THEORY OF FORCES

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1. HISTORICAL THEORIES OF FORCE TRANSMISSION

The study of *physical* objects and related natural phenomena, known as *physics*, establishes the foundation for all the sciences. The scope of physics and the nature of the physical universe can be encompassed under four broad areas of knowledge: the nature of material objects and their structure, the forces on material objects, the nature of light and immaterial energy, and the interaction of material objects with the forms of pure energy: electric fields, magnetic fields, and radiant energy. The fourth area is the subject of this paper, and we describe it as the interaction of light and matter.

Many theories that predict forces on objects have been set forth since Aristotle presented his belief that force is transmitted by direct mechanical contact. Much later, Isaac Newton presented his theory of gravitation and laws of mechanics based on the assumptions of inertial mass and gravitational force. In this way, Newton could predict the motion of objects not in direct contact, thus accounting for "action at a distance" where no cause was specified, though Leibnitz and others considered the absence of *cause* to be a defect.

Competing theories of force transmission are based on direct mechanical contact (Aristotle), non-causal inherent properties (Newton), Theories of Relativity (Einstein), ether theories (Classical Physics), inertia and non-local effects (Mach and Bell), atomistic theories of particle-carrying forces (gauge theory, the Standard Model of Elementary Particles, and Quantum Theory), and electromagnetic field theories of forces between charge elements (Weber, Wesley, Gaussian/Spencer, and some interpretations of Maxwell's Field Theory). None of these force theories has been without problems.

<u>Contact Action</u>. More than two millennia ago, Aristotle (384-322 BC) presented his view that forces are transmitted by mechanical contact [1]. He stated that "every object is pushed, pulled, carried, or twirled by whatever is in contact with it." And he argued that "matter cannot act where it is not." He asserted the following axioms to support his belief in force by direct mechanical contact: (1) There are no voids in the universe. (2) Every motion has a moving cause. (3) The mover must be in contact with the thing moved. (4) For every motion there is an unmoved first mover. Aristotle's theory was consistent with the *law of cause and effect,* and even accounted for the flight of birds through the atmosphere. But "contact action" cannot account for the force of magnetism or gravity acting over a distance in the void of space.

<u>Action at a Distance</u>. Galileo (1564-1642), more than any other "set the Scientific Revolution in motion and pulled modern science out of ancient natural philosophy." "Galileo established mathematical laws describing the motion of falling bodies," performed experiments to learn about nature, and provided "the foundation of classical mechanics [2]." Other scientists began to follow his methods of observation and explanations based on causality.

Isaac Newton (1642-1727) was born in the year Galileo died. His law of gravity described the force of gravitation between two objects; *e.g,* the attraction between the sun and the earth. This was "action at a distance" or "far action." This concept of forces between two objects was a much different concept than Aristotle's "contact action." Newton did not know what caused gravity, and he was careful to state only that there was a force between the two objects separated by a large distance.

Gilbert (1544-1603), Coulomb (1736-1806), and Ampère (1775-1836) discovered additional forces between magnetic poles, charged particles, and current elements. Without providing an explanation, the new force laws for these electrical effects specified the precise magnitude of forces acting over a distance *between two objects*.

Michael Faraday (1792-1867) and Clerk Maxwell (1831-1879) investigated and explained the dynamic forces of electricity and magnetism. They introduced new concepts of *energy fields* to explain how "action at a distance" allows one body to attract another distant body. These electric and magnetic fields contain energy that permeate all space. Maxwell added another idea to explain what carries the fields—the concept of an ether that fills space and gives it properties.

Field Theory for Moving Charge Elements. Electromagnetic Field Theory depends upon the force laws specified by Coulomb, Ampère, and Faraday. As implemented by Potential Theory, all of these laws imply conservation of energy. *Electrodynamics* in Field Theory is based on Faraday's Law where *time* enters to specify rates of natural processes; this *law of magnetic induction* prohibits the exchange of energy by electromotive forces from magnetic flux capture where an object is point-like without spatial extent to capture flux. Point-like particles are incompatible with electromagnetic Field Theory which denies the existence of infinite energy density, magnetic moment, and angular momentum in objects of zero extent. Electromagnetic Field Theory requires physical models with size, structure, distribution and motion of charge to relate forces on and between objects by use of the fundamental force laws. In this respect, Field Theory provides a causal explanation for the role of inertial mass that Newton's laws of mechanics could only assume and define.

The current version of electrodynamics is based on a point-particle idealization that is embedded in Maxwell's equations [3]. This approximation to a point-like particle omits some inductive effects that are important at high velocities of moving charge. The point-particle approximation has necessitated the invention of *relativity theory* in order to describe high speed electrical phenomena and the invention of *quantum mechanics* to describe the stable states of the atom.

One of Maxwell's equations starts with Faraday's *law of magnetic induction* which states that the electromotive force around a circuit is proportional to the time rate of change of magnetic flux linking the circuit. In Faraday's original law, induction effects come from the relative velocity between the electric and magnetic fields.

Jackson [4] (and others, see *e.g.,* ref. [5]) use Stoke's Theorem to put Faraday's Law in *differential* form. Jackson does not perform the Galilean transformation to get the electric (**E**) and magnetic (**B**) fields in the same frame of reference. As a result, he obtains a result that is invalid for high velocity. A second theory, Einstein's Special Relativity Theory (SRT), is needed in order to obtain agreement with experiments on high-velocity bodies. Not only is *field transformation* lost in converting from the integral form to the differential form, but an additional *point-particle approximation* is made to obtain the final form of the differential equation [3].

In order to integrate the equation and obtain a simple equation for inductive effects, the integral is assumed to vanish. But the integral vanishes over an arbitrary surface *only for point-particle (and some spherical) sources.* For finite-size elementary particles, the surface must account for the induced fields and feedback effects. Induction fields exist in the space surrounding the particle, but the approximation omits the effects from induction that become most important at high velocities. Thus, the final equation excludes finite-size effects and portions of induced fields. Maxwell's equation for magnetic inductance is *not* equivalent to the fundamental laws of electrodynamics and fails for high speed phenomena where internal charge rearrangement and induced field effects are the largest.

The electromagnetic Field Theory of Maxwell assumed Newton's view that the flow of *time* is constant. Of the three fundamental laws that govern forces (laws of Coulomb, Ampère, and Faraday), time t is found only in Faraday's Law where (1) motional effects cause the magnetic flux and (2) process rates are under consideration. For this reason, *time* should be defined in terms of Faraday's Law.

Scientific studies show how *time* operates in natural processes at work in the universe. In all dynamic processes (where something is not stationary), scientists must use some definition of *time* to specify rates of process; *i.e.,* how fast something occurs and how long it takes for something to change. While all scientists agree that *time* must somehow be defined in order to describe natural processes or the interval between events, scientists disagree on the nature of *time*. The most highly respected scientists dealt with this fundamental issue. Newton, Faraday, and Maxwell believed in "absolute time" where time flows constantly and without dependence upon any other factor.

Time is best defined as the rate of a fundamental natural process; but *time* is best understood as the duration or interval between events. In our view, the most fundamental natural process is Faraday's *law of magnetic induction.* (It is important to know the most fundamental process, because clocks based on less fundamental processes will speed up and slow down under various conditions.) Faraday's law specifies that a certain amount of electrical force is the result of the change of magnetic flux per unit of **time**. *Time* is fundamentally imbedded in only this law of the three fundamental laws of electricity and magnetism.

The Force of Inertia. "In addition to gravity, Newton claimed, there existed another fundamental force of nature." In the *Principia*, Newton said that inertia is the "innate force of matter," with "a power of resisting, by which every body, as much as in it lies, continues in the present state, whether it be of rest, or moving uniformly forward in a right line."

