produce a continually increasing disturbance as we pass along the spectrum towards the more refrangible end.

On the other hand, that the direction of complete polarization should be independent of the refracting power of the matter composing the cloud has been considered mysterious. Of course, on the theory of thin plates, this direction would be determined by Brewster’s law; but, if the particles of foreign matter are small in all their dimensions, the circumstances are materially different from those under which Brewster’s law is applicable.

The investigation of this question upon the elastic solid theory will depend upon how we suppose the solid to vary from one optical medium to another. The slower propagation of light in gas or water than in air or vacuum may be attributed to a greater density, or to a less rigidity, in the former case; or we may adopt the more complicated supposition that both these quantities vary, subject only to the condition which restricts the ratio of velocities to equality with the known refractive index. It will presently appear that the original hypothesis of Fresnel, that the rigidity remains the same in both media, is the only one that can be reconciled with the facts; and we will therefore investigate upon this basis the nature of the secondary waves dispersed by small particles.

Conceive a beam of plane polarized light to move among a number of particles, all small compared with any of the wave­lengths. According to our hypothesis, the foreign matter may be supposed to *load* the aether, so as to increase its *inertia* without altering its resistance to distortion. If the particles were away, the wave would pass on unbroken and no light would be emitted laterally. Even with the particles retarding the motion of the aether, the same will be true if, to counterbalance the increased inertia, suitable forces are caused to act on the aether at all points where the inertia is altered. These forces have the same period and direction as the undisturbed luminous vibrations themselves. The light actually emitted laterally is thus the same as would be caused by forces exactly the opposite of these acting on the medium otherwise free from disturbance, and it only remains to see what the effect of such force would be.

On account of the smallness of the particles, the forces acting throughout the volume of any individual particle are all of the same intensity and direction, and may be considered as a whole. The determination of the motion in the aether, due to the action of a periodic force at a given point, is discussed in the article Diffraction of Light (§ ii). Before applying the solution to a mathematical investigation of the present question, it may be well to consider the matter for a few moments from a more general point of view.

In the first place, there is necessarily a complete symmetry round the direction of the force. The disturbance, consisting of transverse vibrations, is propagated outwards in all directions from the centre; and, in consequence of the symmetry, the direction of vibration in any ray lies in the plane containing the ray and the axis of symmetry; that is to say, the direction of vibration in the scattered or diffracted ray makes with the direc­tion of vibration in the incident or primary ray the least possible angle. The symmetry also requires that the intensity of the scattered light should vanish for the ray which would be pro­pagated along the axis; for there is nothing to distinguish one direction transverse to the ray from another. The application of this is obvious. Suppose, for distinctness of statement, that the primary ray is vertical, and that the plane of vibration is that of the meridian. The intensity of the light scattered by a small particle is constant, and a maximum, for rays which lie in the vertical plane running east and west, while there is *no scattered ray along the north and south line.* If the primary ray is un­polarized, the light scattered north and south is entirely due to that component which vibrates east and west, and is therefore *perfectly polarized,* the direction of its vibration being also east and west. Similarly any other ray scattered horizontally is perfectly polarized, and the vibration is performed in the hori­zontal plane. In other directions the polarization becomes less and less complete as we approach the vertical.

The observed facts as to polarization are thus readily explained, and the general law connecting the intensity of the scattered light with the wave-length follows almost as easily from con­siderations of *dimensions.*

The object is to compare the intensities of the incident and scattered light, for these will clearly be proportional. The number (*i*) expressing the ratio of the two amplitudes is a function of the following quantities:—(T) the volume of the disturbing particle; (r) the distance of the point under consideration from it; (λ) the wave-length; (*b*) the velocity of propagation of light; (D) and (D') the original and altered densities: of which the first three depend only upon space, the fourth on space and time, while the fifth and sixth introduce the consideration of mass. Other elements of the problem there are none, except mere numbers and angles, which do not depend upon the fundamental measurements of space, time and mass. Since the ratio (*i*), whose expression we seek, is of no dimensions in mass, it follows at once that D and D' occur only under the form D : D', which is a simple number and may therefore be disregarded. It remains to find how *i* varies with T, r, λ, *b.*

Now, of these quantities, *b* is the only one depending on time; and therefore, as *i* is of no dimensions in time, *b* cannot occur in its expression. Moreover, since the same amount of energy is pro­pagated across all spheres concentric with the particle, we recognize that *i* varies as *r.* It is equally evident that *i* varies as T, and therefore that it must be proportional to T∕λr, T being of three dimensions in space. In passing from one part of the spectrum to another, λ is the only quantity which varies, and we have the important law —

When light is scattered by particles which are very small com­pared with any of the wave-lengths, the ratio of the amplitudes of the vibrations of the scattered and incident lights varies inversely as the square of the wave-length, and the ratio of *intensities* as the inverse fourth power.

The light scattered from small particles is of a much richer blue than the blue of the first order as reflected from a very thin plate. From the general theory (see Interference of Light, § 8), or by the method of dimensions, it is easy to prove that in the latter case the intensity varies as λ-2, instead of λ-4.

The principle of energy makes it clear that the light emitted laterally is not a new creation, but only diverted from the main stream.. If I represent the intensity of the primary light after traversing a thickness *x* of the turbid medium, we have

*dl = — hlλ~idx,*

where *h* is a constant independent of λ. On integration, log(I∕I0) = →λ-4x . . . . . . (1)

if I0 correspond to x=o,—a law altogether similar to that of ab­sorption, and showing how the light tends to become yellow and finally red as the thickness of the medium increases *(Phil. Mag.,* 1871, 41, pp. 107, 274).

Sir William Abney has found that the above law agrees remark­ably well with his observations on the transmission of light through water in which particles of mastic are suspended *(Proc. Roy. Soc.,* 1886).

We may now investigate the mathematical expression for the disturbance propagated in any direction from a small particle upon which a beam of light strikes. Let the particle be at the origin of coordinates, and let the expression for the primary vibration be

^ = sin(*nt*-*kx*) .... (2)

The acceleration of the element at the origin is — n2 sin *nt;* so that the force which would have to be applied to the parts where the density is D' (instead of D), in order that the waves might pass on undisturbed, is, per unit of volume,

(D' —D)n2 sin *nt.*

To obtain the total force which must be supposed to act, the factor T (representing the volume of the particle) must be introduced. The opposite of this, conceived to act at the origin, would give the same disturbance as is actually caused by the presence of the particle. Thus by equation (18) of § 11 of the article Diffraction of Light, the secondary disturbance is expressed by

D' —D κ2Tsin *φ* sin *(nt — kr)* D 47rδ2 *r*

D' —D πTsin *φ . , j , λ -* f s@@1.

-—D ^τ-s∙n(n∕-⅛r) . . . (3)1,

The preceding investigation is based upon the assumption that in passing from one medium to another the rigidity of the aether does not change. If we forego this assumption, the question is

@@@l In strictness the force must be supposed to act upon the medium in its actual condition, whereas in (18), previously cited, the medium is supposed to be absolutely uniform. It is not difficult to prove that (3) remains unaltered, when this circumstance is taken into account; and it is evident in any case that a correction would depend upon the square of (D' —D).