FARADAY PRESSURE AND ENERGY CONSERVATION
-A Sequel to DUAL DILEMMA

Stewart Ian Wells
P.O. Box 223, Truckee, CA 96160, United States; cywels@gmail.com

Abstract
This sequel to 'Dual Dilemma from Faraday's Law' is an explication of the underlying principles of electrodynamics as they pertain to the classical conservation laws. Specifically, the analysis follows the seeming non-conservation of angular momentum resulting from counter-torque applied to a charged wheel by an induced electric field circulation, while simultaneously answering the need for energy conservation. In this context, a magnetic 'field pressure' is introduced to account for work demands on mechanical sources in electrodynamic systems. The problem of radiation from accelerated charges is also critically examined, and new formulations are derived to describe the phenomenon. The problem of the seeming non-compliance of the Lorentz force with the third law of motion is resolved, and the paper concludes with a brief refutation of the notion of 'field momentum'.

Foreword

In this sequel to a previous paper [1], the quest continues for an electrodynamics which scrupulously adheres to the laws of momentum and energy conservation in all situations. A reactive ether mechanism has been proposed to ensure compliance with the third law of motion. Now, a transverse 'field pressure' is restored to the physics of electromagnetism to ensure compliance with the law of conservation of energy in cases where defects in the work-energy balance would otherwise occur. The situations described herein involving interacting charged wheels are highly idealized, as was the case in the original Dual Dilemma paper itself. The induced forces being practically miniscule, the associated arguments are thus theoretical, and are not in themselves expected to be confirmable by direct laboratory tests. (Since only relative *magnitudes* of quantities are of concern, relations will be expressed in scalar notation; directions of quantities, where important, should be recognizable from context.)

Interaction Theory

At this point it becomes necessary to interpose a brief discussion of the theory of interaction itself. In the history of electromagnetism, there has never been a universally agreed upon, self-consistent, description of the precise mechanism by which interaction is accomplished. Although nearly all physicists since Faraday have accepted the 'field theory', it remains unclear in many circumstances just how the fields actually interact with charges, currents, or for that matter, other fields. Efforts in physics have been concentrated primarily on the influence of fields on charges and currents, but little on the effects of charges and currents on fields from other sources, and less on what any given field source 'knows' about the activities of other field sources. Thus the great value of the previously cited Whitney paper [2] resides in the very question in its title: "What do electromagnetic systems 'feel'?"

Most physicists are content to presume that the action of the field of one body on another is answered by the action (equal and opposite) of the field of the other body on the one. However, one school of thought, of long tradition, asserts that this is in fact only *half* of the interaction. The other body, in responding to the field of the one, actually relays an equal and opposite response *through the field of the*

one body, back to that *one*. Likewise the one body responds and acts through the field of the other against that other: Not only does a field from a given source exert a force upon a charge, but the charge also exerts a force upon the given field. Ordinarily, this latter force is communicated back to a discreet field source, where its flux lines terminate, thus completing this part of the action. But when the field is *induced*, such as the electric circulation about a changing magnetic flux quantity, the reaction to the force against a test charge must be absorbed in some other manner in order to affirm the third law of motion. This is, in fact, the principal issue underlying DUAL DILEMMA, wherein resolution was sought through implication of the *ether* in the interaction: a 'field traction' is postulated whereby the force on the field manifests in a longitudinal compression effect in the ether, which, in the absence of a field source charge, absorbs the required momentum. [Ordinarily, when an actual field source charge is present, its own tractive effort against the ether opposes that of the other charge against the ether, such that the respective momenta are absorbed entirely by the charges themselves; hence the conventional charge-to-charge interaction hypothesis.]
A direct consequence of the alternative 'traction' hypothesis is the necessity, for the law of energy conservation, that the magnetic field of one source also 'feels' the presence of the magnetic field of another source, in such a way that mutually affects the efficacy of the field production itself. The phenomenon is a manifestation of the Faraday 'field pressure', and is the real reason for the work required to bring like magnetic 'poles' toward one another.

Energy Conservation Resolution
A possible resolution to the problem of energy conservation in the electrodynamic system described in DUAL DILEMMA was only vaguely intimated in a "field reaction mechanism", summarized in the conclusion with the statement:

The mechanical power input to the surrounding charges by action of the electric circulation communicates a reactance, through the fields, against the field-generating source, which demands a compensatory energy withdrawal from that source.

