

operations of the physical universe. Moreover, since light, heat, chemical affinity, etc., have long been referred to such waves in the aether, the more general electrodynamic wave-theory thus gives complete continuity to our theories of physics, thereby confirming the correlation of all natural forces, and giving new physical grounds for the doctrine of the conservation of energy.

In the closing paragraph to his celebrated Treatise on Electricity and Magnetism, 1873, *Maxwell* justly says that "whenever energy is transmitted from one body to another in time, there must be a medium or substance in which the energy exists after it leaves one body and before it reaches the other". This also points to wave action, such as *Gauss* was considering in 1835, and of which *Weber* gave the fundamental law in 1846, *Newton's* law of 1686 being a special case corresponding to circular orbits.

In the Principia, Lib. 2, Prop. 48, Sir *Isaac Newton* deduces the formula for the velocity of waves or pulses propagated in an elastic medium, such as waves of sound in the air,

$$V = CV(E/D).$$

This is now written

$$V = V\{(kgh\sigma/D) \cdot (1 + \alpha t)\} \\ = 331.76 \text{ m } V(1 + 0.003665t) \quad (18)$$

where t is the temperature; α is a coefficient, 0.003665; g = acceleration of gravity, 981 cm; h = normal barometric pressure, 76 cm; σ = 13.6, density of Mercury; D = the density of air, 0.001293; and k = 1.4050 (cf. *Willner's* Experimental Physik, 3.552) is the ratio of the specific heat of air under constant pressure to that under constant volume, introduced by *Laplace* for harmonizing *Newton's* theoretical formula with the observed velocity of sound in air.

In many investigations it is possible to determine the velocity with which waves are propagated, but it is not always possible to determine independently the elasticity or density of the medium — we can only find the ratio E/D . This is partly true of the aether, for example, which transmits light waves or electrodynamic waves with the speed of 300000 kms per second, but gives no process of fixing the elasticity of this medium except by an independent calculation of the density, which, however, may be made by the process first used by Lord *Kelvin* in 1854, (Baltimore Lectures, 1904, p. 261-263), and afterwards adopted by *Maxwell*, Scientific Papers, 2.767.

In section 5 below we find, by the process here described, that at the sun's surface the density of the aether is $\rho = 2 \times 10^{-18}$ and the rigidity 1800. Using these constants in *Newton's* formula, we may verify the observed velocity of wave propagation:

$$V = V(n/D) = V\{1800/(2 \times 10^{-18})\} = 30000000000 \text{ cms} \\ = 3 \times 10^{10}, \text{ the velocity of light.}$$

To compare a perfect monatomic gas like the aether with diatomic gases like the air, we use the formula for the velocity of sound:

$$V = V\{(gh\sigma/D) \cdot k \cdot (1 + \alpha t)\} = \\ = V\{(9.808 \times 0.76 \times 13.59/0.001293) (1.405) (1 + \alpha t)\} \\ = 331.8 \text{ m } V(1 + 0.003665t) \text{ at } t^\circ \text{ C.} \quad (19)$$

This shows that the velocity of light is 904268-times swifter than sound. Squaring this number, and dividing the result by 1.666/1.405 = 1.18624, we get the immense number 689321600000; which shows how much the elasticity of the aether, regarded as a monatomic gas, exceeds that of the air in proportion to its density¹). In the Optics, 3rd edition, 1721, p. 326, *Newton* makes this number 490000000000, which is 71 per cent correct.

In view of this excessive elasticity of the aether, in proportion to its very small density, compared to that of air, we can understand the almost inconceivable velocity of light. It is also necessary to bear in mind this enormous elasticity in order to understand why the aether is practically incompressible. When a wave begins to be generated, the disturbance is propagated away so rapidly that the wave amplitude necessarily is small compared to the wave length. In the calculations of section 5 we have taken the wave length as 101.23 times its amplitude, which *Maxwell*, Lord *Kelvin* and *Larmor* consider a safe basis in all numerical determinations.

The incompressibility of the aether is due to the very high mean velocity of the aether corpuscles, 471239 kms per second, and their enormously long free path, 572959 kms: which makes the medium behave as an elastic solid for quick acting forces, but enables the corpuscles to move out of the way of the swiftest planets with a 10000-fold greater speed. Owing to its enormous elasticity, the aether instantly adjusts itself to any state of steady motion, and thus this medium offers no resistance whatever to uniform celestial motions.

This circumstance fully explains a grave difficulty which has been felt from the age of *Newton*, and hitherto appeared utterly bewildering to natural philosophers. In connection with such extraordinary physical conditions in the medium, it may be useful to recall an account of the interior constitution of the sun given by Professor *Newcomb* in the Encyclopedia Americana, 1904:

"Yet another unknown factor is the temperature of the interior, . . . it may be 1000000 degrees. As the highest temperature which it is possible to produce artificially probably does not amount to 10000 degrees, it is impossible to say what effect such a temperature would have upon matter. Thus we have two opposing causes, the one an inconceivable degree of heat, such that were matter exposed to it on the surface of the earth, it would explode with a power to which nothing within our experience can be compared, and a pressure thousands of times any we can produce, tending to condense and solidify this intensely heated matter. One thing which we can say with confidence as to the effect of these causes is that no chemical combinations can take place in matter so circumstanced. The distinction between liquid and gaseous matter is lost under such conditions. Whether the central portions are compressed into a solid, or remain liquid, it is impossible to say."

¹) In his thoughtful Familiar Lectures on Scientific Subjects, 1867, p. 282, Sir *John Herschel* gives this figure as 114800000000; but he omits altogether the ratio 1.66 which applies to the aether as a monatomic gas. This correction is verified both by theory and by observation on such monatomic gases as Mercury vapor, Helium, Argon, Krypton, Neon, Xenon.