Ethelred as usual did nothing to oppose them, but bought them off with a large sum of money. His efforts at conciliation were completely successful with Olaf, who, after being converted to Christianity, and adopted by Ethelred as his son, remained faithful ever afterwards to his promise of friendship. In the years 997, 998, and 999 the Danes ravaged the coasts of Wessex, Sussex, and Kent. In 1000 Ethelred, energetic at the wrong time and for wrong objects, invaded Normandy, but suffered a disastrous defeat. He concluded a treaty with that country soon afterwards, and in 1002 married Emma, daughter of Richard duke of Normandy. In the spring a treaty had been concluded with the Danes, but in the winter of the same year, Ethelred suspecting that they were plotting treachery, ordered a general massacre of all the Danes in England. Among others murdered was Gunold, sister of Swend; and the Danish king, to revenge her death and that of his countrymen, invaded the coast of Devonshire with a large force. He met with scarcely any opposition, and committed the usual ravages till 1007, when peace was concluded by Ethelred's consenting, as at other times, to the payment of a large sum of money. In 1009 Ethelred collected the "largest fleet that had been seen in the reign of any king," but it was soon afterwards nearly wholly destroyed by a violent storm, just before the Danes renewed their invasion. Ethelred, though he had gathered an army, was dissuaded from attacking them by Edric, and afterwards the English, through the treachery of their leaders, suffered a series of defeats; but in 1012 peace was again bought, and Thurkill, one of the Danish leaders, entered the English service. In 1013 Swend, with a more formidable fleet than any he had yet collected, sailed up the Humber, and then marched southward to London; but meeting there with a strenuous resistance, he was compelled to give up the attack and marched to Bath. Here he was proclaimed king, apparently by the Witan, and with the general consent of the English people, who were doubtless wearied of Ethelred's incompetency, of the treachery of the nobles, and of the oppressive taxes which had been paid for no purpose. London itself soon acknowledged the Danish king, and Ethelred, after for a time taking refuge in Thurkill's fleet, escaped to Normandy. Swend died on February 1014, and on his death Ethelred was recalled by the Witan, on the promise of ruling better in future. In the same year he defeated Cnut, son of Swend, but in 1015 Cnut renewed his attack with a large fleet, and being joined by the traitor Edric, ravaged Wessex and Mercia, and was preparing to attack London, when Ethelred died April 23, 1016. (See Palgrave's *History of the Anglo-Saxons*; Freeman's *Norman Conquest*, vol. i.; and Green's *History of the English People*.)

ETHELWULF, or ÆTHELWULF, an Anglo-Saxon king, succeeded his father Egbert about 836. His reign, like that of his father, was almost wholly occupied with wars against the Danish invaders. For a long time he held them in check, and when in 851 they took Canterbury and London, and defeated Beohrtwulf, king of the Mercians, he met them at Ockley in Surrey, and there "made the greatest slaughter among the heathen army that we have heard tell of unto the present day, and there got the victory." But the Northmen were persevering in their efforts; and it is stated that in 855 they, for the first time, remained over winter in Sheppey. In the same year Ethelwulf made a journey to Rome, accompanied by his youngest and favourite son Alfred, to get the latter consecrated as his successor; and as his first wife Osburga had been for some time dead, he delayed a few months in France to marry Judith, daughter of the king of the Franks. Ethelbald, his eldest surviving son, indignant at his youngest brother being preferred to him as successor to his father's throne, took advantage of his father's absence to stir up a revolution against him, and obtained the support of so powerful a party that an unnatural civil war was only prevented by Ethelwulf agreeing to grant to his son the government of Wessex, he himself being recognized as over-lord, and retaining the rest of the kingdom. He died in 858.

