

4.

relatively to ether, and the ^{stress} ⁴⁵⁵ produced by the fluid trying to get through from vesicle to vesicle in the ether, but in an insulator not succeeding, would be the "electric displacement" and the electrostatic stress. All this is very crude, but perhaps not absolutely unmanageable for an ideal mechanical model. In transverse vibrations of light and magnetism the ether and the fluid in the vesicles would move together: and the stress of the ether dragging molecules denser than itself, in vesicles containing it, so as to give it very nearly always the same motion as its own would be an extreme case of electrostatic stress.

But there can be no comfort whatever in any attempt at a physical theory of electricity and magnetism unless it provides us with a medium capable of giving

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28, CHESTER SQUARE,

S.W.

23/82

April 29 1896

Dear Fitzgerald

Your letter of the 17th followed me to London, and I have been very busy ever since or I should have written sooner in reply. I am sure you will never find comfort in crystallisation or anything analogous to it to explain waves of light in ether; or in anything else than the fundamental doctrine of the undulatory theory of light - true transverse vibrations of moving matter subject to the law of inertia. Hence my "must" to which you object.

Maxwell's expression "electric displacement" is, I believe, absolutely true so far as it indicates a true displacement of matter, as in the undulator

Theory of light; but my difficulty is in respect to the electric quality concerned in this displacement.

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Electric force (X, Y, Z) cannot be a mere displacement, because mere displacement does not, in an elastic solid or in any conceivable "ether", give rise to energy equal to $R^2/8\pi$ per unit volume of field. I could not in Nov. 1846, nor have I ever since that time been able to, regard "displacement" as anything better than a mere "mechanical representation of electric force". But I have always, from that time till now, felt and I now still feel that somehow or other we shall find distortion or

rotation of a medium to be the reality of magnetic force.

We may ideally make a dynamical model with an incompressible inviscid fluid to represent electricity percolating among interspaces between ether and ponderable matter of a metallic conductor, and generating heat by the vibrations in ether which such percolation could not but produce, provided all the substances concerned are perfectly elastic, that is to say perfectly free from viscosity. It is not so easy to include in the model electrostatic force, and charged condensers. If it is to be done at all, it seems it is to be thus: A displacement of electricity, (an incompressible fluid) —

the liquid will take its proper motion instantaneously. Give now the liquid some rigidity; - the instantaneous motion all around will be the same as it was with no rigidity: but a distortional wave motion propagated at a finite velocity will follow. This is exactly the state of things represented by Maxwell's equations, and worked out in an example by Hertz.

Thanks for page 48, t^2 instead of x^2 . The papyrograph was sometimes not clear, and my eye imperfect in detecting errors in the print.

Your spherule of water, moving through ice which melts in front and freezes behind, is virtually the same ^(in result) as my despised shoemaker's wasc.

I stuck to my theory of a turbulent liquid as long as I thought

28, CHESTER SQUARE,

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the prodigiously great forces which we have in electromagnetism, and the smaller, but still very palpable forces of electrostatics, and also at the same time permitting the free mobility of bodies through it, in virtue of which we feel these forces. When I wrote to you my letter of April 9 I thought I saw how it was possible to find this last essential quality in my "ether" of M. P. Part. xcix, but a day later I fell back into utter despair, in which I still remain.

You speak of "vectors and symmetrical equations*" for investigating "the

* Symmetrical equations are good in their place but "vector" is a useless survival, or offshoot, from quaternions and has never been of the slightest use to any creature. Hertz wisely shunted it but unwisely adopted temporarily Heaviside's nihilism. He even tended to nihilism in dynamics, as I warned you soon after his death. He would have grown cont'd foot of page 6

"rate at which an alternating electric current
 "penetrates into a conductor" and "the equations
 "which lead to an exactly similar propagation
 "of electric currents into non-conductors." The
 former are in reality vitally different from the
 latter; and the latter are merely the equations
 of motion of an incompressible elastic solid.
 One of the chief things to be discontented with
 is the refractoriness of all attempts to bring
 the two classes of action into dynamical
 relation with one another, on any hitherto
 imagined constitution for ether, electricity,
 and matter. It is not the equations I object
 to. It is the being satisfied with them, and
 with the pseudo symmetry (pseudo I mean in
 respect to the physical subject) between electro-
 statics and magnetism. I also object to the
 damagingly misleading way in which the
 word "flux" is often used, as if it were a
 physical reality for electric and magnetic
 force, instead of merely an analogue in an
 utterly different physical subject for which
 out of all this, I believe, if he had lived. He certainly was the opposite
 pole of nature to a nihilist in his experimental work and in his
 Doctorate thesis on the impact of elastic bodies.

23/82

the same equations apply, see Electrostatics and
 Magnetism §§ 4, 5-86 (first published Feb. 1842).
 But enough of this carping about words! If
 we could but get the slightest inkling of how
 a fragment of paper jumps to rubbed sealing
 wax, or a fragment of iron to a lodestone,
 I could be supremely happy, and would be
 temporarily content not to ask more of ether,
 not even gravity.

In your letter of the 17th you hit
 off exactly the right thing in respect to
 two spheres in incompressible jelly. But
 you omit to remark that the push along
 the axis, giving a displacement inversely as
 the square or some higher power of the
 distance, represents the alleged infinitely
 rapid propagation of longitudinal dis-
 placement. What I have called the distant
 terms don't include longitudinal dis-
 placement in the axis. Think first of a
 rigid globe in an incompressible liquid.
 Start it instantaneously in motion in the
 direction of any diameter. Every particle of

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experimental result, usually quoted to prove that very high vacuum is an insulator, is merely that a spark will jump through several inches of the outer air between the outer metallic terminals or metals connected with them, without any visible effect of discharge in the interior. But this only proves that the current or the discharge, if any there is in the interior, is not luminous in the highest vacuum. It is no proof that there is no current. I fully expect, however, that the electrometer test will prove that in reality very high vacuum is a very perfect insulator. Then we shall conclude that molecules of gas, tearing and creeping through ether at the almost infinitely slow velocities of 500 metres per sec. or thereabouts, make it leaky for electricity. I think we may see a way through all this to explain the stiffening effect in respect to electric insulation of a gas of greater density than that which gives the greatest striking distance between two conductors, with a given difference of potentials between them.

Yours very truly,
Kelvin

* However
See J. J. Thomson 'Recent Researches in Electricity & Magnetism' § 79.
Extremely interesting & important.

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28, CHESTER SQUARE,
S.W.

I could get anything out of it, and no longer.

I now abandon everything I have ever thought of, or written, in respect to constitution of ether.

Going back to my letter of April 9, Bottomley has tried preliminarily with the gold leaf electroscope, and finds that, when the leaves and the surrounding metal cage are joined to the two terminals of an ordinary vacuum tube with very good, but not measured, vacuum, the leaves if electrified remain diverging: provided the outer glass of the vacuum tube is well cleaned and dried. I have no doubt this experiment has been tried before by many people, but I do not remember any reference to it, at present, in published books or papers. The