> Inertia manifests itself as follows. When the driver of a car slams on the brakes, his body is flung forward on the steering wheel. Some force must be pushing the body. This is the force of inertia. Where does it come from? This has become one of the deepest riddles of science [1].
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> In Newton's mind, the force of inertia was *very different* from the force of gravity. Gravity was called forth by the presence of another body. It depended upon the size of the other body and its location.... Inertia was quite different. It was not an interaction between two particles or extended bodies. The Creator seemed to have built inertia permanently into every particle. The inertia force would lie dormant in matter, then suddenly spring into action without collaborating with other matter.... [T]he force of inertia is the oddball among...the forces of nature [1].

Is there a special point in Absolute Space that defines an inertial reference frame? "If the force of inertia lay dormant in matter until it was roused by the acceleration of the substance; what gave this force its direction in space...? *'Acceleration'* and *'deceleration'* have no meaning unless the motion is expressed relative to another object. Where is this other object which determines the direction of the force of inertia [1]?"

Does "space" have a preferred point of reference to use in force equations? Newton found an answer by "inventing" Absolute Space. "Nevertheless, he had a nagging doubt whether this unique space could ever by found and pinned down. In the *Principia* he actually wrote [1]: 'It follows that absolute rest cannot be determined from the position of bodies in our region.'"

Problems of inertia are often solved by use of a law called the Conservation of Momentum. But this law cannot be applied successfully without defining a proper reference point in space. We know that rockets can be propelled to high velocities by accelerating gases in the opposite direction. Now the mass of the rocket is far greater than the mass of the exhaust gas. But the relative velocity between the rocket and the exhaust gas is the same for both masses, leading us to conclude that the conservation law doesn't hold true for relative velocities. The proper reference point for momentum conservations coincides with the velocity of the combined masses of the rocket and its accelerating gasses before the gases are expelled—*which implies that the proper reference point for objects in space is related to something residing inside those same objects.*

But Mach held that "every speck of matter in the whole universe must influence every other speck simultaneously (giving meaning to "Absolute Space"). Someone illustrated this by saying, "when the subway jerks, it's the fixed stars that throw you down." This idea became known as Mach's Principle which is stated by Graneau as follows:

> The inertial force on particles and bodies on earth and in the solar system is due to their acceleration relative to all matter residing outside the solar system [1, p. 74].

Einstein considered the ideas of Newton and Mach as they explained inertial mass and Absolute Space, but they are incompatible with the General Theory of Relativity he published in 1915. The General Theory relates matter and gravity with inertia and acceleration by means of a mathematical theory. It does not attempt to explain how forces are transmitted in terms of physical models. Einstein had another problem with Mach's principle. By this time, Faraday and Maxwell had produced a successful theory of "field-contact actions." Two bodies didn't actually have to touch each other directly, but the field of each one could act across some distance to create a force on the other. The electric and magnetic fields could explain many observed forces, but since they propagated with finite speed, any fields from the distant stars were not a factor in inertial forces on earth.

> The field-contact actions could not be produced simultaneously in, shall we say, the subway traveler and the distant universe. Forces had to be transmitted by the flight of energy which was unable to exceed the velocity of light. It should take at least thousands of years before the fixed stars could knock the traveler down. Mach's principle cannot be implemented without simultaneous far-actions. Toward the end of his life, Einstein advocated that one should *forget Mach's Principle*. Most physicists have taken his advice [1].

Ether Theories. Ether theories are employed to account for properties that seem to be associated with space, including the effects of inertia, intensity of electric and magnetic fields, and the propagation of field energy. Velocity, the rate of propagation, is particularly important as this enters into any theory of electrodynamics, the interpretation of some natural phenomena, and many experiments. Secondary matters concerning these so-called "properties of space" are issues of the dimensions of space, the nature of inertial reference frames, selection of a coordinate system, and the interdependence of time and space.

One of the best known space mediums is identified by Mach's Principle [6]: "The inertia of any system arises from the interaction of that system and the rest of the universe, including distant parts thereof." If the problem of *instantaneous far-actions* is ignored, Mach's Principle implies conformity with the *law of cause and effect* but does not specify whether gravity, electromagnetism, or some other force law provides the mechanism of interaction.

Frequent challenges are made to Ritz's proposition that the original velocity of radiant energy relative to its source is maintained as energy proceeds into regions of space where the fields of other charged particles become relatively greater than the fields of the source object. Three theories for the *one-way velocity of energy propagation of light in free space* are: (1) the Ritz, or ballistic, theory of light, where the velocity of light is supposed to be *c* relative to the moving source, 2) the "special relativity" theory, where the velocity of light is supposed to be *c* relative to the moving observer, and (3) the...classical theory, where the velocity of light is found to be *c* with respect to the fixed all-pervading luminiferous ether, or Absolute Space [7].

Theories of Relativity. One particular theory of electrodynamics has gained prominence, *i.e.,* Einstein's Special Relativity Theory. Einstein himself gives a frank and fair assessment of the theory in the introduction of his paper [8], properly titled "On the Electrodynamics of Moving Bodies." Einstein begins by noting that application of Maxwell's electrodynamics to moving bodies leads

> to asymmetry which does not agree with natural phenomena. Let us think of the mutual action between a magnet and a conductor. The observed phenomena in this case depends only on the relative motion of the conductor and the magnet, while according to the usual conception, a distinction must be made between the cases where the one or the other of the bodies is in motion [8].

Einstein sides here with natural phenomena—against Mach, etherists, and Absolute Space—and defines the "Principle of Relativity." His first postulate conforms to the *law of cause and effect,* and many people find it to be credible.

Einstein introduced the second postulate of SRT with an apology:

> …we…introduce the further assumption,—an assumption which is at the first sight quite *irreconcilable* with the former one—that light is propagated in vacant space, with a velocity *c* which is independent of the nature of motion of the emitting body [8, emphasis added].

The only justification given by Einstein for adopting "irreconcilable" postulates is to claim they bring about "a simple and *consistent* theory of electrodynamics of moving bodies on the basis of the Maxwellian theory for bodies at rest" [emphasis added to indicate the contradiction!]. By assuming the "Principle of Constancy," he not only achieved the symmetry observed for the force law of magnetism but also accounted for effects observed in bodies with high velocity—mass increase and length compression. (Because compression of an object is of physical origin, Lorentzian "length compression" is a better term than Einsteinian "length contraction".) SRT became a useful tool for predicting the motions of bodies moving at high velocity—precisely where Maxwellian electrodynamics (as then conceived) failed. Einstein's theory could predict forces observed for objects accelerated to very high velocities approaching the speed of light; to do so, he gave up the Principle of Causality with respect to the propagation velocity of light. This marked the end of classical science and eroded commitment to the scientific method.

In 1908, Minkowski reformulated SRT in a way that was equivalent (to Einstein's two postulates) and showed, if SRT is correct, that time and space are not independent coordinates but interrelated—giving us the concept of "curved space." "Curved space" is a consequence of SRT because the Principle of Relativity is selectively applied to specify forces based on *relative distance* between two objects—while the Principle of Constancy is applied to the (light) *velocity* between the two objects. (The second postulate means that all observers measure the same velocity of incoming light, no matter what velocity that observer has in the universe.) But, the Principle of Relativity specifies not only how distance but also how *velocity* is measured. By choosing one postulate for <u>distance</u> and a different postulate to measure <u>velocity</u>, Einstein introduced an error in logic. SRT combines two opposing postulates in a single equation for time $t = d/v$ that relates distance and velocity. So, if SRT is correct, time slows down as velocity increases [8].

A decade later, Einstein presented the General Relativity Theory (GRT) to predict gravitation on the basis of space described by Riemannian mathematics—with a curvature of space different from the SRT curvature. Einstein thought that two theories were needed to describe the same space, but he hoped a unified theory could be found to replace them.