ETHER, $(C_2H_5)_2O$, the *Æther* or *Æther Sulphuricus* of pharmacy, is a colourless, volatile, highly inflammable liquid, of specific gravity 0·723, boiling-point when pure 35·6° C, and fusing-point −31° C. It has a strong and characteristic odour, and a hot sweetish taste, is soluble in ten parts of water, and in all proportions in alcohol, and dissolves bromine, iodine, and, in small quantities, sulphur and phosphorus, also the volatile oils, most fatty and resinous substances, gun-cotton (see COLLODION, vol. vi., p. 149), caoutchouc, and certain of the vegetable alkaloids. The vapour mixed with oxygen or air is violently explosive. The making of ether by the action of sulphuric acid on alcohol was known to Raymond Lully, who wrote in the 13th century; and later Basil Valentin and Valerius Cordus described its preparation and properties. The name ether appears to have been applied to the drug only since the times of Froben, who in 1730 termed it *spiritus æthereus*. Ether is manufactured by the distillation of 5 parts of 90 per cent. alcohol with 9 parts of concentrated sulphuric acid, at a temperature of 140°–145° C., a constant stream of alcohol being caused to flow into the mixture during the operation. (See CHEMISTRY, vol. v. p. 566). It is purified by treatment with lime and calcium chloride, and subsequent redistillation. According to P. Stefanelli (*Ber. deutsch. Chem. Ges.*, 1875, p. 439), the presence of as small a quantity as 1 per cent. of alcohol may be detected in ether by the colour imparted to it by aniline violet; if water or acetic acid be present, the ether must be shaken with anhydrous potassium carbonate before the application of the test. Ether when drunk has a rapid though evanescent intoxicating effect, estimated to be more than three times that of the same bulk of whisky, instead of which it is largely consumed in some parts of Ireland. (See H. N. Draper, *Med. Press and Circular*, iv. 117). Mixed with twice its volume of rectified spirit, it is administered internally as a remedy for nervous headache, flatulence, hiccough, hysteria, and spasmodic vomiting and asthma, occasionally also in angina pectoris, intermittent fevers and typhus, and as an antidote for narcotic poisons, and for relieving the pain caused by biliary calculi. It has been shown by Longet that ether when swallowed even in fatal doses does not at any time produce anæsthesia. Much heat being rendered latent by its evaporation, ether is sometimes employed as a refrigerant in the reduction of hernia. By the use of Dr Richardson's ether spray apparatus for effecting local anæsthesia, a temperature of −6° F. can be obtained. When not allowed to evaporate, ether acts as a rubefacient. Its vapour when inhaled causes at first considerable irritation of the air-passages, and increased rapidity of the pulse, accompanied by much excitement. With the establishment of complete anæsthesia the pulse sinks to 60° or 70° the face becomes pallid, and the muscles are relaxed. Ether occasions more excitement, and requires a somewhat longer period for its exhibition than chloroform, but does not exercise upon the heart the sedative influence of that drug. A history of the employment of ether as an anæsthetic will be found under ANÆSTHESIA, vol. i. p. 786. See also CHLOROFORM, vol. v. p. 680.

ETHER, or ÆTHER (αἰθήρ, probably from αἴθω, I burn, though Plato in his *Cratylus* (410, b) derives the name from its perpetual motion—ὅτι ἀεὶ θεῖ περὶ τὸν ἀέρα ῥέων, ἀειθεὴρ δικαίως ἂν καλοῖτο), a material substance of a more subtle kind than visible bodies, supposed to exist in those parts of space which are apparently empty.

The hypothesis of an æther has been maintained by different speculators for very different reasons. To those who maintained the existence of a plenum as a philosophical principle, nature's abhorrence of a vacuum was a sufficient reason for imagining an all-surrounding æther, even though every other argument should be against it. To Descartes, who made extension the sole essential property of matter, and matter a necessary condition of extension, the bare existence of bodies apparently at a distance was a proof of the existence of a continuous medium between them.

But besides these high metaphysical necessities for a medium, there were more mundane uses to be fulfilled by æthers. Æthers were invented for the planets to swim in, to constitute electric atmospheres and magnetic effluvia, to convey sensations from one part of our bodies to another, and so on, till all space had been filled three or four times over with æthers. It is only when we remember the extensive and mischievous influence on science which hypotheses about æthers used formerly to exercise, that we can appreciate the horror of æthers which sober-minded men had during the 18th century, and which, probably as a sort of hereditary prejudice, descended even to the late Mr John Stuart Mill.

The disciples of Newton maintained that in the fact of the mutual gravitation of the heavenly bodies, according to Newton's law, they had a complete quantitative account of their motions; and they endeavoured to follow out the path which Newton had opened up by investigating and measuring the attractions and repulsions of electrified and magnetic bodies, and the cohesive forces in the interior of bodies, without attempting to account for these forces.

Newton himself, however, endeavoured to account for gravitation by differences of pressure in an æther (see art. ATTRACTION, vol. iii. p. 64); but he did not publish his theory, "because he was not able from experiment and observation to give a satisfactory account of this medium, and the manner of its operation in producing the chief phenomena of nature."

On the other hand, those who imagined æthers in order to explain phenomena could not specify the nature of the motion of these media, and could not prove that the media, as imagined by them, would produce the effects they were meant to explain. The only æther which has survived is that which was invented by Huygens to explain the propagation of light. The evidence for the existence of the luminiferous æther has accumulated as additional phenomena of light and other radiations have been discovered; and the properties of this medium, as deduced from the phenomena of light, have been found to be precisely those required to explain electromagnetic phenomena.

