

The effect is to compress H in one half and expand it in the other half of a period, with corresponding strengthening and weakening of intensity, and also with a shifting of the nodes towards the compressed part. When u/v is made large, there is a great concentration at $\phi_1 = \phi_0 = \frac{1}{2}\pi$, $2\frac{1}{2}\pi$, $4\frac{1}{2}\pi$, &c., with only a weak disturbance of opposite sign between them. That is, there is a tendency to turn the original simply periodic vibration into periodic pulses, which become very marked as u increases towards v . The radiation of energy is very rapid. It involves (*l.c.*) the factor $(1-u^2/v^2)^{-2}$. This becomes so great as seemingly to shut out the possibility of anything more than momentary persistence of revolution. But there might be a solitary partial revolution, or nearly complete, in cometary fashion, which would generate a single pulse, if there cannot be a sequence of several at speeds nearly equal to that of light.

Three suggestions have been made about the X-rays. Röntgen suggested a longitudinal ether disturbance. This has not found favour, because it requires a new theory of electricity. Schuster suggested very rapid vibrations. This is tenable, because in the inside of an atom rudimentary calculations show that vibrations much more frequent than light are easily possible with revolving electrons. Stokes suggested collisional pulses. This is tenable too, for the collisions must produce electromagnetic pulses. I think X-rays are mixed Stokes pulses and Schuster vibrations, the latter arising from the atoms of the body struck. Now a pulse is not the same as a continued vibration, though it may be analysed into the sum of various sorts of continued vibrations, just as the distorted simply periodic vibration in (5) above may be. There ought, then, to be a physical difference between the effects of collisional pulses and continued very rapid vibrations. Apart from the emission of electrons and matter, there might be six sorts of radiation at least, say, light vibrations, below light, above light, collisional pulses, cometary pulses, and possibly periodic pulses. The last may have to be excluded for the reason mentioned. The cometary pulses would resemble the collisional pulses, though less dense. The above light vibrations need not require u/v to be more than a small fraction, though even then their maintenance is a difficulty. They require renewal again and again, perhaps in a collisional manner. There is a good deal to be found out yet in the relations of electricity to matter. There is also sometimes a good deal of misconception as to the relations of theory to fact. A purely dynamical theory of electricity, like Maxwell's, can give no information about the connection between electricity and matter. For example, Zeeman's experiment, as interpreted by Lorentz, brought out the striking fact that it was the negative electricity that revolved, not seemingly the positive, and the fact harmonises with J. J. Thomson's negative corpuscles. Theory could never predict such a fact, because it is not in the theory. It could not be there, because it has no dependence upon the dynamics of electricity in the theory. The same may be said of various other new facts much discussed of late. Now, though the theory cannot predict such facts, it is useful, of course, as a guide in framing hypotheses to account for the new facts, for it is no use flying in the face of solid theory. Whether the solid theory itself (not meaning that the ether is solid) will need to be altered remains to be seen. There is no sign of it yet, though I cannot believe the ethereal theory is complete.

To analyse the dopplerised vibrations expressed by (1). (2) into simply periodic vibrations seemed to involve very complicated work at first, save just for two or three terms. But there is a trick in it, which, when found, allows the complete expansions to be developed in a few lines. First show that (this is the trick)

$$\alpha^3 \cos \phi_1 = -\frac{d^2}{d\phi_0^2} \cos \phi_1, \quad \alpha^3 (\sin \phi_1 - \beta) = -\frac{d^2}{d\phi_0^2} \sin \phi_1. \quad (6)$$

Next, by the theorem known as Lagrange's, $\sin \phi_1$ can be at once put in the form of a series involving the derivatives of various powers of $\cos \phi_0$. Do not find the derivatives from them, but put $\cos^n \phi_0$ in terms of the sum of first powers of cosines by the well known circular formula. The

full differentiations, not forgetting those in (6), may then be done at sight in one operation. The result is

$$\begin{aligned} \alpha^3 (\sin \phi_1 - \beta) = & \sin \phi_0 - \beta \cdot 2 \cos 2\phi_0 - \frac{3}{8} \beta^2 (9 \sin 3\phi_0 + \sin \phi_0) \\ & + \frac{4}{3} \beta^3 (4 \cos 4\phi_0 + \cos 2\phi_0) + \frac{\beta^4}{4} \frac{1}{2^4} (5^5 \sin 5\phi_0 + 5 \cdot 3^4 \sin 3\phi_0 \\ & + 10 \sin \phi_0) - \frac{\beta^5}{5} \frac{1}{2^5} (6^5 \cos 6\phi_0 + 6 \cdot 4^4 \cos 4\phi_0 + 15 \cdot 2^4 \cos 2\phi_0) \\ & \dots (7) \end{aligned}$$

and so on to any extent. Then, to find the other one, differentiate the series in (7) with respect to ϕ_0 and divide the n th term by n . Thus

$$\alpha^3 \cos \phi_1 = \cos \phi_0 + 2\beta \sin 2\phi_0 - \frac{\beta^2}{8} (27 \cos 3\phi_0 + \cos \phi_0) - \dots (8)$$

and so on. This analysis of the vibrations is useful in some special developments, but of course the original distorted simple vibration is the most significant. In fact, the result of the analysis exhibits the common failing of most series developments that the resultant meaning is not evident.

Another way. Use Bessel's series for the sine and cosine of ϕ_1 , and then carry out (6). It is remarkable that the relation between the eccentric and mean anomaly in a planetary orbit should be imitated, for the dynamics is quite different.

When I was a young child I conceived the idea of an infinite series of universes, the solar system being an atom in a larger universe on the one hand, and the mundane atom a universe to a smaller atom, and so on. I do not go so far as that now, but only observe that there is a tendency to make the electrons indivisible, and all exactly alike. But they must have size and shape, and be therefore divisible. Unless, indeed, they are infinitely rigid. Or they may vary in shape without dividing. There are infinite possibilities in the unknown. Kaufmann's measurements go to show that the mass of an electron, if there is any, is only a small fraction of its effective electromagnetic mass, although that is not a definite quantity subject to the Newtonian second law. But it is too soon to say that the electron has no mass at all, that is, to be quite sure that negative electricity is absolutely separable from matter, though it seems likely. It would be well to have, if possible, similar measurements made on positive electricity. If permanently attached to matter, it should not exhibit the increased inertia with increased speed in a sensible manner.

January 11.

OLIVER HEAVISIDE.

Atmospheric Electricity.

YOUR correspondent Mr. George Simpson truly points out that the sun's α rays would be stopped by the upper atmosphere, whereas his β rays would penetrate much further; and perhaps he may have also noticed that an energetic separation of these oppositely charged rays would be effected by the earth's magnetic field, the negative being conveyed toward the poles, and the positive remaining near the tropics along with the maximum sunshine.

Consequently quadrantal earth-currents would be generated, and likewise a Leyden jar action would be set up in the tropical region of the lower atmosphere, sufficient to account for prevalent tropical thunderstorms. Some magnetic perturbations could also be accounted for.

OLIVER LODGE.

Nomenclature and Tables of Kinship.

A CIRCULAR letter, arranged like the following, is about to be issued for carrying out certain inquiries into heredity, and I am anxious, before taking a more definite step, to have it criticised and to receive suggestions. I send it to NATURE not only for my own advantage, but because I think it will interest those readers who occupy themselves in analysing experiences in breeding animals of any kind, although this table has been specially designed to receive hereditary facts concerning man.

The processes that it is desired to facilitate are, in out-