Einstein himself acknowledged that the postulates for SRT are equivalent to the mathematical formulation of Minkowski, while GRT is equivalent to the mathematical formulation of space and time given by Riemann. Einstein's two Theories of Relativity are based on *mathematical* descriptions applied to the relative distance and motion of "two points" or a "point-mass of electricity" [8, pp. 6, 9, 12, 18, 21, *etc*.]—a method that ignores actual distribution of charge in real bodies. These theories, like others being compared in this paper, predict the dynamic forces on moving objects. We note additional common features of SRT and GRT that (1) no ether is acknowledged, nor (2) is any other reference made to Absolute Space.

In these Theories of Relativity where time slows down for an object moving with high velocity, simultaneity does not exist; the "time" when any event occurs is not the same for everyone, but depends upon the environment and his location in the universe. This conclusion stems from the Principle of Constancy.

<u>Force Mediated by Exchange of Particles</u>. Quantum Theory (QT) adopts the atomistic view (1) that matter consists of point-like particles called *fermions* and (2) that forces between objects are carried by other particles called *bosons*, which are exchanged randomly and spontaneously between the fermions. QT makes no attempt to relate the fundamental properties of mass, spin, or moment to a physical model but, rather assumes these properties are inherent in point-like, elementary particles. QT incorporates the *Standard Model of Elementary Particles* as a mathematical description of statistical processes operating in accordance with randomness which must exceed Planck's Constant as specified by the *Heisenberg Uncertainty Principle*. Fundamentally, QT regards all objects as described by waves unless and until an object is observed

or measured. Indeed, the mathematical description of the wave is regarded as the best way to describe and predict natural phenomena, and a precise physical description of an object's properties is considered to be impossible and unnecessary.

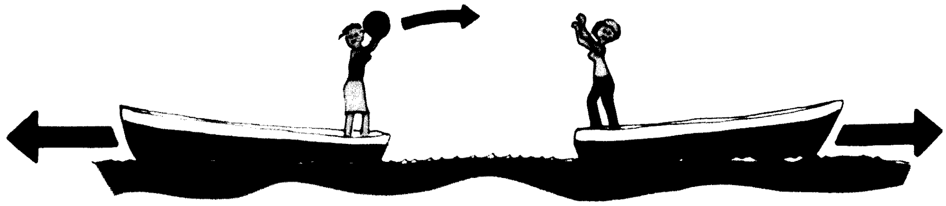

Figure 1.
In Quantum Theory, exchange of particles is responsible for forces.

In spite of the enormous benefit from technology developed on the basis of electromagnetic Field Theory, modern Quantum Theory has adopted conflicting ideas of the ancient Greek philosopher-scientists. In the modern version of Atomism, forces between particles are *not* exerted by fields reaching across space but by photons, mesons or gluons; these force-carrying "particles" known as *bosons* [9] are emitted spontaneously and randomly to "mediate the forces" between the material particles known as *fermions*. While quantum effects have usually been limited to the domain of nuclei and elementary particles, recent frustration with gauge theories have led some to make statements about quantum effects in *macro-sized objects*. Robert Walgate describes how bosons are imagined to travel between objects to attract or repel another object:

> Force Carriers. What causes a force between one particle and another at a distance? Modern physics answers: the exchange of yet other particles. Imagine two skaters throwing a ball at one another. The act of giving momentum to the ball in throwing it—and of receiving momentum in catching it—pushes the skaters apart. This accounts for repulsive forces. But in quantum mechanics, which affects small-scale phenomena, there is a strange extension and delocalization of events that allows a seemingly impossible event: one skater throws the ball away from the other, in the opposite direction, but the other skater is still able to catch the ball. A little thought shows that if such events were possible—as they are in the world of elementary particles—they would cause an attractive force between the skaters [9].
>
> All the "force particles"…that are exchanged between the matter particles…are bosons. This also is significant: it means that photons, for example, can build up in the same state to construct the magnetic field around a magnet, or the electric field around an electric charge [9].

Other assertions of quantum mechanics are just as incredible as the idea that a particle travels the wrong direction to make contact with a second particle, including the contradiction between the two quotes above that "quantum mechanics, which affects small scale phenomena" also explains the large-scale phenomena of attraction and repulsion between two *magnets*. (Recently, apologists for Quantum Theory seem more inclined to apply the small-scale quantum aspects of quantum force theories to macro-size objects.)

Atomists claim that random events mediated by force-carrying particles govern the interactions between objects and between light and matter; bosons (force-carrying particles) seemed particularly well suited to explain forces over short distances but remain unable to account for events outside the atom. (How can photons of light carry forces through opaque objects, as magnetic fields do?)

In Quantum Theory,

- low-energy photons are supposed to carry the force between electrons,
- medium-energy mesons are supposed to carry the force between the more massive protons and neutrons, and

- high-energy gluons are supposed to carry the force that holds quarks together in protons and neutrons.

If this is the case, which of these bosons has the correct energy to mediate the force between the low-mass electron and medium-mass proton? How does a fermion know which of the bosons it should be attracted to? And why do we need a complex theory with multiple particles to replace one simple equation known as Coulomb's Law?

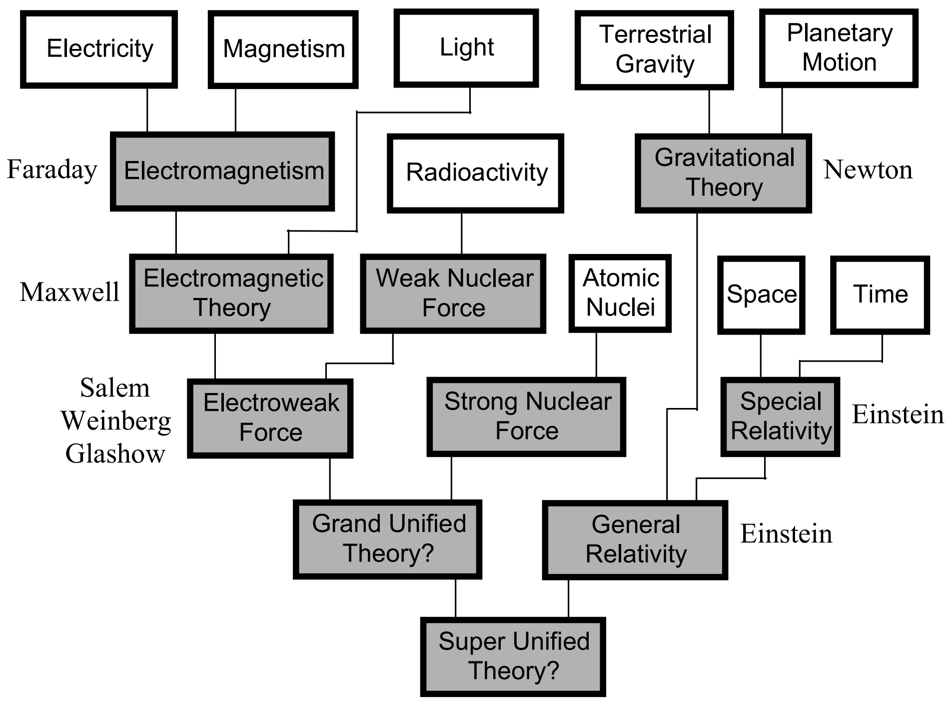

Figure 2.
Unification of the Forces of Nature.

The chart shows a popular concept hoped to unify forces that predict fundamental natural phenomena. Evidently, unification of forces is more a goal than an achievement.

