

Physics of the Ether - SECTION XIV

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SECTION XIV.

115. Constitution of the Ether; Physical Relations. — There are some extremely simple relations between the mean length of path of the particles of an aeriform medium, the mean distance of the particles, and the dimensions of the particles. Clausius, who has investigated this subject, and who applied his results specially to gases, has established, mathematically, a relation as regards the mean length of path of a gaseous molecule, which, applied to the case of the ether, would be as follows : The mean length of path of an ether particle is in the same proportion to the radius of the particle (supposing it to be spherical) as the unit volume of space is to the volume of matter contained therein, i.e. the total volume of the particles contained in this unit volume of space.

Since the volume of matter is directly proportional to the number of particles, the theorem might be otherwise stated, viz. that the mean length of path of a particle is greater in direct proportion as the number of particles (of given size) is less. This fact will become tolerably evident on consideration of the subject, for it is clear that the mean length of path, or the distance that a particle can move without obstruction by other particles of the medium, will depend on the number of these obstructing particles,

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the mean length of path of a particle being greater as the number of obstructing particles is less.

It may be further shown to be a result of the above theorem, that the relation between these values, i. e. the values of the mean length of path, mean distance, and the radii* (or diameters) of the particles of an aeriform medium, is constant, whatever the state of subdivision of the matter forming the medium. Now, it is at first evident that the volume of matter cannot be affected by subdivision of the matter, and therefore the relation of the mean length of path to the radius of the particle, which depends directly (as in accordance with the theorem) on the volume of matter, cannot be affected by subdivision of the matter; so that, therefore, the ratio of the mean length of path to the radius of the particle will remain constant, whatever the state of subdivision of the matter of the medium may be conceived to be. If, therefore, we were to imagine a progressive subdivision of the matter of the medium to go on, the radius (or diameter) of the particles and the mean length of path would diminish in precisely the same ratio, the two, therefore, preserving a constant ratio to each other.

It only remains to show that the relation of the mean distance of the particles to these other values also remains constant, whatever the state of subdivision. We may imagine (according to the proceeding adopted by Clausius) space to be subdivided into a number of small cubes, and that at each corner of all these cubes a particle is placed; then any side of a cube will represent the distance of the particles, or the mean distance when the particles are placed irregularly, or are in motion. Now, it will be apparent, on considering the question, that by subdivision of the matter of the medium, the side of any one of these cubes and the diameter (or radius) of the particle will diminish in the same ratio. Thus, to take any case : if we suppose by the process of subdivision the diameter of each particle to be halved, then the volume of each particle is thereby reduced to one eighth (the volume of a sphere being as the cube of the diameter), and, therefore, there is now matter available for eight times as many particles; and accordingly, therefore, space may now be further subdivided into eight times as many small cubes, at the corners of all of which particles may be placed. But by this process it will be observed that the side of the cube (i. e. the distance of the particles) has become precisely halved, the length of the side of any one cube being inversely as the cube root of their number. The effect, therefore, of reducing the diameter of the particle to one half by the imaginary process of subdivision of the matter has been to reduce the mean distance to one half; and, therefore, the relation of the

- In the case of the molecules of a gas, radius would mean " radius of sphere of action " (as termed by Clausius), i. e. the mean radial distance within which vibrating gaseous molecules, separated by the ether, approach in their mutual interchange of motion.

mean distance of the particles to the diameter has been unaffected by the subdivision.

It follows, therefore, that whatever the state of subdivision of the matter of an aeriform medium may be conceived to be, the values of the mean length of path of the particles, the mean distance of the particles, and the diameter of the particles, preserve a constant ratio to each other, and therefore the proportionate (or relative) values would be determined by a knowledge of the proportion of space to matter contained therein, also a determination of any one of these values in absolute measure would determine all. It may be observed that the proportion of space to matter in the medium is evidently proportional to the density of the medium.

There is, accordingly, no limit to the smallness that the values of the mean length of path, mean distance, and diameter of the particles may attain by subdivision of the matter of the medium, all of these values diminishing indefinitely, and preserving a constant ratio to each other as the subdivision progresses.

116. The mode in which these values vary by the process of subdivision of the matter of the medium may be represented graphically in a simple manner. Fig. 8. / Thus, in the diagram (Fig. 8), if the ratio to the line fs to half an (radius of particle) represent the ratio of the unit volume of space to the volume of matter contained therein, in the case of the medium, then the lines fs and sn will represent the proportionate values of the mean length of path and the diameter of the particle. If an and lg represent any two particles of the medium, the line joining their centres (i. e. the prolongation of the line fa) will represent the mean*. Then if lines be drawn from these points to a common point p , any straight line (such as the line fg) drawn parallel to fg , anywhere between it and the point p , will at its points of intersection represent the values of the mean length of path, mean distance, and diameter of the particles, corresponding to another state of subdivision of the matter of the medium (the parallel straight lines being cut proportionally); these values diminishing indefinitely, and at the same time preserving a constant ratio to each other, as by the progressive subdivision of the matter of the medium, the line fg advances towards the point p .

117. The relation of the mean length of path of a particle of

- The proportionate value of the mean distance is here given somewhat too great, for convenience in the diagram, the principle involved not being affected thereby.

distance of the particles.

an aeriform medium to the radius of the particle being in the relation of the volume of space to the volume of matter (i. e. proportionate to the density of the medium), the known low density of the ether, therefore, makes the influence necessary that the mean length of path, and even the mean distance of the particles, must be a large multiple of their diameters; but on this account the absolute values of the mean length of path and mean distance need not be large, but by the simple condition of subdivision of the matter of the ether, these values may be reduced without limit; as in the illustrative diagram, by the process of subdivision and the attendant reduction of the diameter of the particles, these particles would gradually advance (or slide between the inclined lines) indefinitely near to the point p , carrying the line fg representing the corresponding values of the mean distance and mean length of path, along with them, all the values therefore approaching the vanishing point as the subdivision of the matter of the medium progresses.

The admirable appropriateness of this mathematical relation as a mechanical condition to render practicable the existence of an intense store of energy, and its necessary accompaniment an intense pressure, will be apparent. For the simple condition of an extremely subdivided state of the matter of the medium not only renders a high speed practicable to the particles, by reducing the energy of each almost up to the vanishing point, but this condition has also the effect of curbing the motion within almost infinitesimal limits, and of reducing the mean distance and. multiplying the number of particles to such a degree that the equilibrium of pressure even about the small mass of a molecule becomes practically perfect; and therefore the existence of a pressure of an extreme intensity becomes quite practicable, without disturbance of the equilibrium of the molecules of matter, and the consequent concealment of the pressure from the senses becomes complete.

By the reduction of the mass of the particle and the attendant reduction of its mean length of path as a result of subdivision, not only does the energy of each particle taken separately become vanishingly small even when the particle is moving at the speed of light, but the limits of its path almost vanish; or if we regard the limits of path of each particle, the particle might as well be at rest as far as any power of appreciating the limits of its path by the senses is concerned, and yet by the multiplicity of particles attendant on the extreme state of subdivision, and by the consequent addition of the paths of the innumerable particles in their interchange of motion, a wave advances at the speed of light without the motion of the physical links of the chain being apparent; and although by subdivision the energy almost vanishes when each particle is regarded separately, yet the total energy exists to its full intensity.