

Light scattering and fluid viscosity

According to well-known hydrodynamical theory¹, plane waves of sound propagated through a viscous liquid suffer a diminution of amplitude in the ratio $1/e$ in traversing a number of wavelengths given by the quantity $3C\lambda/8\pi^2\nu$, where C is the velocity of sound, λ is the wavelength of sound and ν is the kinematic viscosity. Taking $\lambda = 4358 \text{ \AA}$, this number for various common liquids which are fairly mobile at room temperature ranges from about 3 in the case of butyl alcohol to about 30 in the case of carbon disulphide. For phenol at 25°C , the number is less than 1, and for glycerine, it is a small fraction of unity. A consideration of these numbers shows that the theories due to Einstein² and L Brillouin³, which regard the diffusion of light occurring in liquids as due to the reflection of light by regular and infinitely extended trains of sound-waves present in them, can only possess partial validity for ordinary liquids, and must break down completely in the case of very viscous ones. In an earlier note in *Nature*⁴, we reported studies of the Fabry–Perot patterns of scattered light with a series of liquids, which showed clearly that the Doppler-shifted components in the spectrum of scattered light fell off in intensity relatively to the undisplaced components, with increasing viscosity of the liquid.

We have now to report some further results which illustrate in a striking way the part played by fluid viscosity in the diffusion of light by liquids. As mentioned in our previous note, the light scattered by liquid phenol at ordinary temperatures gives a Fabry–Perot pattern which is scarcely distinguishable from that of the incident light. When, however, the temperature of the liquid is raised, the viscosity falls off rapidly, and the number $3C\lambda/8\pi^2\nu$ assumes a value which is many times greater than at room temperature. Simultaneously, as can be seen from figure 1, the character of the Fabry–Perot pattern alters, and the Doppler-shifted components come increasingly into evidence; at 70°C they are just as prominent as in ordinary inviscid liquids. The influence of temperature revealed by these studies for the case of the very viscous phenol is to be clearly distinguished from the broadening of the Doppler components with rise of

¹Lamb, *Hydrodynamics*, fifth edition, p. 613.

²Einstein, A, *Ann. Phys.*, 33, 1275 (1910).

³Brillouin, L, *Ann. Phys.*, 17, 88 (1922).

⁴*Nature*, 139, 585 (April 3, 1937).

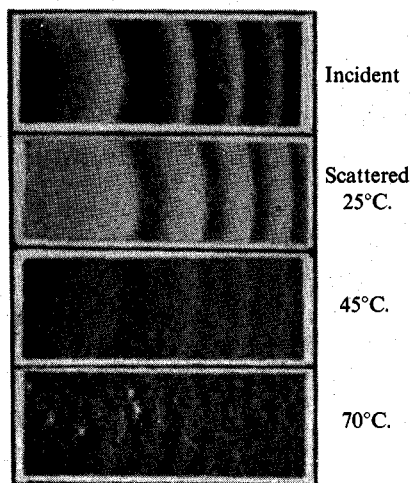


Figure 1. Influence of temperature on the scattering by phenol.

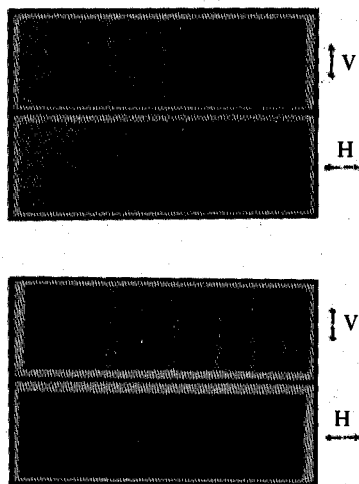


Figure 2. State of polarization; above, toluene; below, phenol.

temperature reported by us in an earlier note⁵ for the case of carbon tetrachloride.

The four patterns reproduced in figure 2 show the remarkable difference in the state of polarization of the Fabry-Perot patterns of transversely scattered light for an inviscid liquid such as toluene and a viscous one such as phenol at room temperature. In the former case, only a continuous radiation is to be observed in the horizontal component; in other words, both the displaced and the undisplaced components in the pattern are sensibly completely polarized with the vibrations vertical. In the case of phenol, however, the undisplaced radiation is evidently partially polarized, as it appears both in the vertical and the horizontal vibrations; a partial polarization of the continuous radiation is also noticeable.

C V RAMAN
B V RAGHAVENDRA RAO

Department of Physics
Indian Institute of Science
Bangalore
29 December

⁵ *Nature*, 135, 761 (May 4, 1935).