Classical physicists use electrical laws that govern forces between objects, between objects and electrical fields, and thus account for "action at a distance." Yet, classical physicists failed to explain certain natural phenomena, and atomists took the opportunity to charge that methods and fundamental laws of classical physics have failed.

Unified Theory of Forces. Modern physics is attempting to construct a unified theory of forces. Figure 2 shows the relationship of fundamental natural phenomena (blocks with white background) and various theories of force transmission (gray background). The chart suggests that more work is required on existing force theories and new ideas are needed.

Neoclassical Field Theory for Physical Models. The interaction of light and matter plays a foundational role in theories of physics that attempt to describe the physical world and predict the natural phenomena expected under various conditions. Theories of QT, SRT, and electromagnetic Field Theory compete to offer methods that predict forces on moving bodies. Section 2 presents a new theory of forces extended by means of electrodynamic fields around material objects—which consist of electrostatic charge distributed over a toroid [10].

Electrodynamics is defined by the Random House Dictionary [11] as "the branch of physics that deals with the interactions of electric, magnetic, and mechanical phenomena." This topic thus deals both with static and dynamic fields as a means for forces acting on objects over a distance. Physicists have not yet even agreed on such fundamentals of electrodynamics as

- The mediator of forces, whether forces are the result of electric fields, particles, or neither.
- The velocity of propagation of forces.
- Whether or not an ether exists to propagate fields and energy.
- The validity of an *absolute* or *relative* coordinate system to specify distance and velocity.
- The characteristics of space and time in the universe—whether time and space are interdependent as in Einstein's Theories of Relativity, and whether space has more than three dimensions, as in String Theories, *etc.*

This writer has proposed the Theory of Distribution [12] to show how moving-body electrodynamics should enter into calculations. A comprehensive theory of electrodynamics is beyond the scope of this paper; instead, the *fundamental* interaction between electric fields and a single elementary particle will be derived from Faraday's Law. Several assumptions are inherent in the approach that follows:

- Electric and magnetic fields (ideally) can achieve static conditions (*e.g,* a standing wave surrounding a spinning charged ring).
- Change in a charge's position (or distribution) produces a corresponding *change* in field intensity that propagates away from the charge at the speed of light.
- The effects of an ether, it one exists, must be ignored, as shown in a section on Potential Energy.
- A *relative coordinate system* is employed such that distance and velocity are measured between charge elements and points in space where electromagnetic fields exist.
- *Time* flows constantly and without dependence upon any other factor.

2. Field Theory for Physical Models

In our view, light is self-propagating energy composed of electric and magnetic fields; unlike material objects, light carries no charge and has no mass. Numerous experiments demonstrate the wave nature of light. This wave theory of light can account for experimental data, rejects the inconsistency of a dual nature, and most importantly, provides a mechanism for the interaction of light and matter by the use of Faraday's *law of magnetic induction.* In this theory, the exchange of energy between matter and the electromagnetic fields of light is based upon a relative velocity of *c* between a spinning charged ring and radiant flux. The *law of cause and effect*, implicitly embedded in Faraday's Law, provides scientific explanation rather than assumption for the exchange of energy in the interaction.

Backed by considerable theory and extensive experimental measurements, electromagnetic Field Theory based on *conservation of energy* appears not only to be an established fact but also the means of implementing the *law of cause and effect* in all physical interactions. The present theory proceeds from the basic view that cause and effect govern all natural processes. And natural process requires physical models of matter than can absorb and release energy by a process of changing size, shape, density or other physical means. Without a physical mechanism, the point-like objects assumed in some modern theories are well-suited for mathematical theories and predictions but are incapable providing *explanations* of physical phenomena [3]. Eight decades of research on Quantum Theory by skilled mathematicians has not simplified physics—but instead has shown the difficulty of developing a scientific theory of interactions between light and matter without a physical model of either.

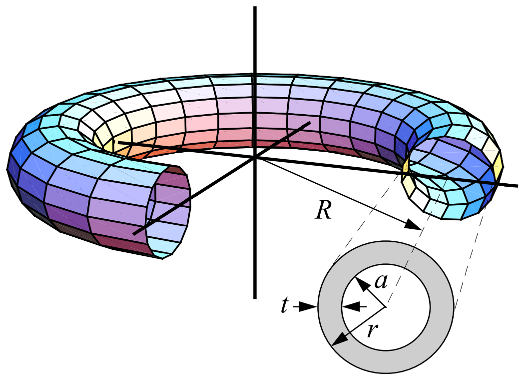

Figure 3.
Spinning Charged Ring Model of Elementary Particles

Electrostatic charge in the thickness layer t at the surface of the ring rotates with velocity c, giving the electron a magnetic moment with flux f and surrounding electric and magnetic fields.

By adopting a physical model of matter, with particles of finite size, physicists can make predictions of what happens when matter and fields interact. Radio and antenna engineers have long understood that large antennas can absorb and emit more energy than small antennas; and no electrical engineer would attempt to exchange energy between a radio wave and a point-like antenna. Magnetic induction can only occur in an extended object able to capture magnetic flux.

The spinning charged ring model of elementary particles [13, 14], Figure 3, is a physical model [3] of finite extent that can exchange energy with space or other particles by the absorption and emission of field energy. Faraday's *law of magnetic induction* provides a precise prediction for the interaction of a magnetic field and a spinning charged ring:

$$\mathsf{E} = \frac{d\phi}{dt} \tag{1}$$

where E is the electromotive force (*voltage*) induced on charge in the ring, ϕ is the magnetic flux that the ring encloses, and t is time.

Discoveries by Coulomb, Ampère, and Faraday of the fundamental electrical force laws have been combined into a theory of fields whose energies reside in space and interact with material objects. Maxwell provided the rigorous formulation of many aspects of Field Theory; and others contributed important concepts such as kinetic energy, potential theory, and association of charge with material objects.

Significant new developments in electromagnetic Field Theory are (1) inclusion of self-charge [15] as an important self-force on an extended object, (2) the Theory of Distribution [12] to show how calculations enter into any theory of electrodynamics, and (3) the following analysis of the fundamental interaction between charged objects and light or electromagnetic fields. These concepts have been applied to provide an explanation for the origin of the so-called "relativistic effects" of length compression and increase in mass [12, 16]. A ring particle with self-charge possesses inertial mass (that resists attempts to accelerate the particle). Acceleration modifies the electric and magnetic fields surrounding the charged object as illustrated in Figure 4 for the case of a sphere.

Figure 4.
D lines for a spherical charge at rest (left) and under acceleration (right).

The *D* lines curve because propagation of electric field changes is less than instantaneous. From reference [17].

Electromagnetic Field Theory has successfully explained how energy fields in space act on objects not in direct contact (action at a distance) and recently *was shown to account for inertial mass and provide an explanation for causality in Newton's Laws of Mechanics* [12, 16]. Field theory is almost exclusively responsible for the enormous technological advances of the past century. And these advancements came about because Field Theory provides the means to explain how light and matter interact; *i.e.,* the interaction of radiant energy, electric fields, and magnetic fields with charged matter.

We propose a new theory of electrodynamics based on Faraday's Law and the interaction of light and matter predicted by electromagnetic Field Theory. The new theory shuns the approach of other theories that predict forces on charged objects by considering only *charge* and *current elements*—which are only infinitesimal portions of real elementary particles. Instead, the entire electromagnetic field of a charged particle is considered as an integral field with correspondence to the entire distribution of charge of an elementary particle.

While Gauss's Theorem can be employed successfully for a sphere in a way to make an electrically charged sphere equivalent to a point-like object, magnetic forces cannot be simplified to explanation from a monopole magnet; only *dipole* magnets exist in nature, with very different fields and forces on moving charged objects. Attempts by modern physics to combine the electric and magnetic forces into a single force are regarded as error.

