Electrodynamic Force Laws and Hot Fusion

A lot of money, promises, and hopes have been expended on hot fusion devices such as Tokamaks, but not a lot of fundamental thought. Rather, the easy way has been taken; namely, it has been *assumed* that the basic law of electrodynamic force is known from the ancients (Maxwell, Lorentz, Einstein), and all we have to do is employ this knowledge, taught to us in school, to frame sufficiently vast and all-encompassing computer programs. (This sort of thing has become habitual among modern scientists, practically a hallmark, a guild symbol, a proof of their professionalism. Consider climate science, an explicit example of *the science is known* syndrome. In other words, scientists have become the very ones to default on anything resembling science. They are not interested in looking for laws. They know the laws. Nature is their open book.)

Consider Maxwell s equations. Are they the last word on their subject? If they are perfect and unalterable for all time, as the physics fraternity by their actions and teachings would have us believe, then it must be very difficult to find any fault with them. Instead, it is very easy: They are *covariant* which is a fancy mathematical way of saying they are *not invariant*. Most people of normal psychology, uninstructed to the contrary, would view this as a fault since invariance of laws (under inertial transformations) has long been recognized as the appropriate mathematical mimicry of the external world s attribute of stability (independence of the describer).

The rebuttal is that covariance, like invariance, is a kind of *form preservation*. But consider: under covariance, the form preserved is not that of the untransformed quantity X_μ, but is a *redefinition* of that quantity ($X'_\mu = \sum_\nu \alpha_\mu^\nu X_\mu$). So, the form preserved is a form redefined! In short, the preservation is smoke and mirrors.

How, then, would one go about making the field equations of electromagnetism honestly invariant? Heinrich Hertz[1] (the last person to think soberly and independently about the topic) asked himself this question and found an elementary answer. The Galilean non-invariance of Maxwell s equations stems from a simple cause; namely, non-invariance of the partial time derivatives appearing in those field equations, $(\partial/\partial t)'=(\partial/\partial t')=(\partial/\partial t)+\vec{v}\cdot\vec{\nabla}\neq(\partial/\partial t)$, where $\vec{v}$ is the frame velocity parameter of the Galilean inertial transformation. Incidentally, palaeontology reveals that the partial time derivatives in Maxwell s equations, by their symmetry with the corresponding partial space derivatives, are the Ur-source of spacetime symmetry, a mass delusion that provides the only physical excuse for mathematical covariance. (Do I really need to argue that time is *not* symmetrical with space? Consider the way they are measured. But measurement, you say, doesn t matter to a physicist. Point taken, in regard to the post-Einstein theorist, who would never be seen dead going into a laboratory to measure anything.)

How did Hertz fix this? By replacing those non-invariant partial time derivatives with their total time derivative counterparts, $d/dt=\partial/\partial t+\vec{v}_d\cdot\vec{\nabla}$, which are invariant[2]. Here, $\vec{v}_d$ is a new velocity parameter representing the frame velocity of the *field detector*. This parameter does not enter Maxwell s version of the field equations, but instead appears as test particle velocity in an add-on known as the Lorentz force law. But now, by substituting *d/dt* for $\partial/\partial t$ directly in the field equations, we perceive already a substantial improvement in those equations; namely, they require no extra force law, but incorporate all that needs to be said about electrodynamic force in the field equations themselves.

This is clearly a remarkable theoretical accomplishment. Why was no attention paid to it? Because there was no room in the physicists pantheon for another deity: Maxwell and Einstein had got there first.

Besides, Hertz was already pigeonholed as the experimentalist who had assured Maxwell s glory; and experimentalists are lesser deities, also known as second-class citizens. You see how it works? Theoretical physics is judged not on merit but by easier criteria, semi-political, if you will. In other words, physics is a human activity. That secret is never revealed to students of the subject. But it is an expensive secret to keep. Expensive even in dollars, as the Tokamak example shows.