Function of the æther in the propagation of radiation.—The evidence for the undulatory theory of light will be given in full, under the article on LIGHT, but we may here give a brief summary of it so far as it bears on the existence of the æther.

That light is not itself a substance may be proved from the phenomenon of interference. A beam of light from a single source is divided by certain optical methods into two parts, and these, after travelling by different paths, are made to reunite and fall upon a screen. If either half of the beam is stopped, the other falls on the screen and illuminates it, but if both are allowed to pass, the screen in certain places becomes dark, and thus shows that the two portions of light have destroyed each other.

Now, we cannot suppose that two bodies when put together can annihilate each other; therefore light cannot be a substance. What we have proved is that one portion of light can be the exact opposite of another portion, just as $+a$ is the exact opposite of $-a$, whatever a may be. Among physical quantities we find some which are capable of having their signs reversed, and others which are not. Thus a displacement in one direction is the exact opposite of an equal displacement in the opposite direction. Such quantities are the measures, not of substances, but always of processes taking place in a substance. We therefore conclude that light is not a substance but a process going on in a substance, the process going on in the first portion of light being always the exact opposite of the process going on in the other at the same instant, so that when the two portions are combined no process goes on at all. To determine the nature of the process in which the radiation of light consists, we alter the length of the path of one or both of the two portions of the beam, and we find that the light is extinguished when the difference of the length of the paths is an odd multiple of a certain small distance called a half wave-length. In all other cases there is more or less light; and when the paths are equal, or when their difference is a multiple of a whole wave-length, the screen appears four times as bright as when one portion of the beam falls on it. In the ordinary form of the experiment these different cases are exhibited simultaneously at different points of the screen, so that we see on the screen a set of fringes consisting of dark lines at equal intervals, with bright bands of graduated intensity between them.

If we consider what is going on at different points in the axis of a beam of light at the same instant, we shall find that if the distance between the points is a multiple of a wave-length the same process is going on at the two points at the same instant, but if the distance is an odd multiple of half a wave-length the process going on at one point is the exact opposite of the process going on at the other.

Now, light is known to be propagated with a certain velocity ($3{\cdot}004 \times 10^{10}$ centimetres per second in vacuum, according to Cornu). If, therefore, we suppose a movable point to travel along the ray with this velocity, we shall find the same process going on at every point of the ray as the moving point reaches it. If, lastly, we consider a fixed point in the axis of the beam, we shall observe a rapid alternation of these opposite processes, the interval of time between similar processes being the time light takes to travel a wave-length.

These phenomena may be summed up in the mathematical expression

$$u = A \cos (nt - px + a)$$

which gives u, the phase of the process, at a point whose distance measured from a fixed point in the beam is x, and at a time t.

We have determined nothing as to the nature of the process. It may be a displacement, or a rotation, or an electrical disturbance, or indeed any physical quantity which is capable of assuming negative as well as positive values. Whatever be the nature of the process, if it is capable of being expressed by an equation of this form, the process going on at a fixed point is called a *vibration*; the constant A is called the *amplitude*; the time $\frac{2\pi}{n}$ is called the *period*; and $nt - px + a$ is the *phase*.

The configuration at a given instant is called a *wave*, and the distance $\frac{2\pi}{p}$ is called the *wave-length*. The velocity of propagation is $\frac{n}{p}$. When we contemplate the different parts of the medium as going through the same process in succession, we use the word undulatory to denote this character of the process without in any way restricting its physical nature.

A further insight into the physical nature of the process is obtained from the fact that if the two rays are polarized, and if the plane of polarization of one of them be made to turn round the axis of the ray, then when the two planes of polarization are parallel the phenomena of interference appear as above described. As the plane turns round, the dark and light bands become less distinct, and when the planes of polarization are at right angles, the illumination of the screen becomes uniform, and no trace of interference can be discovered.

Hence the physical process involved in the propagation of light must not only be a directed quantity or vector capable of having its direction reversed, but this vector must be at right angles to the ray, and either in the plane of polarization or perpendicular to it. Fresnel supposed it to be a displacement of the medium perpendicular to the plane of polarization. Maccullagh and Neumann supposed it to be a displacement in the plane of polarization. The comparison of these two theories must be deferred till we come to the phenomena of dense media.

The process may, however, be an electromagnetic one, and as in this case the electric displacement and the magnetic disturbance are perpendicular to each other, either of these may be supposed to be in the plane of polarization.

All that has been said with respect to the radiations which affect our eyes, and which we call light, applies also to those radiations which do not produce a luminous impression on our eyes, for the phenomena of interference have been observed, and the wave-lengths measured, in the case of radiations which can be detected only by their heating or by their chemical effects.

