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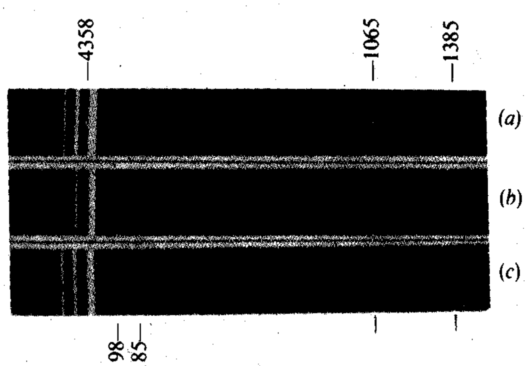
Lattice oscillations in crystals

The ions or molecules occupying the cells of a crystal lattice are in general optically anisotropic, and should also be capable of executing small angular oscillations about their positions of equilibrium. If the crystal is illuminated by monochromatic light of frequency ν, the local fluctuations in optical polarization produced by such oscillations should result in scattered radiations appearing with altered frequency, and theory indicates that these should exhibit *peculiar polarization characters.*

Taking an individual ion or molecule to be optically an ellipsoid, its polarizability along three mutually perpendicular directions being A, B, C respectively, it is clear that if the light-vector E in the incident beam is parallel to an axis A of the ellipsoid and its angular oscillations are also about the same axis, there would be no fluctuations in optical polarization and therefore no radiations of altered frequency. If, however, the ion or molecule oscillates about a second axis B with an angular amplitude θ and frequency ν^* the optical polarization would fluctuate with frequency $\nu \pm \nu^*$; the corresponding scattered radiations would arise from a Hertzian dipole which is parallel to the third axis C of the ellipsoid and has the strength $\frac{1}{2}(C - A)\theta E$, where $\theta = (h, 2\pi^2 I\nu^*)$, I is the moment of inertia and h is Planck's constant. The scattered radiations would thus be of maximum intensity in the plane containing the oscillation axis and the incident light-vector and would vanish in the direction perpendicular to this plane. In other words, the displaced lines in the spectrum due to these oscillations in the lattice would disappear in just the direction in which the displaced lines arising



Effect of orientation of crystal on light scattering in sodium nitrate.

from the symmetric internal vibrations of the ion or molecule would be of maximum intensity.

(*a*), (*b*), and (*c*) illustrate the foregoing remarks: they are spectra of the 4358 A radiation of the mercury arc, transversely scattered by a sodium nitrate crystal, the incident light being plane polarized. The three spectra correspond to three mutually perpendicular settings of the crystal; the directions of the incident light-vector and of observation of the scattered light are normal to each other and remain unaltered throughout. It will be noticed that in (*a*), in which the optic axis of the crystal is parallel to the direction of observation, the lattice lines 98 cm^{-1} and 185 cm^{-1}) have disappeared, while in (*b*) and (*c*) they appear strongly. On the other hand, the internal oscillations (1065 cm^{-1} and 1385 cm^{-1}) of the NO_3 ion appear strongly in (*a*) and (*b*), while in (*c*) they are very weak. The latter result is to be expected, as (*c*) corresponds to the case in which the incident light-vector is along the optic axis of the crystal, and the polarizability of the NO_3 ions is a minimum in this direction.

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