To make a long story short, Hertz s invariant field equations yield an invariant wave equation

$$\vec{\nabla}^2\vec{E} - \frac{1}{c^2}\frac{d^2\vec{E}}{dt^2} = 0 \,,$$

which has a wave propagation speed solution

$$u = \frac{\omega}{k} = \pm c + \left(\frac{\vec{k}}{k}\right)\cdot\vec{v}_d \,,$$

where $\vec{k}$ is the light propagation vector and $\vec{v}_d$ is field detector (absorber) velocity relative to the observer s inertial frame. It is easily shown[3] that the indicated influence of detector velocity on light speed is to adjust light speed so as to cancel the effect of absorber motion during the propagation interval; so, neither source motion nor detector motion alters the measured speed of light c which is the quotient of source-sink separation distance *at the instant of emission*, divided by propagation time.

But what is this separation distance at the instant of emission ? According to special relativity, such a spatially extended instant of time cannot uniquely exist, because of the relativity of simultaneity. Since we are giving up covariance in favor of invariance, it follows that we are giving up special relativity. This means we must take a new look at the concept of time. Fortunately, this has already been done for us by the scientists of the Global Positioning System (GPS). They recognized that coordinating a global satellite system would be facilitated by correcting the running rates of all clocks so as to eliminate the known physical effects of motion and gravity changes, with the result that all clocks run in step. GPS time is essentially Newtonian in character. Hence the concept of a now throughout physical space is restored, and instant of emission acquires a useful physical meaning. We have only to refer everything to GPS time and forget relativity.

Returning to electrodynamic force, I said that the governing law is now contained in the Hertzian field equations. To dig it out, it is helpful to introduce the electromagnetic potentials $\left(\phi, \vec{A}\right)$. In Maxwell s theory these are defined by $\vec{E} = -\vec{\nabla}\phi - \frac{1}{c}\frac{\partial}{\partial t}\vec{A}$. Invariance demands the obvious reformulation $\vec{E} = -\vec{\nabla}\phi - \frac{1}{c}\frac{d}{dt}\vec{A} = -\vec{\nabla}\phi - \frac{1}{c}\left[\frac{\partial}{\partial t} + \left(\vec{v}_d \cdot \vec{\nabla}\right)\right]\vec{A}$. Applying a vector identity, recognizing that $\vec{B} = \vec{\nabla} \times \underline{\vec{A}}$, and supposing the detector to be a point particle or a small, non-rotating rigid body, we find that[2]

$$\vec{E} = \vec{E}_{Maxwell} + \frac{\vec{v}_d}{c} \times \vec{B} - \frac{1}{c}\vec{\nabla}\left(\vec{v}_d \cdot \vec{A}\right)$$

Thus, $q\vec{E} = Force = \vec{F}_{Lorentz} - \frac{q}{c}\vec{\nabla}\left(\vec{v}_d \cdot \vec{A}\right)$. That is, our modified force on charge q is just the Lorentz force that everybody uses, plus the gradient of a scalar quantity. It is a property of such gradients that they integrate to zero around any closed curve. Maxwell claimed that currents flow only in closed circuits, so it is apparent that any physical effects of this extra force term will be hard to observe, and will not appear in experiments employing regular circuital current flows.

However, currents flow everywhere irregularly throughout *plasmas* without regard for circuit closures; so, in plasma experiments, such as those involving Tokamaks and related hot fusion devices, the indicated extra force term might exist, might act, and might throw off all calculations made with the unmodified Lorentz force law. The effect would be destabilizing, equivalent to that of the famous Ampere longitudinal forces[2] that were banished from physics through the advent of the relativity-dictated Lorentz (purely transverse) force law. Such destabilizing effects should appear, regardless of the super-duperness of the computer used in making the physical predictions. In fact, the more super the computer, the more assured the wrong answer for the simple reason that a nonphysical force law is being used. But then, the force law being used is the politically correct one; so it may well be worth throwing away a few billions of other people s dollars to preserve the prosperity of important scientific reputations. Never mind how the experiments turn out that s the experimentalists responsibility. The trick is to push both them and the money under the bus, while keeping a fixed smile of judicious optimism.

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[1]H. R. Hertz, *Electric Waves* (Dover , New York, 1962), Chap. 14 (translated by D. E. Jones).

[2]T. E. Phipps, *Old Physics for New* (Apeiron, Montreal, 2012).

[3]T. E. Phipps, Physics Essays 27, No. 4, 591 (2014).