Elasticity, tenacity, and density of the æther.—Having so far determined the geometrical character of the process, we must now turn our attention to the medium in which it takes place. We may use the term æther to denote this medium, whatever it may be.

In the first place, it is capable of transmitting energy. The radiations which it transmits are able not only to act on our senses, which of itself is evidence of work done, but to heat bodies which absorb them; and by measuring the heat communicated to such bodies, the energy of the radiation may be calculated.

In the next place this energy is not transmitted instantaneously from the radiating body to the absorbing body, but exists for a certain time in the medium.

If we adopt either Fresnel's or Maccullagh's form of the undulatory theory, half of this energy is in the form of potential energy, due to the distortion of elementary portions of the medium, and half in the form of kinetic energy, due to the motion of the medium. We must therefore regard the æther as possessing elasticity similar to that of a solid body, and also as having a finite density. If we take Pouillet's estimate of 1·7633 as the number of gramme-centigrade units of heat produced by direct sunlight falling on a square centimetre in a minute, this is equivalent to $1·234 \times 10^6$ ergs per second. Dividing this by $3·004 \times 10^{10}$, the velocity of light in centimetres per second, we get for the energy in a cubic centimetre $4·1 \times 10^{-5}$ ergs. Near the sun the energy in a cubic centimetre would be about 46,000 times this, or 1·886 ergs. If we further assume, with Sir W. Thomson, that the amplitude is not more than one hundredth of the wave-length, we have $Ap = \frac{2\pi}{100}$, or about $\frac{1}{16}$; so that we have—

Energy per cubic centimetre	$= \frac{1}{2}\rho V^2 A^2 p^2 =$	1·886 ergs.
Greatest tangential stress per square centimetre,	$= \rho V^2 A p$	= 30·176 dynes.
Coefficient of rigidity of ether, . . .	$= \rho V^2$	= 842·8
Density of æther, . .	$= \rho$	$= 9·36 \times 10^{-19}$

The coefficient of rigidity of steel is about 8×10^{11}, and that of glass $2·4 \times 10^{11}$.

If the temperature of the atmosphere were everywhere 0° C, and if it were in equilibrium about the earth supposed at rest, its density at an infinite distance from the earth would be 3×10^{-346} which is about 3×10^{327} times less than the estimated density of the æther. In the regions of interplanetary space the density of the æther is therefore very great compared with that of the attenuated atmosphere of interplanetary space, but the whole mass of æther within a sphere whose radius is that of the most distant planet is very small compared with that of the planets themselves.[1]

The æther distinct from gross matter.—When light travels through the atmosphere it is manifest that the medium through which the light is propagated is not the air itself, for in the first place the air cannot transmit transverse vibrations, and the normal vibrations which the air does transmit travel about a million times slower than light. Solid transparent bodies, such as glass and crystals, are no doubt capable of transmitting transverse vibrations, but the velocity of transmission is still hundreds of thousand times less than that with which light is transmitted through these bodies. We are therefore obliged to suppose that the medium through which light is propagated is something distinct from the transparent medium known to us, though it interpenetrates all transparent bodies and probably opaque bodies too.

The velocity of light, however, is different in different transparent media, and we must therefore suppose that these media take some part in the process, and that their particles are vibrating as well as those of the æther, but the energy of the vibrations of the gross particles must be very much smaller than that of the æther, for otherwise a much larger proportion of the incident light would be reflected when a ray passes from vacuum to glass or from glass to vacuum than we find to be the case.

Relative motion of the æther.—We must therefore consider the æther within dense bodies as somewhat loosely connected with the dense bodies, and we have next to inquire whether, when these dense bodies are in motion through the great ocean of æther, they carry along with them the æther they contain, or whether the æther passes through them as the water of the sea passes through the meshes of a net when it is towed along by a boat. If it were possible to determine the velocity of light by observing the time it takes to travel between one station and another on the earth's surface, we might, by comparing the observed velocities in opposite directions, determine the velocity of the æther with respect to these terrestrial stations. All methods, however, by which it is practicable to determine the velocity of light from terrestrial experiments depend on the measurement of the time required for the double journey from one station to the other and back again, and the increase of this time on account of a relative velocity of the æther equal to that of the earth in its orbit would be only about one hundred millionth part of the whole time of transmission, and would therefore be quite insensible.

The theory of the motion of the æther is hardly sufficiently developed to enable us to form a strict mathematical theory of the aberration of light, taking into account the motion of the æther. Professor Stokes, however, has shown that, on a very probable hypothesis with respect to the motion of the æther, the amount of aberration would not be sensibly affected by that motion.