As with the Induced Potential Dilemma, an apparent violation of the Work-Energy Theorem occurred in the described system of charged wheels, whereby the rotating secondary was seen inexplicably to gain energy through action of the induced electric circulation of the accelerating primary. In the discussion of the power equation (Dual Dilemma eq. 4), it had been suggested that the seeming breach of energy conservation from the free power input to the secondary was nonetheless answered by an increased load upon the primary, "felt" somehow through the fields; but no definitive mechanism for the phenomenon was provided.
The issue is too important to be left unresolved –and a resolution may best be obtained through an application of 'physical reasoning'. As the Work-Energy Theorem mandates that the work done on an isolated system is ascertained by the difference in total energy content between its initial and final states, *regardless of the pathway connecting them*, this may be perceived as a corollary to *Kirchoff's Law*, by which *any* isolated system (electrical, mechanical, thermodynamic, etc.) taken through a *closed path* of energy states, cannot, upon return to its initial state, have lost or gained energy in the process.

Figure 1 depicts two pathways between states A and B of a (positively) charged wheel system:
[If there is concern over the Coulomb forces, these may be eliminated by replacing the charged wheels with two pairs of concentric oppositely charged spheres, set in appropriate respective counter-rotation, such that the Coulomb fields vanish, but the primary and secondary magnetic fields still oppose.]

In the initial state A, the wheels are separated by a great vertical distance (along their common axis).

The primary is at rotational rest, while the secondary is already rotating at ω_2. The primary is then moved toward the secondary. The primary is then accelerated to ω_1, equal and opposite to the secondary, bringing the system to state B. Power has been applied to the secondary during this acceleration by action of the induced electric circulation resulting from the expanding magnetic field of the primary.

In the alternative pathway, beginning from state A, the primary is *first* accelerated to ω_1, then moved into close proximity with the rotating secondary, such that the final state B of the system is again reached. Along this latter pathway, *work* is done on the system in moving the magnetic field-producing primary against the opposing magnetic field of the secondary. This work appears in the power input to the secondary, again from the growth of primary magnetic flux through the core of the secondary.

Energy is thus conserved along the latter pathway, but seemingly not in the former, where the only work done was that incurred in the generation of the primary field, which does not account for the kinetic 'free energy' acquired by the secondary. This would be a violation of the work-energy theorem, and hence of the Kirchoff Law, should the system be taken through a complete circuit --out on one path and back on the other.

This apparent violation can be vanquished only if the accelerating primary in pathway A feels an *additional reactance* from the presence of the already rotating secondary. Since the Lorentz force from the magnetic field of the secondary acts only at right angles to the charge motion of the primary, the secondary field does not from this cause impede the primary acceleration in any manner. The provenance of this added load must be surmised from the situation through its own internal clues:
It is to be observed that the load must be proportional to the angular *velocity* ω_2 of the secondary, and to the *acceleration* $\vec{\alpha}_1$ of the primary, since these factors determine the power input to the secondary. These two conditions are suspiciously implicated in the associated magnetic field magnitude, and magnetic field change rate, respectively, of the secondary and primary. It is as though the *expanding* primary magnetic field 'presses' against the existing secondary magnetic field in the former pathway, just as the *approaching* primary magnetic 'pole' feels a resistance from the secondary in the latter pathway. This, indeed, is reminiscent of the transverse 'pressure' between field lines, originally postulated by Faraday himself [3] and believed to exist in addition to their longitudinal 'tension'. The 'lines' themselves may be a mere conceptual convenience, but the 'Faraday pressure' can certainly be regarded as real, and serves to transfer work done on the primary into the secondary, or *vice versa*.

Here then, at last, is found a resolution to the Induced Potential Dilemma:

Work done in transporting the test charge (assuming the role of the secondary) *against* the electric field circulation sustains its magnetic field *in alignment* with the *direction of change* of the primary magnetic field. This action facilitates the growth of the primary magnetic field, evidently by relieving the effort required to produce it. It is as though the secondary field acts to 'draw in' the primary field. The *external* work done on the secondary (test charge) under these circumstances does not raise its potential *per se*; rather it appears in the total magnetic field energy, which in turn becomes, *ipso facto*, a store of energy – and which subsequently, through its collapse, would be applied back to the secondary (or test charge). Conversely, when the secondary receives power input in the course of motion *along* the primary electric circulation, the secondary magnetic field *opposes* the direction of change of the primary magnetic field, and, acting to impede its expansion, demands a greater work input to the primary. The *internal* work done on the secondary under these circumstances is thus *indirectly* accomplished by the performance of other external work –in this case the extra work done on the primary. It is noteworthy that this compressive action does *not* appear in the conventional field energy densities $B^2/2\mu_o$; $\varepsilon_o E^2/2$, nor is it manifest in any discernible 'compression potential', but is instead simply a *measure* of the work done in the system.

