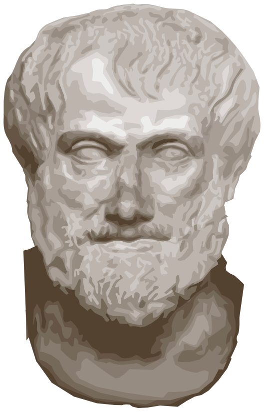
Union of Euclid's Axiomatic Method with Newton's Empirical Scientific Method Leads to an Improved Electrodynamic Force

Charles W. Lucas, Jr.
Common Sense Science
29045 Livingston Drive
Mechanicsville, MD 20659-3271
Bill.Lucas001@gmail.com

Abstract. Euclid's rigorous axiomatic method of deriving theorems/theories is reviewed as well as Newton's less rigorous empirical scientific method. Then the method of Maxwell is introduced showing a partial combination of the axiomatic and empirical scientific methods. Finally the union of the axiomatic and empirical scientific method is perfected to obtain an improved version of the electrodynamic force law capable of replacing the original electric force law and magnetic force law. The inclusion of the finite size of charged particles plus the conservation of energy and Newton's 3rd Law as embedded in Lenz's Law appear to be capable of enhancing the electrodynamic force law and the equations of electrodynamics such that there is no longer a role for Einstein's Special Relativity Theory in electrodynamics.

Introduction. The first significant development in Natural Philosophy was recorded by the ancient Greeks. Euclid, in the process of developing geometry, defined the axiomatic method of proofs to be used in logically establishing theorems in geometry. To the extent that the postulates chosen were valid, the logically developed theorems would be valid with good certainty. The ancient Greeks, like Plato and Aristotle, were so impressed that they put the slogan over the door of their academies of natural philosophy "Let No One Ignorant of Geometry Enter Here". The modern world has also been impressed by Euclid to the extent that his book **Elements** (**of Geometry**) has been published in more languages and editions than any other natural philosophy or scientific book in the history of the world. Euclid's approach worked well in mathematics, but in physics and other areas of Natural Philosophy, the ancient Greek natural philosophers were not able to guess the appropriate axioms or postulates.



Euclid
Greek mathematician of the third century B.C.

When Isaac Newton published his **Principia**, he stated that he intended to illustrate a new way of doing natural philosophy that overcomes some of the limitations of the axiomatic method. This method is now called the empirical scientific method. The goal of Newton's method was to find empirically the forces of nature.

> And therefore our present work sets forth mathematical principles of natural philosophy. For the whole difficulty of philosophy seems to be to find the forces of nature from the phenomena of motions and then to demonstrate the other phenomena from these forces… For many things lead me to have a suspicion that all phenomena may depend on certain forces by which the particles of bodies, by causes yet unknown, either are impelled toward one another and cohere in regular figures, or are repelled from one another and recede. Since these forces are unknown, philosophers have hitherto made trial of nature in vain. But I hope that the principles set down here will shed some light on either this mode of philosophizing or some truer one [1].

Newton claims that in the past natural philosophers tried to understand nature in vain, because they did not use an empirical approach based on experimentation. The empirical approach is more effective in discovering the causes and effects of nature. As a result he argues that the empirical approach is a more secure path toward truth in natural philosophy. The problem of the ancient Greek philosophers is that they could not guess the relevant propositions for natural philosophy upon which to apply logic to derive the theorems or theories of natural philosophy outside of geometry and mathematics. These need to be discovered by experiment.

This approach does not lead to all truth at once, as Newton himself recognized with regard to his study of gravity. He never claimed to understand the causes and nature of inertia and gravity, even though he could define the Force of Inertia and the Universal Law of Gravitation as shown below.

$$F_I = m_I \, a \quad Force\ of\ Inertia$$

$$F_G = G \, \frac{m_{G1} \, m_{G2}}{{R_{12}}^2} \quad Universal\ Force\ of\ Gravity$$

When Newton was asked what 'm_I = *inertial* mass' was, he replied that inertial mass was a measure of some characteristic of matter that caused the force of inertia and that inertial mass increased as the amount of matter increased. When Newton was asked what 'm_G = *gravitational* mass' was, he replied that gravitational mass was a measure of some characteristic of matter that caused the force of gravity between bodies of matter and increased as the amount of matter increased. When the experimental inertial and gravitational masses were found to be equal in magnitude for the same body, Newton realized that instead of the force of inertia and the force of gravity being different fundamental forces, they might have a common cause. As the quote from the **Principia** below shows, Newton did not know the cause of the force of gravity.

> I have not as yet been able to deduce from phenomena the reason for these properties of gravity, and I do not feign hypotheses. For whatever is not deduced from the phenomena must be called a hypothesis; and hypotheses, whether metaphysical or physical, or based on occult

> qualities, or mechanical, have no place in experimental philosophy. In this experimental philosophy, propositions are deduced from the phenomena and are made general by induction [2].

