_2; velocity of sound in CS_2 at 123 Mc/sec = 1223 m/sec; E)

The preceding paper showed that stimulated Brillouin radiation can be built up in the off-axis resonator.[2] In the off-axis resonator both the forward and the backward Brillouin components are observed. When the off-axis angle is small, it is difficult to resolve the forward Brillouin component from the ruby laser wave length. We used an optical heterodyning technique to measure the small frequency shift due to the forward Brillouin scattering.

The experimental arrangement is shown in Fig. 1. The ruby *Q*-switched laser and off-axis resonator have been described elsewhere.[2,3] The off-axis angle was measured to be 0.0433 radian. Carbon disulfide was used as a scattering medium. The output beam from the off-axis resonator and a part of the laser beam were combined with a mirror and a beam splitter and were reflected by magnesium oxide reflector. A biplanar phototube with an S-20 cathode was used to detect the reflected light, and the output of the phototube was observed by a traveling-wave oscilloscope.

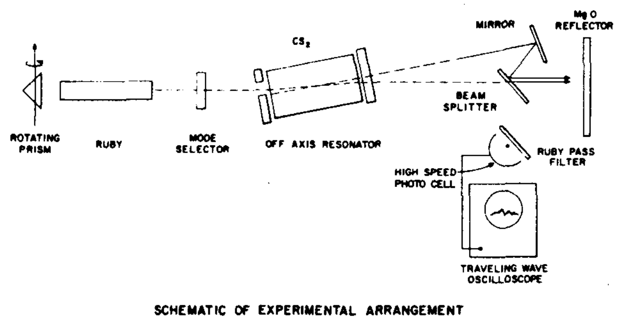

Fig. 1. Schematic diagram of the experimental arrangement.

The results are shown in Fig. 2. The beat frequency was determined to be 123 megahertz. The peak output power of the small-angle stimulated Brillouin radiation was also determined to be 17 kW.

The frequency shift for Brillouin scattering is given by

$$\Delta\omega = \omega_0 \frac{\nu n}{c} \sin \theta/2 \ ,$$

where ω_0 is the angular frequency of the incident radiation, ν is the velocity of sound in the medium, n is the index of refraction, c is the velocity of light, and θ is the angle between the incident radiation and the scattered radiation.

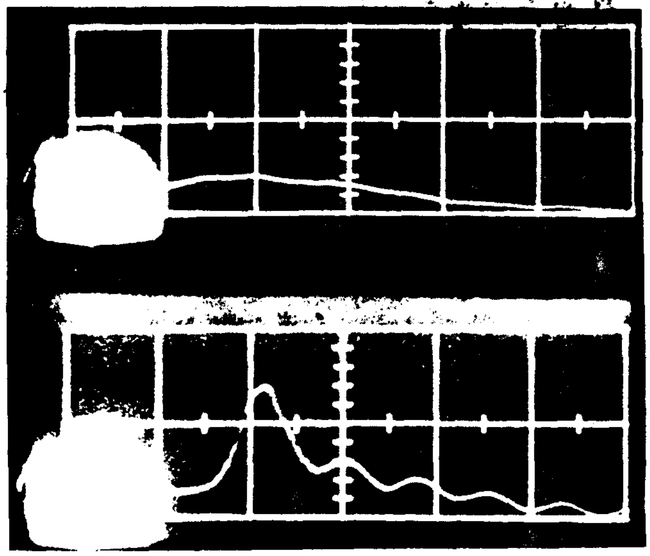

Fig. 2. Oscilloscope traces of the output of high-speed photo cell at a sweep speed of 10 nsec/div. The upper trace shows only ruby laser radiation; the lower trace shows 123-megahertz beat between the forward-stimulated Brillouin radiation and the ruby laser radiation.

The velocity of sound in carbon disulfide was calculated to be 1223 ± 24 m/sec from the above equation and the present results. The error, ±24 m/sec, is a maximum estimate from the uncertainty in the angle, frequency, and index of refraction. This is probably the first measurement of the sound velocity of carbon disulfide at vhf, and is consistent with the previous results on the sound-velocity measurements at lower frequencies and at uhf.[3,4]

Thus the presence of the small-angle stimulated Brillouin scattering has been confirmed through present work.

In conclusion, it should be pointed out that the off-axis stimulated Brillouin scattering and optical heterodyne technique will provide a method to investigate the dispersion of sound. The precision in measuring the sound velocity by the present method can be improved very much by improving the precision in measuring the off-axis angle and in calibrating the sweep rate of the oscilloscope, and a very broad frequency range of 50 megahertz to several gigahertz can be covered by changing the off-axis angle.

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[2] See p. , this issue.

[3] H. Takuma and D. A. Jennings, *Appl. Phys. Letters* **4**, 185, (1964).

[4] K. F. Herzfeld and T. A. Litovitz, *Absorption and Dispersion of Ultrasonic Waves*, Academic Press, New York, 1959, p. 362.

[5] E. Garmire and C. H. Townes, *Appl. Phys. Letters* **5**, 84, (1964).