By application of the original force laws of Coulomb, Ampère, and Faraday to physical models of matter—meaning charged objects of real size, shape and boundaries—we have calculated the accumulation of energy by an electron during a period of acceleration. Especially by the use of Faraday's Law, we can account for the process rates that accumulate potential energy in an electron through compression and the energy added in external electromagnetic fields surrounding the electron. Of course, an accelerated electron acquires kinetic energy in the reference frame of its original existence prior to acceleration, and our analysis of acquired kinetic energy allows us to understand and define inertial reference frames.

Using the spinning charged ring model of matter and the electromagnetic wave model of light, the interaction between light and matter can be described by the use of Faraday's *law of magnetic* *induction.* The exchange of energy by means of magnetic flux linkage is described for an electron during four phases of (1) being at rest, (2) being accelerated and acquiring an induction field, (3) a period of transition when the induction field is radiated into space, and (4) then a final period of rest in a new frame of reference.

Initial Period: The Free Electron at Rest. Consider a spinning charged ring electron in a field-free region of space and isolated from other particles. Under these conditions, an electron is at rest, has a rest-mass energy m_o, radius R_o, one unit of electric charge e, and one unit of magnetic charge (flux ϕ_o), the latter two quantities being conserved [14]. The free electron takes on the stable characteristics of size and energy that are consistent with a minimum potential energy. The inertial mass of this "free" electron is a characteristic derived from its electrical features [12, 16]; the free electron has constant velocity (zero) in its own inertial reference frame. Table 1 shows characteristics of the free electron at rest [18]. (In addition to a refinement of the ring model proposed in [16], Bostick has proposed an additional refinement [19] that this writer believes is necessary. However, the first order approximations of the toroidal model are adequate for the present theory.)

Under static conditions, the shape and intensity of electric and magnetic fields surrounding any charged object are determined by the shape, magnitude, and motion of the charge itself. The energy of any such configuration resides in the fields occupying space, somewhat as the heat and light energy from the sun reside in space and propagate in space to the earth. The fields surrounding the spinning charged ring exert pressure that compresses the ring to a corresponding size, shape and potential energy.

Characteristic	*Value*	*SI Unit*
Radius, R_o	3.86607×10^{-13}	meter
Current, I_o	1.97736×10^{1}	Ampère
Capacitance, C_o	3.12812×10^{-25}	Farad
Inductance, L_o	2.08910×10^{-16}	Henry
Magnetic Flux, ϕ_o	4.13809×10^{-15}	Joule
Electrostatic Energy, E_{so}	4.10312×10^{-14}	Joule
Magnetostatic Energy, E_{mo}	4.08412×10^{-14}	Joule
Rest-mass, m_o	9.10953×10^{-31}	kilogram
Rest-mass Energy, E_o	8.18724×10^{-14}	Joule

Table 1.
Characteristics of the Free Electron

The rest-mass energy of an electron corresponds to the *static* fields surrounding it and thus must be regarded as *potential* energy. Its kinetic energy (of motion) remains at zero with respect to the inertial reference frame moving with it; but relative to some other inertial reference frame, the electron can have a non-zero kinetic energy.

Acceleration Phase. Let the electron previously at rest be accelerated by a uniform electric field. As the electron acquires velocity and kinetic energy, the following relationships are maintained by electrodynamic processes acting upon the ring electron to increase the electron's total energy E. As shown in references [12, 16], the energy acquired by the ring increases with velocity in accordance with equations (2) and the ring becomes smaller with the inductance increasing, as given by the first and second of equations (4). (Equations (2) and all others are based on the Galilean transformation.)

$$E = \gamma E_o \qquad\qquad E_m = \gamma E_{mo} \qquad (2)$$

$$E_{so} = \frac{e^2}{2\,C_o} \qquad E_{mo} = \frac{\phi_o^2}{2L_o} \qquad E_{mo} = \frac{L_o\,I_o^2}{2} \tag{3}$$

$$R = R_o / \gamma \qquad L = \gamma\,L_o \qquad C = C_o\,/\,\gamma \tag{4}$$

$$\phi = \gamma\,\phi_o \qquad I \equiv \frac{\phi}{L} = \frac{\gamma\,\phi_o}{\gamma\,L_o} = I_o \tag{5}$$

where the subscripts "m" and "o" indicate magnetic energy and initial rest frame conditions, respectively; where R is the ring radius, L is the ring inductance, I is the ring current, C is the ring capacitance, and γ gives the velocity of the ring relative to the initial rest frame velocity according to

$$\gamma = \left(1 - \frac{v^2}{c^2}\right)^{-1/2} \tag{6}$$

Substituting the equations (2-5) into the following definitions shows that the relationship $E = \gamma\, E_o$ has been maintained:

$$E_m = \frac{\phi^2}{2L} = \frac{\gamma^2 \phi_o^2}{2\,\gamma\,L_o} = \gamma\,E_{mo} \tag{7}$$

$$E_m = \frac{LI^2}{2} = \frac{(\gamma\,L_o)}{2} I_o^2 = \gamma\,E_{mo} \tag{8}$$

As the ring is accelerated, a radiation field is attached to the ring and travels with the ring—even while the radiation field begins to dissipate. During this period of acceleration, self-charge of the ring electron modifies its surrounding electromagnetic fields (see Figure 4) and magnetic induction stores energy in the space surrounding the electron—creating a radiation field. Current I circulating in the ring does not change, as shown by equation (5). But the ring becomes smaller while energy, inductance, and accumulated magnetic flux ϕ_{acc} all increase in proportion to γ.

During the period of acceleration, energy is acquired in the fields surrounding the ring, and a corresponding increase in magnetostatic pressure at the surface of the ring makes it smaller. Energy accumulates in accordance with the following relationships which are derived from geometry and equations (2) through (6).

$$d = \frac{c^2 F\,t^2}{2\,E_o \gamma} = E_o\left(\gamma - 1)\,/\,F\right) \tag{9}$$

$$\gamma = \frac{E_o - d\,F}{E_o} = \frac{1 + \sqrt{1 + \dfrac{2F^2\,t^2}{E_o}}}{2} \tag{10}$$

where d is the distance traveled by an electron in its rest frame of reference under the acceleration of a force F over a period of time t, and E_o is the rest-mass energy of the electron. Energy accumulates both in the ring and its external fields as follows:

$$E_s = \frac{\gamma e^2}{2C_o} \qquad E_m = \frac{\gamma \phi_o^2}{2L_o} \tag{11}$$

$$E = \gamma E_o \qquad E_a = \mathbf{F}\cdot\mathbf{d} = E_o(\gamma - 1) \tag{12}$$

$$E_k = E_o \frac{\gamma v^2}{2c^2} = E_o\left(1-\gamma^{-2}\right)\gamma/2 \tag{13}$$

$$E_r = E_a - E_k = E_o(\gamma-1)^2 / 2\gamma \tag{14}$$

where E_s is electrostatic energy, E_m is magnetostatic energy $E_a = \mathbf{F}\cdot\mathbf{d}$ is energy added to the electron during acceleration, E_k is kinetic energy, E_r is energy of the induced radiation field, L_o is the inductance and C_o is the capacitance of the electron ring at rest.

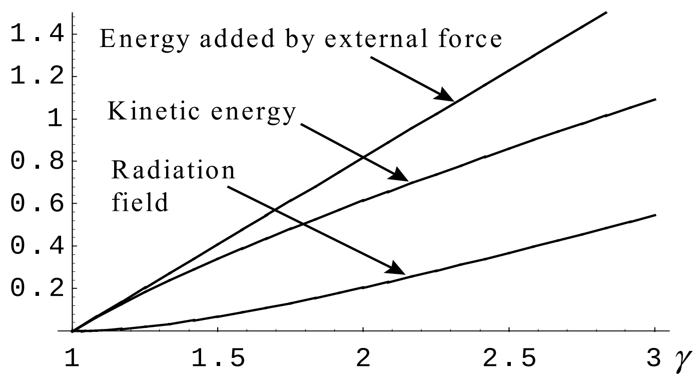

Figure 5.