Later Newton softened his renunciation of hypotheses by adding “unless as conjectures or questions proposed to be examined by experiments” [3]. He had come to realize that hypotheses could be used to predict additional phenomena which could be examined by experiments and serve as a check on the veracity of the hypothesis.

Newton’s approach was evaluated by his critic Christiaan Huygens, the foremost figure in science at the time, in his **Discourse on the Cause of Gravity.**

> One finds in this subject a kind of demonstration which does not carry with it so high a degree of certainty as that employed in geometry; and which differs distinctly from the method employed by geometers in that they prove their propositions by well-established and incontrovertible principles, while here principles are tested by the inferences which are derivable from them. The nature of the subject permits no other treatment. It is possible, however, in this way to establish a probability which is little short of certainty. This is the case when the consequences of the assumed principles are in perfect accord with the observed phenomena, and especially when these verifications are numerous; but above all when one employs the hypothesis to predict new phenomena and finds his expectations realized [4].

Here the test of hypotheses is to use them to predict new phenomena which can be tested empirically.

Newton took a very practical approach to forces. He assumed the total force on a body was due to the sum of the individual forces of the particles making up that body.

> For it is reasonable that forces directed toward bodies depend on the nature and the quantity of matter of such bodies, as happens in the case of magnetic bodies. And whenever cases of this sort occur, the attractions of the bodies must be reckoned by assigning proper forces to their individual particles and then taking the sums of these forces [5, Scholium at the end of Book I, Section II].

Newton also realized that mathematics is a tool to enable an analysis of forces, to help identify the causes of forces and to argue more securely.

> Mathematics requires an investigation of those quantities of forces and their proportions that follow from any conditions that may be supposed. Then, coming down to physics, these proportions must be compared with the phenomena, so that that it may be found out which conditions of forces apply to each kind of attracting bodies. And then, finally, it will be

> possible to argue more securely concerning the physical species, physical causes, and physical properties of these forces [6].

In the mechanical philosophy of Newton's time all forces had to be contact forces due to causality. According to Descartes [7] the mechanical philosophy could only allow contact forces between physical bodies, if there were some sort of medium or aether to convey the force between the bodies. Newton realized, however, that no hypothetical contact mechanism seems even imaginable to effect "attractive" forces among particles of matter generally. In the face of criticism from Huygens and others, Newton claimed that he is employing mathematically formulated theory in physics in a new way in which forces are treated abstractly, independently of physical cause or contact mechanism. In other words the two functions could be performed separately with progress being made on the one when no progress could be made on the other.

The first type of proposition in Newton's Principia is a mathematical proposition that links parameters in rules characterizing forces to parameters of motion. As one can easily see, measurement is very important to the methodology of the **Principia**. Newton recognized that measurement invariably involves theoretical assumptions, and thus must remain provisional. Since measurement in physics involves physical procedures and assumptions, science must include within itself its own empirically revisable theory of measurement. The second type of proposition in the **Principia** consists of combinations that contrast different conditions of force in terms of different conditions of motion.

By contrast, an examination of the mathematical theories of Galileo and Hyugens shows that the propositions that they were pursuing were ones that made a distinctive empirical prediction that provided an answer to some practical question, or explained some known phenomena. Newton in the **Principia** was not so interested in conjecturing hypotheses and then testing the implications of those hypotheses, but rather to use mathematics to provide a basis for specifying experiments and observations by which the empirical world can provide answers to questions.

> Mathematics requires an investigation of those quantities of forces and their proportions that follow from any conditions that may be supposed. Then, coming down to physics, these proportions must be compared with the phenomena, so that it may be found out which conditions of forces apply to each kind of attracting bodies [8].

In Definition 8 for force at the beginning of the **Principia** Newton says "this concept is purely mathematical, for I am not considering the physical causes and sites of forces". Thus we could say that Newton differed from his predecessors in that he treated forces from a mathematical point of view instead of the physical. From the mathematical point of view any unbalanced force acting on a body is a quantity with magnitude and direction. In Book 1 Newton considers centripetal forces with a direction specified toward a center and the magnitude taken to vary as a function of distance from that center. In Book 2 Newton considers resistive forces with the direction specified opposite to the direction of motion and the magnitude varying as a function of velocity.

In Book 3 Newton considers gravitational forces and resistive forces arising from the inertia of the fluid from the physical point of view. Newton requires five conditions to be met for a component of a mathematically characterized force to be considered a physical force as follows:

1. The direction of the force must be determined by some material body other than the one it is acting on.
2. All aspects of the force's magnitude must be given by a general law such that the action and reaction forces are always the same magnitude but in opposite direction.
3. Some of the physical quantities in a force law must pertain to the other body in a way that determines the direction of the force.
4. The force law must hold for some forces that are indisputably real.
5. If the force acts on a macroscopic body, then it must be composed of forces acting on the microphysical parts of that body.