The only practicable method of determining directly the relative velocity of the æther with respect to the solar system is to compare the values of the velocity of light

[1] See Sir W. Thomson, *Trans. R. S. Edin.*, vol. xxi. p. 60.

deduced from the observation of the eclipses of Jupiter's satellites when Jupiter is seen from the earth at nearly opposite points of the ecliptic.

Arago proposed to compare the deviation produced in the light of a star after passing through an achromatic prism when the direction of the ray within the prism formed different angles with the direction of motion of the earth in its orbit. If the æther were moving swiftly through the prism, the deviation might be expected to be different when the direction of the light was the same as that of the æther, and when these directions were opposite.

The present writer[1] arranged the experiment in a more practicable manner by using an ordinary spectroscope, in which a plane mirror was substituted for the slit of the collimator. The cross wires of the observing telescope were illuminated. The light from any point of the wire passed through the object-glass and then through the prisms as a parallel pencil till it fell on the object-glass of the collimator, and came to a focus at the mirror, where it was reflected, and after passing again through the object-glass it formed a pencil passing through each of the prisms parallel to its original direction, so that the object-glass of the observing telescope brought it to a focus coinciding with the point of the cross wires from which it originally proceeded. Since the image coincided with the object, it could not be observed directly, but by diverting the pencil by partial reflection at a plane surface of glass, it was found that the image of the finest spider line could be distinctly seen, though the light which formed the image had passed twice through three prisms of 60°. The apparatus was first turned so that the direction of the light in first passing through the second prism was that of the earth's motion in its orbit. The apparatus was afterwards placed so that the direction of the light was opposite to that of the earth's motion. If the deviation of the ray by the prisms was increased or diminished for this reason in the first journey, it would be diminished or increased in the return journey, and the image would appear on one side of the object. When the apparatus was turned round it would appear on the other side. The experiment was tried at different times of the year, but only negative results were obtained. We cannot, however, conclude absolutely from this experiment that the æther near the surface of the earth is carried along with the earth in its orbit, for it has been shown by Professor Stokes[2] that according to Fresnel's hypothesis the relative velocity of the æther within the prism would be to that of the æther outside inversely as the square of the index of refraction, and that in this case the deviation would not be sensibly altered on account of the motion of the prism through the æther.

Fizeau,[3] however, by observing the change of the plane of polarization of light transmitted obliquely through a series of glass plates, obtained what he supposed to be evidence of a difference in the result when the direction of the ray in space was different, and Angström obtained analogous results by diffraction. The writer is not aware that either of these very difficult experiments has been verified by repetition.

In another experiment of M. Fizeau, which seems entitled to greater confidence, he has observed that the propagation of light in a stream of water takes place with greater velocity in the direction in which the water moves than in the opposite direction, but that the change of velocity is less than that which would be due to the actual velocity of the water, and that the phenomenon does not occur when air is substituted for water. This experiment seems rather to verify Fresnel's theory of the æther; but the whole question of the state of the luminiferous medium near the earth, and of its connexion with gross matter, is very far as yet from being settled by experiment.

Function of the æther in electromagnetic phenomena.—Faraday conjectured that the same medium which is concerned in the propagation of light might also be the agent in electromagnetic phenomena. "For my own part," he says, "considering the relation of a vacuum to the magnetic force, and the general character of magnetic phenomena external to the magnet, I am much more inclined to the notion that in the transmission of the force there is such an action, external to the magnet, than that the effects are merely attraction and repulsion at a distance. Such an action may be a function of the æther; for it is not unlikely that, if there be an æther, it should have other uses than simply the conveyance of radiation."[4] This conjecture has only been strengthened by subsequent investigations.

Electrical energy is of two kinds, electrostatic and electrokinetic. We have reason to believe that the former depends on a property of the medium in virtue of which an electric displacement elicits an electromotive force in the opposite direction, the electromotive force for unit displacement being inversely as the specific inductive capacity of the medium.

The electrokinetic energy, on the other hand, is simply the energy of the motion set up in the medium by electric currents and magnets, this motion not being confined to the wires which carry the currents, or to the magnet, but existing in every place where magnetic force can be found.

Electromagnetic Theory of Light.—The properties of the electromagnetic medium are therefore as far as we have gone similar to those of the luminiferous medium, but the best way to compare them is to determine the velocity with which an electromagnetic disturbance would be propagated through the medium. If this should be equal to the velocity of light, we would have strong reason to believe that the two media, occupying as they do the same space, are really identical. The data for making the calculation are furnished by the experiments made in order to compare the electromagnetic with the electrostatic system of units. The velocity of propagation of an electromagnetic disturbance in air, as calculated from different sets of data, does not differ more from the velocity of light in air, as determined by different observers, than the several calculated values of these quantities differ among each other.