Energy given by an external force increases the electron's velocity, kinetic energy, and radiation-field energy. Energy added by the external force of acceleration provides the electron with kinetic energy and radiation field energy. Multiply energy (vertical axis) by 10^{-13} to get energy in Joules.

Figure 5 shows how the energy from an external force of acceleration increases the ring's kinetic energy (as measured from the original frame of reference where the electron was at rest) and the ring's new radiation field which is both growing in energy and simultaneously radiating energy.

Energy is stored *in the ring* during a period of acceleration by decreasing its size, with a resulting increase of electrostatic energy and magnetostatic energy shown in Figure 6. During a transient period of acceleration, an electromotive force (emf) is induced inside the ring in accordance with Faraday's *law of magnetic induction*[*] as given by $\mathit{E}_{\text{internal}} = d\phi/dt$. As shown above, the current in the ring remains constant. The power absorbed by the ring is the product of emf (*voltage*) and current in the ring—and is expressed as a function of γ:

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[*]Faraday's Law and Field Theory correctly predict that magnetic effects (*e.g.,* flux generation and a magnetic moment) do not exist for point-particles of zero size and cross section. An approximation of a monopole point-charge can often predict an electric field with accuracy, but no such approximation can be made for magnetic dipoles where magnetic effects (and their dipole field characteristic) come from current loops of finite size.

$$\frac{dE_m}{dt} = \mathsf{E}_{\text{internal}} I_{\text{internal}}$$

$$= \left(\frac{d\phi(\gamma)}{dt}\right)\left(\frac{\phi(\gamma)}{L(\gamma)}\right) = I_{\text{o}}\left(\frac{d\phi(\gamma)}{dt}\right) \quad \text{Watts} \qquad (15)$$

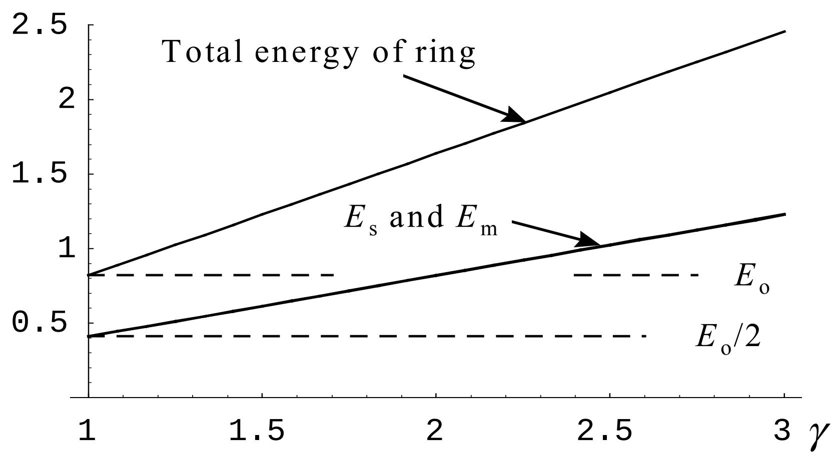


Figure 6.
Compression Energy Stored by the Electron Ring.

Total energy stored in the ring by compression consists of electrostatic energy and magnetostatic energy. E_o is the rest-mass energy of the electron; $E_o/2$ is the electrostatic or magnetostatic energy of the electron at rest; E_s and E_m are nearly equal and represent the electrostatic and magnetostatic energies, respectively, of the compressed electron while being accelerated by an external force. Multiply energy (vertical axis) by 10^{-13} to get energy in Joules.

Equation (15) shows the role of magnetic flux in the transfer of energy into a ring. During a period of acceleration, energy is being accumulated by compressing the ring and increasing the energy in the electric and magnetic fields surrounding the electron. The processes of energy absorption, change of size and mass are illustrated in Figure 7.

Transition Period: The Radiation Phase (immediately after ring acceleration stops).# After a period of acceleration, the ring has acquired additional energy and a smaller size. Surrounding induction fields of electrostatic and magnetostatic energy and internal forces that give the electron its natural size will begin to restore the electron to the size and rest-mass it originally possessed as a free electron. During this transition phase, energy accumulated and given by equation (15) is released by radiation into space at a rate $dE_{\text{radiation}}/dt$ that will be estimated from Poynting's theorem.

#It is well known, of course, from radio transmissions that radiation of energy into space is the result of charge *acceleration*. In order to separately describe basic processes, our analysis of the energy accumulated during the acceleration phase ignored radiation during that period (*i.e,* by assuming high acceleration so that $T \ll \tau$ in Figure 7).

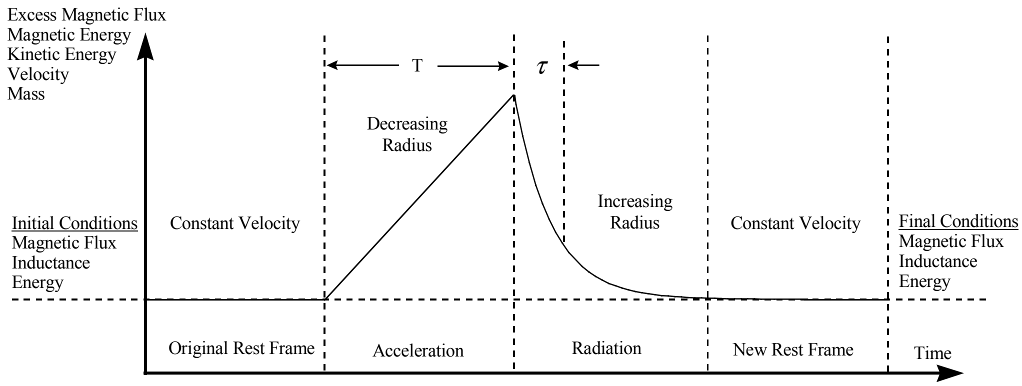


Figure 7.

Dynamic characteristics of an electron during four periods of initial rest, acceleration, radiation, and final rest. Time constant τ is estimated by the author to be about 11 minutes.

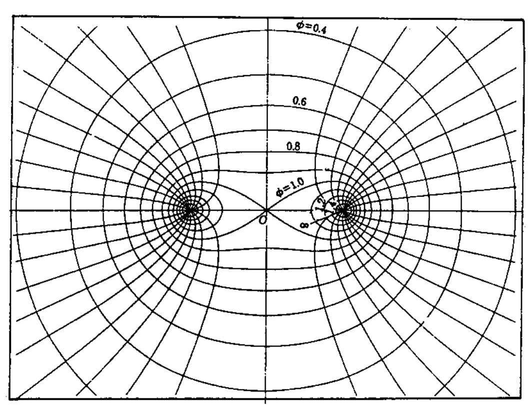
Electromagnetic Field Theory shows the rate that energy accumulates or departs from a volume of space. Barnes interpretation of Poynting's theorem shows the rate is proportional to the energy of the electric and magnetic fields [17]:

$$\oint (\mathbf{E}\times\mathbf{H})\cdot\mathbf{n}\,dS = \frac{d}{dt}\int\left(\frac{\varepsilon_o E^2}{2}+\frac{\mu_o H^2}{2}\right)dv \qquad (16)$$

We will use equation (16) to estimate the decay time of the radiation field surrounding the electron. The vector **E** x **H** is called the Poynting vector and indicates the direction and magnitude of power flow per unit area. The electrostatic and magnetostatic fields surrounding a spinning charged ring electron at rest are shown separately in Figures 8 and 9. Figure 10 shows the **E** and **H**-fields together; it is observed that the **E** x **H** cross product is perpendicular to the plane of the paper, but vector **n** lies in the plane of the paper. This means that the vector dot product (**E** x **H**)·**n** in equation (16) is zero; and no radiation occurs for the electron at rest. Under acceleration, however, the axial symmetry is broken, the vector dot product is non-zero, and the electron acquires a radiation field.

