ACOUSTIC MEASUREMENTS OF THE DISPERSION OF HYPERSONIC VELOCITY IN LIQUIDS

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Measurements of the hypersonic velocity in liquids utilizing Brillouin-Mandel'shtam scattering of light by thermally excited acoustic waves have given contradictory results. Rao[1] reported that the velocity of sound in carbon tetrachloride at 5 GHz was 1.5 times its value at 7 MHz, while that in acetone was 0.8. Venkateswaran[2] later found no detectable dispersion between the ultrasonic and hypersonic velocities of a large number of liquids, including both CCl_4 and acetone. Rank, Shull, and Axford[3] also verified the lack of dispersion in acetone. More recent work by Fabelinskii and others,[4-6] with precisions of two to five percent, showed no dispersion in acetone but an 11% increase in the velocity of sound in CCl_4 at a frequency of 5 GHz.

In an attempt to resolve these discrepancies, measurements in these liquids have been made utilizing a direct acoustic method. Acoustic waves at a frequency of 3 GHz are generated by an X-cut quartz crystal excited by means of a cavity resonator.[7] The damping of the crystal's vibration, due to radiation into a liquid placed in contact with the vibrating crystal, is observed. The method yields the specific acoustic impedance, ρV, of the liquid. The results are summarized in Table I. The precisions of 0.6-1.8% are based on 9 to 19 independent measurements. Since the electrical power into the cavity was less than one milliwatt, heating of the liquid was negligible.

The close agreement between the hypersonic velocity V and the ultrasonic velocity V_0 in water, in which there is no experimental[5] or theoretical evidence for expecting dispersion at this frequency, indicates that there is no appreciable inherent error in the equipment or method. Similarly, no dispersion is observed for acetone, contrary to the work of Rao but in agreement with others. Dispersion is observed in CCl_4 verifying the more recent optical measurements.

It is well known that dispersion of the velocity of sound and anomalous absorption are interrelated.[6] A large body of absorption data on many liquids already exists, but at ultrasonic rather than at hypersonic frequencies. The anomalous absorption mechanism in CCl_4 has supposedly been identified as thermal relaxation of the internal specific heat; this permits extrapolation to the dispersive frequency region,[8] utilizing spectroscopic specific-heat data[9] together with the ultrasonic absorption data.

Table II gives the dispersion, $(V/V_0)-1$, for CCl_4 at 3 GHz, obtained by the direct hypersonic method together with the dispersion predicted by the absorption data at 15 MHz of Pellam and Galt[10] and that corresponding to the optical measurements of Fabelinskii.[4] The usual velocity dispersion relation[11] was employed to correct Fabelinskii's value of $V = 1040 \pm 27$ m/sec at 5 GHz to 3 GHz. The same specific-heat data[9] were used in both cases.

Note that although the direct hypersonic and the optical data agree within the precision of the optical data, both of these methods give results that are significantly lower than that obtained from extrapolated absorption data. Further work is planned in order to elucidate the reason for this discrepancy. We will also extend the acoustic measurements to 10 GHz and measure the

Table I. Comparison of ultrasonic and hypersonic velocities in liquids; $T = 20°C$.

Liquid	Frequency, f (GHz)	Specific acoustic impedance, ρV (g cm^{-2} sec^{-1})	Velocity of sound: Hypersonic, V (m/sec)	Velocity of sound: Ultrasonic, V_0 (m/sec)
Water	2.951	$1.47 \times 10^5 \pm 1.2\%$	1480 ± 20	1490[a]
Acetone	2.951	$0.93 \times 10^5 \pm 1.8\%$	1180 ± 20	1190[a]
CCl_4	2.977	$1.55 \times 10^5 \pm 0.6\%$	972 ± 5	938[a,b]

[a]L. Bergmann, Der Ultraschall (S. Hirzel Verlag, Stuttgart, Germany, 1954), pp. 375-380.
[b]G. W. Marks, J. Acoust. Soc. Am. 27, 680 (1955).

Table II. Dispersion of hypersonic velocity in CCl_4 at 3 GHz.

Source and method	$(V/V_0)-1$
Authors—direct	4%
Fabelinskii—optical[a]	6%
Pellam and Galt—ultrasonic absorption[b]	11%

[a]Fabelinskii's value of $V = 1040 \pm 27$ m/sec, measured optically at 5 GHz, has been extrapolated to 3 GHz; see reference 11.

[b]Pellam and Galt's value for the excess absorption, $\alpha/f^2 = 510 \times 10^{-17} \pm 1\%$, was measured at 15 MHz; see reference 8 for the computation of V/V_0.

velocity of hypersound in other liquids.

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[8]See, for example, reference 6, Eqs. (14-4), (18-3), and (13-5).
[9]Reference 6, Table 93-1.
[10]J. R. Pellam and J. K. Galt, J. Chem. Phys. 14, 608 (1946).
[11]Reference 6, Eq. (13-5).

PROPERTIES OF THE ALPHA PARTICLES EMITTED IN THE SPONTANEOUS FISSION OF Cf^{252} †

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The properties of the alpha particles emitted in the spontaneous fission of Cf^{252} have been examined in a three-parameter correlation experiment. The experimental apparatus consisted of a fission chamber containing two fixed semiconductor detectors (for the two fission fragments), one movable semiconductor detector (for the alpha particle), and a 1.5×10^7-fission/min Cf^{252} source on a 100-$\mu g/cm^2$ Ni foil backing. A 16-mg/cm^2 Au foil was placed in front of the alpha-particle detector in order to prevent the 6.1-MeV alpha particles from the alpha decay of Cf^{252} and fission fragments from reaching the detector. The Au foil could be replaced by a thick Es^{253}-Am^{241} source which served for the energy calibration of the alpha-particle detector. The energy calibration of the two fission-fragment detectors was done by comparing the single-fragment energy distribution with that obtained by a time-of-flight method by Fraser et al.[1] The opening angle subtended by each detector (±5°) was large enough to make negligible any corrections in the counting efficiency for different values of the alpha-particle energy and angle and the fission-fragment mass ratio (all affecting the angle between the two fission fragments). Triple-coincidence events were processed by a multidimensional analyzer and stored on tape. The data were then analyzed in various ways with the aid of a computer. A total of 2×10^5 triple-coincidence events were analyzed in this fashion. In our experiment we only detected alpha particles of energy greater than 10 MeV. This cutoff was chosen so as to exclude from our analysis accidental coincidences of binary-fission events with 6.1-MeV alpha particles from Cf^{252} contamination of the alpha counter assembly. Such events would be indistinguishable from true triple-coincidence events involving 9.5-MeV alpha particles which have traversed the Au foil. The angle of the alpha-particle detector was varied between 60° and 120° with respect to either fission counter. We present here first a brief summary of our main results. A more detailed description of the apparatus and experimental results will be published elsewhere.

The angular distribution (corrected for finite detector size and finite extension of the source) of the alpha particles is peaked at an angle of 81° with respect to the direction of the light fragment. It is approximately symmetric with respect to this angle and we obtain for this dis-