If the velocity of propagation of an electromagnetic disturbance is equal to that of light in other transparent media, then in non-magnetic media the specific inductive capacity should be equal to the square of the index of refraction.

Boltzmann[5] has found that this is very accurately true for the gases which he has examined. Liquids and solids exhibit a greater divergence from this relation, but we can hardly expect even an approximate verification when we have to compare the results of our sluggish electrical experiments with the alternations of light, which take place billions of times in a second.

The undulatory theory, in the form which treats the phenomena of light as the motion of an elastic solid, is still encumbered with several difficulties.[6]

The first and most important of these is that the theory indicates the possibility of undulations consisting of vibrations normal to the surface of the wave. The only way of

[1] *Phil. Trans.*, clviii. (1868), p. 532.
[2] *Phil. Mag.*, 1846, p. 53.
[3] *Ann. de Chimie et de Physique*, Feb. 1860.

[4] *Experimental Researches*, 3075.
[5] *Wiener Sitzb.*, 23 April 1874.
[6] See Prof. Stokes, "Report on Double Refraction," *British Ass. Report*, 1862, p. 253.

accounting for the fact that the optical phenomena which would arise from these waves do not take place is to assume that the æther is incompressible.

The next is that, whereas the phenomena of reflection are best explained on the hypothesis that the vibrations are perpendicular to the plane of polarization, those of double refraction require us to assume that the vibrations are in that plane.

The third is that, in order to account for the fact that in a doubly refracting crystal the velocity of rays in any principal plane and polarized in that plane is the same, we must assume certain highly artificial relations among the coefficients of elasticity.

The electromagnetic theory of light satisfies all these requirements by the single hypothesis[1] that the electric displacement is perpendicular to the plane of polarization. No normal displacement can exist, and in doubly refracting crystals the specific dielectric capacity for each principal axis is assumed to be equal to the square of the index of refraction of a ray perpendicular to that axis, and polarized in a plane perpendicular to that axis. Boltzmann[2] has found that these relations are approximately true in the case of crystallized sulphur, a body having three unequal axes. The specific dielectric capacity for these axes are respectively

4·773	3·970	3·811

and the squares of the indices of refraction

4·576	3·886	3·591

Physical constitution of the æther.—What is the ultimate constitution of the æther? is it molecular or continuous?

We know that the æther transmits transverse vibrations to very great distances without sensible loss of energy by dissipation. A molecular medium, moving under such conditions that a group of molecules once near together remain near each other during the whole motion, may be capable of transmitting vibrations without much dissipation of energy, but if the motion is such that the groups of molecules are not merely slightly altered in configuration but entirely broken up, so that their component molecules pass into new types of grouping, then in the passage from one type of grouping to another the energy of regular vibrations will be frittered away into that of the irregular agitation which we call heat.

We cannot therefore suppose the constitution of the æther to be like that of a gas, in which the molecules are always in a state of irregular agitation, for in such a medium a transverse undulation is reduced to less than one five-hundredth of its amplitude in a single wave-length. If the æther is molecular, the grouping of the molecules must remain of the same type, the configuration of the groups being only slightly altered during the motion.

Mr S. Tolver Preston[3] has supposed that the æther is like a gas whose molecules very rarely interfere with each other, so that their mean path is far greater than any planetary distances. He has not investigated the properties of such a medium with any degree of completeness, but it is easy to see that we might form a theory in which the molecules *never* interfere with each other's motion of translation, but travel in all directions with the velocity of light; and if we further suppose that vibrating bodies have the power of impressing on these molecules some vector property (such as rotation about an axis) which does not interfere with their motion of translation, and which is then carried along by the molecules, and if the alternation of the average value of this vector for all the molecules within an element of volume be the process which we call light, then the equations which express this average will be of the same form as that which expresses the displacement in the ordinary theory.

It is often asserted that the mere fact that a medium is elastic or compressible is a proof that the medium is not continuous, but is composed of separate parts having void spaces between them. But there is nothing inconsistent with experience in supposing elasticity or compressibility to be properties of every portion, however small, into which the medium can be conceived to be divided, in which case the medium would be strictly continuous. A medium, however, though homogeneous and continuous as regards its density, may be rendered heterogeneous by its motion, as in Sir W. Thomson's hypothesis of vortex-molecules in a perfect liquid (see art. ATOM).

The æther, if it is the medium of electromagnetic phenomena, is probably molecular, at least in this sense.