Distinguishing Features of the Model

Although the system depicted in Figure [1] now conforms to the requirements of energy conservation, the ether traction model does display some rather peculiar features:

-A vertical force applied to the turning primary produces acceleration on charge elements of the secondary in the horizontal plane. I.e., Energy from $F_z \cdot dz$ *does not appear as kinetic energy in the vertical direction, but as rotational kinetic energy of the secondary.*

-If an appropriate magnitude of torque were applied to the secondary in order to maintain its constant angular velocity against the circulating field of the primary, it would entirely relieve the original primary *torque, which primary would nonetheless continue to accelerate due to the* secondary *torque!*

Furthermore, the inter-relationships of the various elements of the system (charged and neutral rotating wheels and inductors) described in DUAL DILEMMA Figure [1] exhibit several other highly counter-intuitive features in the chain of events resulting from the application of torque to the primary:

-A rapidly rotating, highly charged secondary will receive a far greater magnitude of torque from the induced primary field than that received *by the primary wheel itself, due to the field pressure, which necessitates a proportionately greater* applied *primary torque.*

-This additional resistance does not contribute to the actual inertia of the primary, but only to its 'virtual inertia', caused by the field pressure, which is certainly felt and transmitted through the accelerating agency against the neutral.

-The external torque required to maintain a given acceleration rate of the primary in the presence of the secondary, though impressed *upon the primary, is therefore* expressed*, in reaction to the secondary, upon the ether itself, which acquires the otherwise 'missing' angular momentum.*

-The extra work done on the primary by the additional torque does not contribute to its kinetic energy (KE), nor to its field energy (FE), but instead contributes to the KE and FE of the secondary, (or to whatever drive train with which it might be engaged).

-The absorption of angular momentum by the ether (effectively infinite mass and moment of inertia) does not answer the gain in angular momentum by the secondary wheel, but instead answers the gain of angular momentum in the neutral –which itself was not *answered by a requisite gain in the primary.*

In this theoretical development, it is prudent to recall that the 'ether traction', which is postulated for induced fields, also occurs in the static fields associated with motionless charges and magnets. However, as these latter fields have their seat in ponderable field sources, the mutual tractive reactions of the ether against these sources will exactly cancel, and no net momentum will be imparted to the ether in such cases; e.g., if two separate static charges are allowed to drive one another in equal and opposite directions, the traction of the field of one charge against the ether (in reacting to the force it exerts on the other charge) is exactly counter-balanced by the traction of the field of the other charge against the ether (in reacting to the force it exerts on the one charge). Thus, only in cases where a charge reacts to an electrodynamically induced field (which is not itself seated in a ponderable field source) does any net ether traction occur, whereby the third law of motion is upheld through ether momentum acquisition.

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Summary of Effects

In summary, then, whenever the primary and secondary magnetic fields *oppose*, the secondary acts to *resist* acceleration of the primary; whenever the primary and secondary magnetic fields *align*, the secondary acts to *assist* the acceleration of the primary. Though rather counter-intuitive, the action is nevertheless necessary for the conformance of electromagnetic systems with the laws of momentum and energy conservation: the extra 'compressive effort' is not explicitly stored in the field structure around the apparatus, but rather in its dynamical energy, which transfers indirectly through the field structure.

As the initial angular velocity of the secondary approaches an ever greater proportion to that of the primary, more energy is delivered to the secondary from work applied to the primary, and more momentum is distributed to the ether and to the neutral from effort exerted on the primary –these relations are direct consequences of the field pressure and ether traction phenomena.

Where $(KE)_2$ is the dynamical energy, and $(FE)_2$ is the conventional field energy, of the secondary:

Work on the primary $\tau_1 d\theta_1 \rightarrow \Delta(KE)_2 + \Delta(FE)_2 = \Delta U_2$ --the total energy gain of the secondary.

Effort on the primary $\tau_1 \Delta t = -\Delta(I\omega)_o \rightarrow \Delta(I\omega)_e$ --the respective angular momentum acquisitions by the neutral and the ether.

With the angular acceleration defined as $\alpha = \dfrac{d\omega}{dt}$, work done on primary is proportional to ω_2:

$$\tau_1 d\theta_1 = I_1\alpha_1 d\theta_1 + I_2\alpha_2 d\theta_2 + d(FE) = I_1\alpha_1\omega_1 dt + I_2\alpha_2\omega_2 dt + d(FE) = \tau_1\omega_1 dt = dU_{total} \quad , \qquad (1)$$

where the kinetic energy acquired by the neutral and the ether, owing to their immense relative inertia, is only nominal. Thus work done on the *primary* is actually pared into the *secondary* energy.

