

## LETTERS TO THE EDITOR.

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## On Röntgen's Rays.

PROF. RÖNTGEN'S remarkable discovery will materially affect our views concerning the relation between the ether and matter; but further experimental evidence is required before any opinion can be expressed as to the character of the rays, which behave in so straightforward a manner that they seem to upset all one's notions of the laws of nature. Prof. Röntgen, on the strength of his carefully-conducted experiments, has arrived at a conclusion adverse to the idea that the rays only differ from light rays by the smallness of wave-length. Perhaps the following considerations may show that the evidence is not conclusive in this respect.

Röntgen's rays are not kathode rays—there can be no doubt on that point—but they are generated at the point of impact between the kathode ray and solid substances.

The discoverer has not been able to obtain any interference effects, possibly, as he says, owing to the weakness of the radiation. An absence of interference would not, however, be sufficient to show that the radiation is not of the nature of ordinary light, but only that it does not possess sufficient regularity, or, in other words, that the disturbance is not sufficiently homogeneous. That this is the case is not at all improbable, for the radiation is produced by an impact, which in the first instance may be an impulsive motion propagated outwards, and after passing through the screen, would only possess such regularity as is impressed on it by the absorption of the longer waves.

The great argument against the supposition of waves of very small length lies in the absence of refraction; but is this conclusive?

When we speak of the size of the atoms, we mean their distance in the solid and liquid state. The properties of the ether may remain unaltered within the greater part of the sphere of action of a molecule. The number of molecules lying within a wave-length of ordinary light is not greater than the number of notes which lie within a sound-wave, but, as far as I know, the velocity of sound is not materially affected by the presence of dust in the air. Hence there seems nothing impossible in the supposition that light-waves, smaller than those we know of, may traverse solids with the same velocity as a vacuum. We know that absorption bands greatly affect the refractive index in neighbouring regions; and as probably the whole question of refraction resolves itself into one of resonance effects, the rate of propagation of waves of very small lengths does not seem to me to be pre-judged by our present knowledge. If Röntgen's rays contain waves of very small length, the vibrations in the molecule which respond to them would seem to be of a different order of magnitude from those so far known. Possibly we have here the vibration of the electron within the molecule, instead of that of the molecule carrying with it that of the electron.

I should like, further, to express a certain sense of satisfaction that Röntgen's rays are not deflected in a magnetic field. They are thus clearly separated from kathode rays. The idea that kathode rays are due to vibrations has become fashionable; yet the fact that the magnet deflects them just as it would an electrified molecule, has always seemed to me to be conclusive against this view. No one has, so far, given any plausible reason why a ray of *invisible* light should be able to run round in a spiral, while a ray of *visible* light goes straight; and, so far, Röntgen's rays behave as we should expect well-conducted vibrations to do.

It is not my intention to argue in favour of any particular theory, or against Röntgen's suggestion that we have at last found the formerly missed longitudinal wave. I only desire to put those points forward which at first sight seem to go against the supposition of ordinary light vibrations, and to raise the question whether they constitute an insuperable difficulty.

ARTHUR SCHUSTER.

IN connection with the wonderful discovery by Prof. Röntgen of photographic rays, apparently hitherto unknown, and in connection with the speculation which concludes Prof. Röntgen's most interesting paper, that these rays may perhaps be longi-

tudinal vibrations of the luminiferous ether, the following extracts will probably be found of interest to the readers of NATURE. They are taken, by permission of Lord Kelvin, from his Baltimore Lectures, delivered at the Johns Hopkins University in 1884.

The first extract is from the reprint (now in progress) of Lecture IV. Referring to mathematical work immediately preceding, Lord Kelvin says:—" . . . We can do that [obtain certain forms of solutions of equations] for the purpose of illustrating different problems in sound, and in order to familiarise you with the wave that may exist along with the wave of distortion in any true elastic solid which is not incompressible. We ignore this condensational wave in the theory of light. We are sure that its energy, at all events, if it is not null, is very small in comparison with the energy of the luminiferous vibrations we are dealing with. But to say that it is absolutely null, would be an assumption that we have no right to make. When we look through the little universe that we know, and think of the transmission of electrical force, and of the transmission of magnetic force and of the transmission of light, we have no right to assume that there may not be something else that our philosophy does not dream of. We have no right to assume that there may not be condensational waves in the luminiferous ether. We only do know that any vibrations of this kind, which are excited by the reflection and refraction of light, are certainly of very small energy compared with the energy of the light from which they proceed. The fact of the case as regards reflection and refraction is this, that unless the luminiferous ether is absolutely incompressible, the reflection and refraction of light must generally give rise to waves of condensation. Waves of distortion may exist without waves of condensation, but waves of distortion cannot be reflected at the bounding surface between two mediums without exciting in each medium a wave of condensation. When we come to the subject of reflection and refraction, we shall see how to deal with these condensational waves, and find how easy it is to get quit of them by supposing the medium to be incompressible. But it is always to be kept in mind as to be examined into, are there or are there not very small amounts of condensational waves generated in reflection and refraction, and may, after all, the propagation of electric force be by these waves of condensation?

"Suppose that we have at any place in air, or in luminiferous ether (I cannot distinguish now between the two ideas) a body that, through some action we need not describe, but which is conceivable, is alternatively positively and negatively electrified; may it not be that this will give rise to condensational waves? Suppose, for example, that we have two spherical conductors united by a fine wire, and that an alternating electromotive force is produced in that fine wire, for instance by an 'alternate current' dynamo-electric machine; and suppose that sort of thing goes on away from all other disturbance—at a great distance up in the air, for example. The result of the action of the dynamo-electric machine will be that one conductor will be alternately positively and negatively electrified, and the other conductor negatively and positively electrified. It is perfectly certain, if we turn the machine slowly, that in the air in the neighbourhood of the conductors we shall have alternately positively and negatively directed electric force with reversals of, for example, two or three hundred per second of time with a gradual transition from negative through zero to positive, and so on; and the same thing all through space; and we can tell exactly what the potential and what the electric force is at each instant at any point. Now, does any one believe that, if that revolution were made fast enough, the electro-static law of force, pure and simple, would apply to the air at different distances from each globe? Every one believes that if that process be conducted fast enough, several million times, or millions of million times per second, we should have large deviations from the electro-static law in the distribution of electric force through the air in the neighbourhood. It seems absolutely certain that such an action as that going on would give rise to electrical waves. Now it does seem to me probable that those electrical waves are condensational waves in luminiferous ether; and probably it would be that the propagation of these waves would be enormously faster than the propagation of ordinary light waves.

"I am quite conscious, when speaking of this, of what has been done in the so-called electro-magnetic theory of light. I know the propagation of electric impulse along an insulated wire surrounded by gutta-percha, which I worked out