Sir W. Thomson[4] has shown that the magnetic influence on light discovered by Faraday depends on the direction of motion of moving particles, and that it indicates a rotational motion in the medium when magnetized. See also *Maxwell's Electricity and Magnetism*, art. 806, &c.

Now, it is manifest that this rotation cannot be that of the medium as a whole about an axis, for the magnetic field may be of any breadth, and there is no evidence of any motion the velocity of which increases with the distance from a single fixed line in the field. If there is any motion of rotation, it must be a rotation of very small portions of the medium each about its own axis, so that the medium must be broken up into a number of molecular vortices.

We have as yet no data from which to determine the size or the number of these molecular vortices. We know, however, that the magnetic force in the region in the neighbourhood of a magnet is maintained as long as the steel retains its magnetization, and as we have no reason to believe that a steel magnet would lose all its magnetization by the mere lapse of time, we conclude that the molecular vortices do not require a continual expenditure of work in order to maintain their motion, and that therefore this motion does not necessarily involve dissipation of energy.

No theory of the constitution of the æther has yet been invented which will account for such a system of molecular vortices being maintained for an indefinite time without their energy being gradually dissipated into that irregular agitation of the medium which, in ordinary media, is called heat.

Whatever difficulties we may have in forming a consistent idea of the constitution of the æther, there can be no doubt that the interplanetary and interstellar spaces are not empty, but are occupied by a material substance or body, which is certainly the largest, and probably the most uniform body of which we have any knowledge.

Whether this vast homogeneous expanse of isotropic matter is fitted not only to be a medium of physical interaction between distant bodies, and to fulfil other physical functions of which, perhaps, we have as yet no conception, but also, as the authors of the *Unseen Universe* seem to suggest, to constitute the material organism of beings exercising functions of life and mind as high or higher than ours are at present, is a question far transcending the limits of physical speculation. (J. C. M.)

ETHEREDGE, SIR GEORGE (*c.* 1636–1689), an English dramatist, was born in or near London about the year 1636. He was a scion of an ancient and distinguished family of Oxfordshire. He was educated at Cambridge, but left the university early to travel in France and Flanders. It is probable that he witnessed in Paris the performances of some of Molière's earliest comedies; and he seems, from an allusion in one of his plays, to have been personally acquainted with Bussy Rabutin. On his return to London he studied the law at one of the Inns of Court. His tastes were those of a fine gentleman, and he indulged freely in pleasure. Sometime soon after the Restoration he composed his comedy of *The Comical Revenge, or Love in a Tub*, which introduced him to Lord Buckhurst, afterwards the earl of Dorset. This was brought out at the Duke's Theatre in 1664, and a few copies were printed in the same year. The main edition of this play, however, was not issued until 1669. It is partly in rhymed heroic verse, like the stilted tragedies of the Howards and Killigrews, but it contains comic scenes that are exceedingly bright and fresh. The sparring between Sir Frederick and the Widow introduced a style of wit hitherto unknown upon the English stage. The success of this play was very great, but Etheredge waited four years before he repeated his experiment. Meanwhile he gained the highest reputation as a poetical beau, and moved in the circle of Sir Charles Sedley, Lord Rochester, and the other noble wits of the day. In 1668 he brought out *She would if she could*, a comedy in many respects admirable, full of action, wit, and spirit, but to the last degree frivolous and immoral. But in this play Etheredge first shows himself a new power in literature; he has nothing of the rudeness of his predecessors or the grossness of his contemporaries. We move in an airy and fantastic world, where flirtation is the only serious business of life. At this time Etheredge was living a life no less frivolous and unprincipled than those of his Courtals and Freemans. He formed an alliance with the famous actress Mrs Barry; she bore him a daughter, on whom he settled £6000, but who unhappily died in her youth. His wealth and wit, the distinction and charm of his manners, won him the general worship of society, and his temperament is best shown by the names his contemporaries gave him, of "gentle George" and "easy Etheredge." The age upbraided him for inattention to literature; and at last, after a silence of eight years, he came forward with one more play, unfortunately his last. *The Man of Mode, or Sir Fopling Flutter*, indisputably the best comedy of intrigue written in England before the days of Congreve, was acted and printed in 1676, and had an unbounded success. Besides the merit of its plot and wit, it had the personal charm of being supposed to satirize, or at least to paint, persons well known in London. Sir Fopling Flutter was a portrait of Beau Hewit, the reigning exquisite of the hour; in Dorimant the poet drew the elegant Sir Charles Sedley, and in Medley a portrait of himself; while even the drunken shoemaker was a real character, who made his fortune from being thus brought into public notice. After this brilliant success Etheredge retired from literature; his gallantries and his gambling in a few years deprived him of his fortune, and he looked about for a rich match. In 1683 he met with a wealthy elderly widow, who consented to marry him if he made a lady of her. He accordingly got himself knighted, and gained her hand and her money. It is said that before this, about 1680, he had been sent on an embassy to Turkey; it is certain that in 1686 he was appointed resident minister in the Imperial German Court at Ratisbon. He was very uncomfortable in Germany, and solaced himself by writing amusing epistles in prose and verse to his friends in England. In 1688 he published a prose *Account of the rejoicing at the Diet of Ratisbon.* In 1689 he is believed to have died in Ratisbon in a tragical manner, for whilst conducting a party of friends to the stairs after a banquet at his house, he fell over into the court below and broke his neck. But his death occurred at the moment when England was convulsed with revolution, and no one has preserved the exact date of it.