The notable feature of this process is the insufficient appearance of energy in the primary itself, though the full magnitude of the torque is applied exclusively to it. Instead, the majority of the energy will appear in the secondary, through the *induced* torque it experiences. Likewise, the angular momentum from $\tau_1 dt$ will appear, not in the primary, but in the *ether* (to balance the opposite gain in the *neutral*). Torque, then, between primary and neutral is greater for high ω_2 in the secondary; and τ_1, though *impressed* on I_1, is not *expressed* in L_1 --instead, ether must absorb a proportionately greater torque τ_e to balance the counter-torque τ_o against the neutral, such that $\Delta L_o = -\Delta L_e$, and that $\Delta L_2 = -\Delta L_1$.

Resistance against the primary from greater dU_2 in the secondary follows from energy conservation; i.e., energy delivered to secondary through the circulating E'_1, acting upon Q_2 at greater ω_2, mandates a greater work input to the primary during its acceleration. This can only signify that to maintain a given

α_1, *a greater torque* must be applied through $\Delta\theta_1$ over Δt --meaning that a greater counter-torque τ_o is applied against the neutral, giving it a greater measure of angular momentum than it would acquire if the secondary were initially at rest. For a given α_1 in the apparatus as described, regardless of the value of ω_2, the quantity $\frac{d}{dt}L_2$ $[=\tau_2]$ is essentially invariant --though, somewhat paradoxically, $\frac{d}{dt}L_o$ is not. In other words, the application of greater τ_1 at high ω_2 largely *bypasses* the primary, and does not result in a proportionately greater ΔL_1 nor ΔU_1. Instead, the greater τ_1 results in greater ΔL_e and ΔL_o, and greater ΔU_2 --though not in a commensurately greater ΔL_2. Thus ΔL_e balances ΔL_o as if τ_1 were actually applied (against the neutral) principally to the ether:

$$\tau_1 \Delta t = \Delta L_1 + \Delta L_e = -(\Delta L_2 + \Delta L_o)\,. \qquad (2)$$

A Final Conundrum And Its Resolution

The foregoing development of theoretical material, while advancing well-considered hypotheses to accommodate the laws of motion and energy conservation within the structure of electrodynamics, is nevertheless deficient in one particular aspect. The Ether Traction Hypothesis successfully accounts for the energy delivered to an initially *stationary* secondary, when the primary is also initially motionless. However, the added resistance imposed by energy considerations upon the primary acceleration, *in the presence of an initially moving secondary*, produces this theoretical conundrum: The resistance, whether conceived through the 'Faraday Pressure' or any other field mechanism, not only results in a more rapid rate of energy delivery to the secondary (as per the 'power equation' DUAL DILEMMA (4)), but of necessity entails a greater momentum delivery to the neutral from the primary over a given time interval. In other words, the resolution of momentum-energy problems will rest upon the dependency of the magnitude of the primary acceleration rate *on the value of* ω_2 in producing energy --whenever a primary torque is applied. Thus the response of the primary to the applied torque is determined by the power delivered to the secondary –which is a function of the secondary angular velocity. In this relation, the law of energy conservation demands that the greater the angular velocity of the secondary, the greater the power input to it from the induced primary field, and therefore the lesser share of input energy $\tau_1 d\theta_1$ will be received by the primary. The conundrum that arises is then that for any finite ω_2, when initial ω_1 is zero, $\tau_1\omega_1 = 0$, and any non-zero primary angular acceleration rate α_1 will produce a finite E'_1 and a finite power input $P_2 = r_2 E'_1 Q_2 \omega_2$ to the secondary, *without any power input to the primary.* That is, with $\omega_1 = 0$, it follows that $\tau_1\omega_1 = 0$ despite $P_2 \neq 0$; there is no accounting for the power input to the secondary. (Unless an *infinite* primary torque were to be admitted!)

To resolve the conundrum, it must first be observed that the extra gain in neutral momentum is in the same rotational direction as that of the secondary, and thereby *ether* is bound to acquire the 'missing' momentum, equal to and opposite to, that gained by the neutral and secondary. This is the momentum that fails to manifest in the primary, (the primary which does not receive the full expression of τ_1).