Figure 8.
Electrostatic Field of Charged Ring.

Lines of force and equipotential surfaces from reference [20].



When acceleration of the electron produces a radiation field, the **E** and **H**-field vectors fall behind the accelerating electron, as illustrated in Figure 4. In this case, a small component (of average magnitude c_1) of the **E** x **H** cross product vector will be aligned with surface vector **n** and radiate energy through surface *S*.

The radiation field produced by an accelerated electron stays with the electron for about 11 minutes according to an estimate we now obtain by the use of equation (16). For the left side, we express the rate of energy flow through surface *S* as dE_r/dt. As Barnes has shown [17], the right side of equations (16) is the loss of energy within the volume enclosed by surface *S*. On this basis, we write equation (17):

$$\frac{dE_r}{dt} = -c_1 \left(E_r - E_o \right) \tag{17}$$

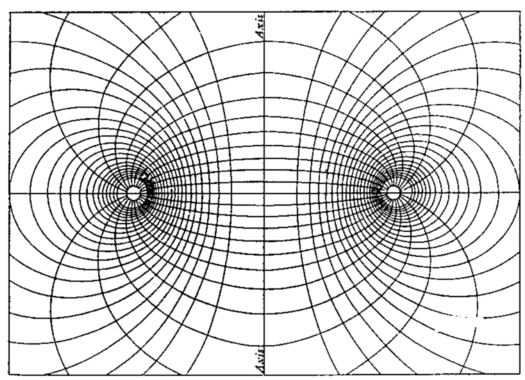
where E_r is the energy accumulated in the radiation field, E_o is the rest-mass energy of the electron, and c_1 is a constant representing the fraction of energy whose vector $(\mathbf{E} \times \mathbf{H}) \cdot \mathbf{n}$ passes through surface *S*. Integration of equation (17) gives

$$E_r = E_o + \left(E_{ro} - E_o \right) \exp\left(-c_1 \, t \right) \tag{18}$$

We wish to know the value of c_1 because its reciprocal is the time constant of the radiation field. The fractional power average given by c_1 should be obtained by integrating over the volume of energy given by Poynting's theorem. For now, a tentative estimate $c_1 = .0015$ or 0.15% is made by inspection of Figures 8, 9, and 10. Note the small circles where great field intensity is found close to the ring. Most of the electron's energy resides close to the electron surface. As illustrated by Figure 4, **E** and **H** fields close to the ring will be less distorted under acceleration than field vectors more distant from the electron surface; less distortion means a smaller radiation field and less radiation.

Figure 9.
Magnetostatic Field of
Spinning Charged Ring.

Lines of force and equipotential surfaces, from reference [21].



Beta decay (disintegration of a neutron) is probably the natural dynamic process most closely related to the decay of an electron's radiation field. The author's estimate of $\tau = 1/c_1$ equal to about 11 minutes was influenced by the neutron's so-called "half-life" of 10^{-13} minutes.

The Final Period: The Electron at Rest In a New Inertial Frame of Reference. The radiation field associated with an accelerated electron slowly leaves the electron once it is isolated from all accelerating fields. As energy accumulated (during a previous period of acceleration) is radiated into space, the electron returns to its stable position of a minimum energy potential by adjusting its size and various related electrical characteristics. Thus, the electron reverts to the same potential energy and rest-mass energy it possessed in the initial period when it was also a free electron at rest.

The acceleration previously experienced by the electron has now increased its velocity as measured with respect to its original frame of reference, and the electron has acquired kinetic energy in that (original) frame of reference. But in the new frame of reference established by reference to itself, the electron has only potential energy and is at rest.

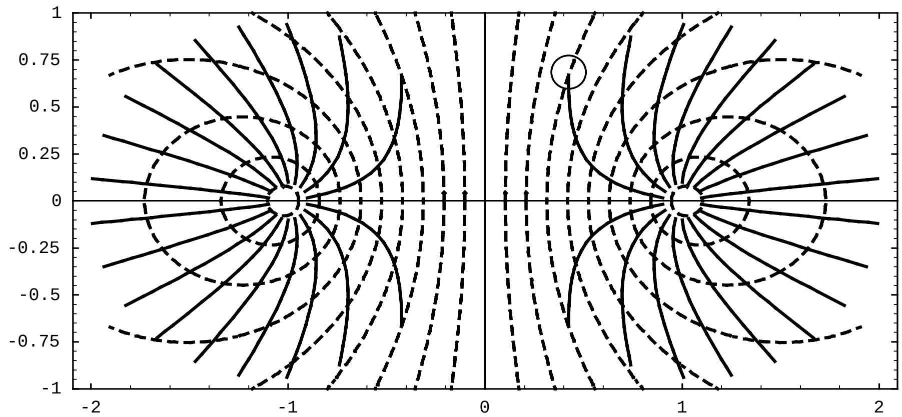


Figure 10.
E lines (solid) and H lines (dashed) at evenly spaced intervals.

Near the surface of the ring, where **E** and **H** are most intense, the **E** and **H** field vectors are perpendicular to each other, and the vector cross product **EXH** is perpendicular to the plane of the paper. At greater distances from the ring, the fields are weaker and not perpendicular (*e.g.,* at the circle). When axial symmetry of the fields is broken by acceleration, the vector (**EXH**) • **n** is non-zero, resulting in radiation of energy.

The basic laws of electromagnetism, consisting of Coulomb's law, Ampère's law, and Faraday's law, are all based on relative distance and motion between a causal agent (another charge) and an effect (resulting force or electrodynamic field). This implies a *relative coordinate system* can be used more directly and simply than the use of a single point located in Absolute Space. As a result of the inverse square law and the effects of motion in electro-dynamics, it is reasonable to conclude, in the absence of an ether, that a single non-moving point in space cannot be found to represent an all encompassing inertial frame of reference.

Velocity and Inertial Frames of Reference. Understanding the radiation field (and various other energies accumulated when an electron is accelerated) provides insight into the meaning of *velocity* of an elementary particle and its *inertial frame of reference*. After a long period $T \gg \tau$ without acceleration, no radiation field exists and a particle's kinetic energy and velocity can be expressed with reference to any inertial frame. (For reasons that are now clear, an inertial frame is one where acceleration and a radiation field are absent.)

But when a charged particle is being accelerated, or recently has been accelerated and still retains a radiation field, only one reference frame is suitable for specifying its velocity (and velocity factor γ): a frame whose velocity coincides with the velocity of the charged particle at rest prior to acceleration. Only then is the velocity acquired during acceleration a meaningful term.