Etheredge deserves to hold a more distinguished place in our literature than has generally been allotted to him. In a dull and heavy age, he inaugurated a period of genuine wit and sprightliness. He invented the comedy of intrigue, and led the way for the masterpieces of Congreve and Sheridan. Before his time the manner of Ben Jonson had prevailed in comedy, and traditional "humours" and typical eccentricities, instead of real characters, had crowded the comic stage. Etheredge paints with a light faint hand, but it is from nature, and his portraits of fops and beaux are simply unexcelled. No one knows better than he how to present a gay young gentleman, a Dorimant, "an unconfinable rover after amorous adventures." His genius is as light as thistledown; he is frivolous, without force of conviction, without principle; but his wit is very sparkling, and his style pure and singularly picturesque. No one approaches Etheredge in delicate touches of dress, furniture, and scene; he makes the fine airs of London gentlemen and ladies live before our eyes even more vividly than Congreve does; but he has less insight and less energy than Congreve. Had he been poor or ambitious he might have been to England almost what Molière was to France, but he was a rich man living at his ease, and he disdained to excel in literature. Etheredge was "a fair, slender, genteel man, but spoiled his countenance with drinking." His contemporaries all agree in acknowledging that he was the soul of affability and sprightly good-nature.

There is no recent edition of the works of Sir George Etheredge. A critical collection of them would fill a very important gap in our literature.

ETHERIDGE, JOHN WESLEY (1804–1866), a Wesleyan minister, and a writer on church history and biblical literature, was born near Newport, Isle of Wight, 24th February 1804. He received most of his early education from his father, who was master of an academy at Portsea, which was afterwards removed to Newport. Though he never attended any university he acquired ultimately a thorough knowledge of Greek, Latin, Hebrew, Syriac, French, and German. In 1824 he was placed on the plan as a local preacher. In 1826 his offer to enter the ministry was accepted, and after probationary trial at Hull, Bingley, Lambeth, and Brighton, he was received into full connexion at the conference of 1831. For two years after this he remained at Brighton, and in 1833 he removed to Cornwall, being stationed successively at the Truro and Falmouth circuits. From Falmouth he removed to Darlaston, where in 1838 his health gave way. For a good many years he was a supernumerary, and in 1843 he took up his residence at Paris, where in the public libraries he found great facilities for prosecuting his favourite studies. His health having considerably improved, he, in 1843, became pastor of the Methodist church at Boulogne. He returned to England in 1847, and was appointed successively to the circuits of Islington, Bristol, Leeds, Penzance, Penryn, Truro, and St Austell in east Cornwall. Shortly after his return to England he received the degrees of M.A. and Ph.D. from the university of Heidelberg. He died at Camborne, May 24, 1866.

His principal works are *Horæ Aramaicæ* (1843); *History of the Syrian Churches* (1847); *The Apostolic Acts and Epistles, from the Peshito or Ancient Syriac* (1849); *Jerusalem and Tiberias, a Survey of the Religious and Scholastic learning of the Jews* (1856); *The Targums of Onkelos and Jonathan ben Uzziel* (1st vol. in 1862, 2d in 1865). See *Memoir*, by Rev. Thornley Smith (1871).

[1] *Over de theorie der terugkaatsing en breking van het licht*,—Academisch Proefschrift door H. A. Lorentz. Arnhem, K. van der Zande, 1875.

[2] "Ueber die Verschiedenheit der Dielektricitatsconstante des krystallisirten Schwefels nach verschiedenen Richtungen," by Ludwig Boltzmann, *Wiener Sitzb.*, 8th Oct. 1874.

[3] *Phil. Mag.*, Sept. and Nov. 1877.

[4] *Proceedings of the Royal Society*, June 1856.