In the specific example where the primary and secondary bear like charges, and the secondary is maintained at a constant angular velocity ω_2 with the primary and neutral initially at rest, the ether must absorb angular momentum L_e at the rate:

$$\frac{dL_e}{dt} = -\frac{dL_o}{dt} - \frac{dL_1}{dt} - \frac{dL_2}{dt} \ ; \qquad (3a)$$

or, $$\frac{dL_e}{dt} = -I_o \frac{d\omega_o}{dt} - I_1 \frac{d\omega_1}{dt} - I_2 \frac{d\omega_2}{dt} \qquad (3b)$$

[At this point, it should be observed that the primary itself, owing to its own reactive field, sustains an apparently enhanced (or 'virtual') moment of inertia $"I_1" = |I_1| + \left|Q_1 E_1 r_1 \frac{dt}{d\omega_1}\right|$, which, though encountered by the applied torque, does not directly contribute to its own angular momentum.]

Since the energy relation $dU_{total} = \tau_1 d\theta_1$ principally delivers energy to the rotating secondary, for a given $I_1\alpha_1$, it is observed that τ_1 must primarily be proportional to the ratio of ω_2 to ω_1:

$$\tau_1 = |I_1\alpha_1| + |Q_1 E'_1 r_1| + \left|r_2 E'_1 Q_2 \frac{\omega_2}{\omega_1}\right| \ . \qquad (4)$$

This is because τ_1 must enlarge to accommodate the *power* delivered to the secondary at high ω_2.

Then from

$$dU_{total} = \tau_1 d\theta_1 = I_o\alpha_o\omega_o dt + I_1\alpha_1\omega_1 dt + I_2\alpha_2\omega_2 dt + I_e\alpha_e\omega_e dt + d(FE), \qquad (5)$$

where I_o and I_e are of such great magnitude as to render their energy acquisition insignificant.

We are then obliged to affirm:

$$\tau_1 d\theta_1 \to I_1\alpha_1 d\theta + I_2\alpha_2 d\theta_2 + d(FE). \qquad (6)$$

Now observing that $\left|r_2 E'_1 Q_2 \frac{\omega_2}{\omega_1}\right| = \left|I_2\alpha_2 \frac{\omega_2}{\omega_1}\right|$, from (4) it develops that

$$\tau_1 = |I_1\alpha_1| + |Q_1 E'_1 r_1| + \left|I_2\alpha_2 \frac{\omega_2}{\omega_1}\right|, \qquad (7)$$

which compels the observation that as $\omega_1 \to 0$, $\tau_1 \to \infty$ --just in order to ensure that the work input $\tau_1 d\theta_1$ accounts for the energy acquisition $\tau_2\omega_2 dt$. For any finite α_1, this requirement is not merely counter-intuitive; it is conceptually impossible. With $\omega_1 = 0$, the rate of work $\frac{dW}{dt}$ done *on* the system must also be zero; hence its rate of energy acquisition $\frac{dU_{total}}{dt}$ is likewise zero. Yet since (app.7) yields:

$$\alpha_1 = \left|\frac{\tau_1}{I_1}\right| - \left|\frac{Q_1 E'_1 r_1}{I_1}\right| - \left|\frac{I_2 \alpha_2}{I_1}\frac{\omega_2}{\omega_1}\right| \quad (8)$$

definite angular momentum is imparted to the respective components of the system for any finite applied torque τ_1 $(= -\tau_o)$. But where finite acceleration might have required infinite τ_1, finite τ_1 yields $\alpha \to 0$, whereupon $\frac{dB_1}{dt} \to 0$ and $E'_1 \to 0$; as a consequence, an apparently 'infinite' moment of inertia would be encountered in the primary. Needless to say, no such moment of inertia can actually appear in the primary –if it could, no motion could ever be imparted to the system.

<u>Resolution Through General Flux Equation</u>

However troubling, these seemingly persistent conflicts within the basic conservation laws can be resolved through closer attention to the relations of electromagnetic induction as they appear in context: A faulty description of the actual physics had been surreptitiously advanced, whereby the magnitude of E'_1 was naively correlated with the magnitude of α_1 alone. Closer inspection reveals that the induced electric field cannot just suddenly spring into existence without incurring an essentially *infinite* induced magnetic field B'_1 in the process. That is, a sudden appearance of finite electric field magnitude implies $\frac{dE'_1}{dt} \to \infty$, with the concomitant $\nabla \times B'_1 \to \infty$. These occurrences are physically impossible, and the total induction equation must be written to produce finite values for these latter factors.

