CHAPTER VII

Scattering of light in amorphous solids

71. The methods of examination by the use of X-rays introduced by Laue and by Professors Sir W H Bragg and W L Bragg have thrown much light on the problem of the structure of crystalline solids, but our information regarding the structure of amorphous solids like glass is still scanty. What information we do possess, we owe to the recent work of Debye and Scherrer by the X-ray powder method. They find that most solids hitherto classified as amorphous are really composed of a large number of minute crystals. Dehydrated colloidal silica and stannic acid show the presence of such crystalline aggregates in an otherwise amorphous medium. Optical glass alone, of all the solids investigated, does not show any crystalline inclusions. Its diffraction photograph is exactly the same as that of a liquid.

72. The essential difference, then, between a crystal and an amorphous solid is that, in a crystal, the atoms are similarly oriented and arranged in a perfectly regular manner, whereas, in an amorphous solid, there is no regularity of arrangement of the molecules and there may even be local fluctuations of density as in a liquid; only, these local fluctuations do not alter rapidly with time as in the case of liquids, but remain quasi-permanent for very long periods of time. Why a mixture of complex silicates like glass develops the phenomenon of rigidity to such a high degree in a non-crystalline condition, awaits explanation.

73. If, then, glass is an undercooled liquid, we should expect the scattering power of glass for ordinary light to approximate to that of a liquid rather than to that of a crystal. Lord Rayleigh in his paper on "Scattering by Solid Substances", mentions that a specimen of Chance's Optical Glass showed a scattering about 300 times that of dust-free air. He was, however, inclined to attribute the scattering to inclusions and explained the observed imperfectness of the polarisation of the scattered light as due to the large size of the included particles. In view of the fact that the closest scrutiny under a powerful microscope even with dark-ground illumination, fails to indicate the presence of any visible inclusions, and in view of Debye and Scherrer's X-ray analysis of optical glass, it seems more reasonable to assume that the scattering is really molecular. Its magnitude is much larger than in the case of clear crystals and agrees with what might be expected on the basis of a non-uniform distribution of molecules such as would have existed in the liquid state at the temperature of solidification of the material.

Lack of data regarding the compressibility of melted glass at high temperatures makes it impossible to make a quantitative calculation of the scattering coefficient on the basis of the Einstein–Smoluchowski equation. Observations made in Calcutta on a specimen of optical glass show a scattering power nearly four times that of pure water at ordinary temperatures. The track of a beam of sunlight is sky-blue in colour and is nearly, but not completely, polarised when viewed in a transverse direction. It does not show any fluorescence. (Many specimens of common glass exhibit a green, yellow or pink fluorescence when a beam of sunlight is sent through them; such fluorescence can be easily detected by examining the scattered light through a double image prism, when the two images would show different colours.)

74. Quantitative studies of the intensity and polarisation of the light scattered by well-annealed glasses of known composition at different temperatures would yield results of value regarding the molecular structure of glasses and of amorphous bodies in general. Experiments on the scattering of light in fused quartz of optical quality would also be of special interest in view of the recent observation of Rayleigh that this material exhibits a feeble double-refraction.