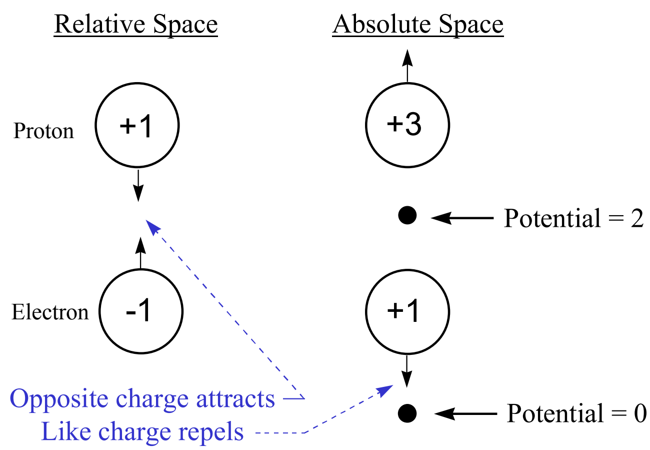
Potential energy. The present theory of electrodynamics, based on the Principle of Relativity, also accounts for the *potential energy* of a charged object. Since "like charges" repel, compression of charge elements to any specified size and shape establishes an electrostatic potential energy. In the case of the spinning charged ring, a balance of forces at the surface of the ring is achieved by a magnetic pinch effect and an energy field of magnetostatic potential energy nearly equal to the magnitude of energy in the electrostatic field (see Table 1). In this way, a particle's *self-charge* establishes the particle's potential energy.

Where a *second charged object* is involved, mutual energy of coupling must also be considered; and the total potential energy is determined by the force laws and the *relative* distance between the two objects.

The competing notion of *Absolute Space* implies that space itself has properties, and a preferred point or position exists where an object will have a minimum or zero of mutual potential energy. Thus, an electron at another point in space will have a greater mutual energy of coupling (between the object and space) and some potential energy derived from its location in space. Specifying that two charged objects have potential energy relative to the potential at some point in Absolute Space, instead of to each other, leads to erroneous results for the force between two charged objects (Figure 11).

Figure 11.
Potential Energy in Relative and Absolute Space.

Left: two objects in relative space attract each other due to opposite charges on the



two objects. Right: two objects with the same relative difference of potential but specified at their potential with respect to Absolute Space repel each other because both have a positive charge. A relative coordinate system gives the correct result measured experimentally as specified by Coulomb's Law.

Entropy. According to the Second Law of Thermodynamics, it is impossible to recover all the energy added to a system, including an accelerated spinning charged ring. In this case, some of the energy of acceleration becomes kinetic energy of the ring, and some of it goes into the radiation field. Energy that is radiated will be lost to the ring and not recovered. The electrodynamics presented here explains how entropy and the Second Law of Thermodynamics operate on the energy.

3. Validation Criteria for Competing Theories

The Scientific Method provides a means to select among competing models and theories of force transmission. The author suggests the following criteria as a scientific way to evaluate the various theories proposed to predict the motions of bodies.

1. Predictions of the theory must be in accordance with experimental data.
2. All parts of the theory must be consistent. One part of a theory must not contradict another part of the same theory.
3. Each subtheory entering into a larger theory must meet all the validating criteria and be based on the same principles, definitions, and axioms.
4. Generality and simplicity should prevail over a multiplicity of theories and models.
5. Contradictions disqualify any theory presented to be a description of reality. A contradiction disguised as a "paradox" invalidates a theory or model.

6. The principle of *unity* demands consistency of scientific theory/models over all ranges, scales, and domains.
7. The principle of *causality* demands explanations of effects based on preceding causes rather than random, spontaneous events.
8. The principle of *reality* demands an objective, ongoing existence independent of observation, measurement, or contemplation.
9. Truth, not success, is the goal for describing the physical universe.
10. Interpolation provides more credibility than extrapolation.
11. Existence of mathematical equations, propositions or theories cannot by themselves validate a physical model or theory. Singularities in equations should not be used to predict natural phenomena.
12. Scientific criteria are better than consensus.
13. Accuracy is more important than imagination, no matter how well a theory or model is described.
14. Models and theories that lead to applications benefiting mankind are desirable.

4. Conclusions

Application of electromagnetic Field Theory based on the original laws of Coulomb, Ampère, and Faraday provides a general framework and consistent, systematic approach for predicting forces on accelerated bodies .

Faraday's *law of magnetic induction* (that deals with time and motional effects) is the fundamental law governing electrodynamic interactions. This basic law of dynamics can be used to calculate the exchange of energy between light and matter, provided that light is acknowledged to be a wave of electrical fields and provided that matter has a physical and electrical nature.

Under static conditions, the ring's total energy is approximately equipartioned with electrostatic and magnetostatic energies [13]. While dynamic processes of exchanging energy are driven by *magnetic* forces and Faraday's Law, the *electrical* forces also enter into the dynamics properties of the ring at every instant—in accordance with Field Theory.

Previous papers [12, 16] deduced the existence of inertial mass and deformation of elementary particles by noting simply that any moving charge element of a ring particle could not exceed the speed of light *c* (relative to the ring's total self-charge as measured with respect to the center of the ring). The same conclusion is evident in this paper, although here the result was induced from Faraday's Law and conservation of energy.

The *law of conservation of energy* can be implemented by electrical laws that account for potential and kinetic energy. By the Theory of Distribution [12] used here, conservation of energy is maintained without the medium of an ether. A relative coordinate system is suitable for physical calculations involving exchange of energy, provided that self-charge effects are included and the distance to other particles is considered.

In the absence of an ether, an object composed of charged elementary particles has velocity equal to zero (which should be measured with respect to itself). As specified by Faraday's Law, the internal electromotive force on any charged object by other objects depends upon externally induced flux which normally is much less than the object's self-generated flux owing to the large separation distances between most objects. Therefore, self-charge and self-generated magnetic flux must be included in any description of a particle's force-field environment.

Faraday's Law implies the existence of simultaneity—for it specifies that time flows constantly and is unaffected by velocity, space or other factors. Faraday's Law provides a definition of **time** by specifying the rate of a fundamental *process*—the interaction of magnetic flux and matter.

An electrical/physical basis exists to establish the valid reference frame for every object at any point in space. The basis rests upon the Theory of Distribution which requires the inclusion of self-charges and their dynamic electrical fields at every specified point. Thus, as a result of many moving, charged particles distributed throughout the universe, no unmoving point of Absolute Space can specify a static field environment; and the inertial reference frame at any point in space changes every instant. The concepts of Absolute Space and an ether should be abandoned.

Following a period of acceleration by any external force, an elementary particle radiates accumulated excess energy of induction in about 11 minutes.

Ordinary objects composed of elementary particles bound together by internal atomic or molecular forces will travel together, and each aggregate of matter (object) also establishes its own frame of reference. Objects throughout the universe each have a frame of reference that is largely independent of other objects. Mach's Principle of immediate external influences is effectively irrelevant due to the inverse square law and large distances between objects in comparison with the small distance between charged elements of a particle acting upon itself.

In the absence of an ether, an object can have any velocity with respect to other objects in the universe, including a superluminal velocity. An object's location, motion and charge are the factors that determine its own inertial reference frame. Its kinetic energy is conveniently expressed as zero in a frame moving with it, but is non-zero when specified with respect to other reference frames.

Inertial mass of charged particles is a derivative property of particles and their fields acting upon themselves to resist velocity changes and maintain constant velocities. Without an ether to restrain an object's velocity, the only measure of motion is with respect to itself or another object, and matter can move at any velocity relative to other objects in the universe. This suggests that space travel can exceed a velocity of c relative to the earth, provided adequate fuel for acceleration is available in a suitable inertial frame.

Recent research and discoveries, including this explanation of interaction between light and matter based on electromagnetic Field Theory, are showing that the scientific method is still applicable, causality remains in effect on all scales, and errors in logic that pervade modern theories need not and cannot be the basis for science.

5. ACKNOWLEDGMENT

The author gratefully acknowledges the influence of writings by Thomas G. Barnes in developing this theory of electrodynamics [15, 17, 22]. Barnes even anticipated the current work when he wrote [17] "This is a field in which there is a need for new ideas and research to help clarify the inconsistencies in the realm of electrodynamics."

Charles W. Lucas, Jr., conceived and explained many of the ideas found in this paper, including the analysis of Maxwell's equation for magnetic inductance.

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