Let $\Phi_M = \Phi_{M1} + \Phi_{M2}$, and let this identify the *total magnetic flux quantity* which appears within the respective rotating charge densities (ρ_1, ρ_2) and induced electric field (E'_1).
Here $\Phi_{M2} \propto 2(\pi r_2^{\,2})\mu_o r_2^{\,2}\rho_2\omega_2$ --the constant background flux contributed by the (effectively constant) rotation of the secondary. Then the proportionality

$$\Phi_M \propto \oint r_1\omega_1 dQ_1 + \frac{d}{dt}[\oint E'_1 ds] + \Phi_{M2} \quad (9)$$

qualifies this relation, given the geometry of the situation, where *ds* is the length element of the circulating field path $2\pi r_1$. Hence, as $\tau_2 \to 0$ and $\alpha_2 \to 0$ (from the virtually vanishing $\frac{d}{dt}[\oint E'_1 ds]$ as $\alpha_1 \to 0$), no traction could occur in the ether, in the absence of secondary torque, to balance the obvious $\frac{dL_o}{dt} = \tau_o$. It is as if the primary exhibits a seemingly infinite moment of inertia but fails to acquire any angular momentum –a violation of the third law of motion. And if finite τ_1 *were* to yield finite α_1, then $\frac{dB_1}{dt} \neq 0$, and $E'_1 \neq 0$, when $\omega_1 = 0$ and $\omega_2 \neq 0$, with the result that the action would freely deliver energy to the secondary through $Q_2 E'_1 r_2 \omega_2$, without any work input to the primary/neutral part of the system –a violation of the law of energy conservation.

Therefore in the thesis thus far elaborated, the laws of electrodynamics might not seem to conform with the laws of mechanics after all.

In seeking a way out of this quandary, we first affirm that the value for E'_1, everywhere uniform along a given circular pathway (perimeter length s), must itself be proportional to the whole of $-\frac{d\Phi_M}{dt}$; and then noting that $\frac{dE'_1}{dt} \propto -\frac{d^2\Phi_M}{dt^2}$, we may also write:

$$\frac{d\Phi_M}{dt} \propto [\rho_1 r_1 \frac{d\omega_1}{dt} + \frac{d^2 E'_1}{dt^2}] \qquad . \tag{10}$$

Assembling all this information yields the general form of the magnetic flux equation:

$$\Phi_M = \Phi_{M1} + \Phi_{M2} = \int k\alpha_1 dt - l\left(\frac{\partial^2\Phi_M}{\partial t^2}\right) + n\Phi_m \tag{11}$$

where k and l are dimensional constants needed to maintain the respective terms in units of *webers*, and n is any numerical coefficient which multiplies a unit flux quantity Φ_m . [The partial differentials merely allow the general case for terms resulting from motion of the system through a space-varying magnetic field (not under consideration here).]

From these relations is directly obtained the equation for the induced circulating electric field intensity:

$$E'_1 = -\frac{k}{s(t_0)}\left(\frac{\partial\Phi_M}{\partial t}\right) \tag{12}$$

where s is the perimeter path length of the *circulating field*, which itself is in units of *volts/meter*.

In seeking solutions for (10), (11) we might first wish to consider the case of *constant* acceleration:

A trivial solution to equation (10) may be found in setting $\Phi_{M1} = \alpha_1 t$ --trivial because it does not also meet the stipulation that E'_1, which is proportional to $(-\frac{\partial\Phi_M}{\partial t})$, cannot just suddenly spring into existence to a finite magnitude (signifying again that at the instant when sudden finite acceleration is experienced by the primary, *an infinite magnetic flux quantity would also be produced in the process*).

In other words, another term, whose second derivative is the *negative* of itself, must be present in order to forestall this catastrophe. Terms of this sort may be constructed from combinations of $\pm ke^{\pm it}$.

Thus where $\int k\alpha_1 dt = k\alpha_1 t$, a *real* function for Φ_M is obtainable only when the above exponential terms are wrought into sinusoidal functions ($= K[e^{it} + e^{-it}]$ etc.). A generalized 'bare bones' form for the resulting equation, where a, b, c, d are constants, can be written as:

$$\Phi_M = at + b\sin t + c\cos t + d \quad (= at - \frac{\partial^2 \Phi_M}{\partial t^2} + d) \tag{13}$$

In order to transform this into a functional dimensioned equation, we may proceed as follows:

Discernment of the values for the coefficients b and c is accomplished by inspecting the actual physics of the situation. Since E'_1 is zero when $-\frac{\partial \Phi_M}{\partial t}$ is zero, it must also begin at zero at the instant of the primary acceleration (so as not to succumb to an infinite rate of change). Thus when $t = 0$,

$$E'_1 = -\frac{\partial \Phi_M}{\partial t} = a + b\cos t - c\sin t \;= 0 \;. \tag{14}$$

Since $c\sin t = 0$ at the initial instant of acceleration $(t = 0)$, we see that b must be equal to $-a$ for the expression to sum to zero at this time. Finally, setting (13) equal to the constant background (d) for $t = 0$, we see that at this instant the terms $at + b\sin t + c\cos t$ must also sum to zero; thus $c = 0$.

Therefore, the fully dimensioned equations relating total magnetic flux Φ_M and induced electric field intensity E'_1 to time t, for constant angular acceleration $\alpha_1 = n\alpha_o$, (numerical constant times unit) become:

$$\Phi_M = k\alpha_1 t - l\sin\frac{t}{t_o} + \Phi_{M2} \qquad [= k\alpha_1 t + \Phi_{M2} - (t_o)^2 \frac{\partial^2 \Phi_M}{\partial t^2}] \tag{15}$$

$$E'_1 = -k\alpha_1 + l\cos\frac{t}{t_o} \qquad [= -\frac{1}{2\pi r_1}\frac{\partial \Phi_M}{\partial t}] \;. \tag{16}$$

Again, k and l are the dimensioned constants necessary to conform the units of the terms with the particular geometry of the situation; and t_o is merely a unit time interval (e.g. 1 second) inserted to keep the argument of the sine and cosine dimensionless, and the second derivative of the flux in webers. The numerical values of the constants are determined to render $\Phi_M = \Phi_{M2}$ when $t = 0$, and $E'_1 = 0$, when $t = 0$. Thus Φ_M is calculated in units of volt-seconds, and E'_1 in units of volts/meter.

The generation of a periodic term in the complete functions for Φ_M, E'_1 from a non-periodic, purely constant acceleration might at first seem rather perplexing. *However, it will be observed that this state of affairs is not maintained under these circumstances by a constant applied torque*. Rather, τ_1 must adapt to meet the requirement imposed by a *constant acceleration* $\alpha_1 = n\alpha_o$ (numerical constant times unit):

$$\tau_1 = I'_1\,\alpha_1 = [m_1 r_1^{\,2} n\alpha_o - Q_1 E'_1\, r_1] - [Q_2 E'_1\, r_2], \tag{17}$$

where I'_1 signifies the '*virtual* moment of inertia' of the primary –the *total* resistance actually *felt* by the accelerating agency. This 'moment' is comprised of two essential components:

1) the torque on the primary divided by α_1 --which consists of the ponderable inertia of the primary wheel, plus the reaction of its charge against its own induced electric field [pair of right-side terms in first bracket],
2) the reaction of the charged secondary to the induced field, which secondary exerts a mechanical resistance against the primary through magnetic field pressure [right-side term in second bracket].

These components constitute the several direct and indirect reactive phenomena encountered in accelerating the primary, including the significant second bracketed term (electrodynamically induced torque against the secondary), which is the negative of the torque applied to the ether through field traction. The coefficients k and l are dimensioned constants which maintain the terms in units of τ. Here, the applied torque itself is seen to contain the periodic cosine function, necessary to maintain constant α_1, just as the periodic terms appear in the functions for Φ_M and E'_1 over time t.

This conclusion is somewhat tentative, and so highly counter-intuitive as to seem outright wrong; but the mathematics nevertheless indicates it to be so –the solution is one that 'fits' the equation.
The phenomenon is evidently due to the oddly fluctuating fields encountered by the charge --and the result in fact lends some credence to the claim that *uniformly* accelerated charges can emit radiation.

<u>Non-Periodic Functions</u>

But to suppose that *only* periodic functions are admissible as physically viable solutions is theoretically intolerable –since through more 'physical reasoning' it becomes evident that a charge, if it has anyhow arrived at a constant acceleration, can maintain this state against a *constant* reactive E'_1 field, while producing a *steadily* increasing magnetic flux $\Phi_{M1} = ka_1 t$. Hence it is to be reasoned that this state of affairs may be *approached* through an appropriate *variable* acceleration rate, which in turn will require yet more complicated respective force or torque functions.

In the charged wheels arrangement heretofore elaborated, we recall the requirements that $E'_1 \propto -\dfrac{d\Phi_M}{dt}$, and that $\Phi_M = \Phi_{M1} + \Phi_{M2} = \int k\alpha_1 dt - l\left(\dfrac{\partial^2 \Phi_M}{\partial t^2}\right) + n\Phi_{M0}$, and seek a function for α_1 which also satisfies the stipulation that both E'_1 and Φ_{M1} must be zero when $t = 0$, but for which $\Phi_{M1} \to k\alpha_1 t$ at greater values of t.

A careful inspection of the situation will reveal that solutions for Φ_M and α_1 may be sought in functions developed from ($\pm\ e^{\pm t}$), with the proviso that $\alpha_1 dt$ integrates to *twice* the numerical value for that obtained from $\dfrac{\partial^2 \Phi_M}{\partial t^2}$. One conspicuous solution for α_1 may be found in:

$$\alpha_1 = \alpha_o [\sinh \frac{t}{t_o}]; \qquad (18)$$

this is a function that agreeably involves the corresponding equation pair for Φ_M and E'_1:

$$\Phi_M = \Phi_{M1} + \Phi_{M2} = \frac{1}{2} k \alpha_o t_o [\cosh \frac{t}{t_o} - 1] + \Phi_{M2} \quad (19a)$$

$$E'_1 = -\frac{d\Phi_M}{dt} = -\frac{1}{2} \frac{k\alpha_o}{s} [\sinh \frac{t}{t_o}] \ . \quad (19b)$$

Here α_o is a unit acceleration quantity, t_o is a unit time interval, s is the field perimeter length, and k is a proportionality constant, with dimensions $\frac{\Phi_M}{\omega}$, suited to the particular geometry of the situation.

The torque function necessary to support these latter relations is supplied by:

$$\tau_1 = I'_1 \alpha_1 = [m_1 r_1^2 \alpha_o (\sinh \frac{t}{t_o}) - Q_1 E'_1 r_1] - [Q_2 E'_1 r_2], \quad (20)$$

which again is composed from the various direct and indirect reactive phenomena.

Equation (20) can easily be extrapolated to the case of rectilinear acceleration of a charge, and thus it certifies the earlier surmise: that a state of constant acceleration of a charge against its constant reactive field may be maintained through an appropriate dynamical approach.

. . . .

<u>Final Resolution of the Lorentz Force Dilemma</u> *--a notable affirmation of the Ether Traction model.*

The Ether Traction Hypothesis, if projected into the magnetic force domain, displays one exemplary theoretical asset. The long-standing dispute over the magnetic force law ('Ampere/Weber' central force formulation vs. 'Biot-Savart/Lorentz' tangential force formulation) may be resolved through appeal to ether traction. It is well-known that the Lorentz Force Law does not provide an adequate mechanism for angular momentum conservation when applied to variously moving charged particles. The 'sidewise' force component $Q\vec{v} \times \vec{B}$ does not in general constitute a *central* force; therefore parallel-traveling charged bodies will experience a net magnetic torque, *if their line of separation is not strictly perpendicular to the direction of motion*. The phenomenon also poses great difficulty for special relativity, in that the torque experienced in the one frame would vanish in the rest frame of the bodies.

But suppose the general form of field transformation $\vec{E}' = \gamma(\vec{v} \times \vec{B})$ holds [where γ could be any constant or any velocity-dependent factor]. Then by crossing a magnetic field, a charge would encounter an *equivalent* electric field, which in turn would be expected to engage in 'ether traction' just as would any other electric field in responding to the force it exerts on a charge. The necessary counter-torque, *now absorbed by the ether*, will account for the 'missing' angular momentum in such situations --again conforming the relations of electrodynamics with the laws of mechanics.

Field Momentum?

The long-held view in mainstream physics that the third law of motion in electrodynamics could only be upheld through the hypothetical mechanism of 'field momentum' may now be summarily dismissed:
In consideration of a single charged wheel set in clockwise rotation, the magnetic field is claimed to carry the angular momentum associated with the extra torque applied to overcome the electrodynamic reactance imposed by Faraday's Law; an oppositely charged wheel set in counter-clockwise rotation must produce a magnetic 'field momentum' in the opposite sense. *Yet the latter field is identical to the former field in both magnitude and direction!* This absurdity alone should have long ago promoted dismissal of the field momentum construct. Even more to the point, in the case of the charged wheel system described in DUAL DILEMMA, the secondary, when endowed with overwhelmingly great moment of inertia, will nonetheless acquire angular momentum through action of the induced electric field of the accelerating primary. No substantial contribution to, or subtraction from, the overall magnetic field is incurred from such secondary; hence its mechanical angular momentum acquisition is unanswered by any possible construction of the hypothetical concept of 'field momentum'.
It is the *ether*, which after all, must carry the opposing momentum.

Afterword

The phenomena herein described demonstrate the need for a fixed ether in physical theory. Special relativity is decidedly incompatible with any such absolute reference frame. Unless the reformed concept of a peculiar 'Lorentz invariant' ether, later postulated by Einstein [4] in contradiction to the original theory [5], can be verified, the Special Theory of Relativity might best be discarded altogether.

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