Notably absent from this list is anything about the mechanism or process effecting the force. Adherents of the "mechanical philosophy" such as Descartes and Huygens would have required not only a mechanism causing the force, but also a contact mechanism for delivering the force. Newton believed that progress could be made in determining the properties of the force mathematically even though not all aspects of the force were known, such as its cause and the mechanism by which it was delivered.

Newton was not the first to conclude that the forces between real bodies in the universe are very complex. He believed that an investigation of the microstructural forces within bodies was key to understanding the macro forces between bodies. This program is described in detail in the unpublished portion of the Preface to the **Principia** as given below:

> I therefore propose the inquiry whether or not there be many forces of this kind, never yet perceived, by which the particles of bodies agitate one another and coalesce into various structures. For if Nature be simple and pretty conformable to herself, causes will operate in the same kind of way in all phenomena, so that the motions of smaller bodies depend upon certain smaller forces just as the motions of larger bodies are ruled by the greater force of gravity. It remains therefore that we enquire by means of fitting experiments whether there are forces of this kind in nature, and then what are their properties, quantities, and effects. For if all natural motions of great or small bodies can be explained through such forces, nothing more will remain than to inquire the causes of gravity, magnetic attraction, and the other forces [9].

Although Newton was somewhat vague in his writings about how to make the transition from mathematically characterized forces to physically characterized forces, he did realize the potential of the microscopic forces for this purpose. Of course, he did specify the use of predictions of new or additional phenomena as a way of checking force laws. Here the process is to address the complexity of real forces in a sequence of successive approximations. Each force approximation is based upon certain idealizations with systematic deviations from it being used to improve the next version of the force law. Before Newton the small residual discrepancies between idealized theory and the real world were dismissed as being of no practical importance. After Newton every systematic deviation from current theory automatically has the status of a pressing unsolved problem.

Newton views these successive approximations for forces as exact. His fourth Rule for Natural Philosophy says:

> In experimental philosophy, propositions gathered from phenomena by induction should be considered either exact or very nearly true notwithstanding any contrary hypotheses, until yet other phenomena make such propositions either more exact or liable to exceptions. This rule should be followed so that arguments based on induction may not be nullified by hypotheses [10].

Attempting to proceed in successive approximations in this way involves restrictions on how second-order phenomena are to be marshaled as evidence. In the case of orbital motions in the solar system, any systematic discrepancy from the idealized theoretical motions had to be identified with a specific physical force—if not a gravitational force, then one governed by some other generic force law. However, not just any kind of force was permissible. Newton's first Rule for Natural Philosophy "no more causes … should be admitted than are both true and sufficient to explain their phenomena", has the effect of confining the number and type of forces to no more than the experimental data clearly demands. Requiring the force laws to be deduced from phenomena is a way of meeting this Rule. This approach is an attempt to limit risk in developing force theories as much as possible to just "inductive generalization". For example this restriction would preclude inventing unobservable forces due to dark matter and dark energy to "save" the Theory of General Relativity.

Newton acknowledged the risk of inductive generalization in his famous methodological passage in the Opticks, in the discussion of the methods of "analysis and synthesis" in the next to last paragraph of the final Query, which was added in 1706:

> The Analysis consists in making Experiments and Observations, and in drawing general Conclusions from them by Induction, and admitting of no Objections against the Conclusions, but such as are taken from Experiments, or other certain Truths. For Hypotheses are not to be regarded in experimental Philosophy. And although the arguing from Experiments and Observations by Induction be no Demonstration of general Conclusions; yet it is the best way of arguing which the Nature of Things admits of, and may be looked upon as so much the stronger, by how much the Induction is more general. And if no Exception occur from

> Phenomena, the Conclusion may be pronounced generally. But if at any time afterwards any Exception shall occur from Experiments, it may then begin to be pronounced with such Exceptions as occur. By this way of Analysis we may proceed from Compounds to Ingredients and from Motions to the Forces producing them; and in general, from Effects to their Causes, and from particular Causes to the more general ones, till the Argument end[s] in the most general [11].

Newton's arguments for a universal force of gravity and a universal force of inertia illustrated his new empirical approach to natural philosophy and physics in general. This new approach was based on a generic mathematical theory, the contrast between mathematical and physical points of view, the roles of deduced theory and idealizations in ongoing research, and the insistence on pushing theory far beyond its original experimental domain.

Newton's empirical approach to science was quite successful in his time in answering many questions in natural philosophy. In the area of electric and magnetic phenomena later investigators used Newton's approach to make significant progress in defining empirical mathematical laws. Ampere defined his circuital law relating magnetic fields to electric currents that produce them in 1826. Faraday defined his law of electromagnetic induction in 1831. Lenz defined his law for non-conservative electric fields in 1834. Gauss defined his law for electric fields and magnetism in 1835.

In 1861 Maxwell developed a theory of electrodynamics in the axiomatic fashion using fundamental axioms based on Gauss's empirical laws for electric and magnetic fields, plus a modified version of Ampere's empirical circuital law that included the displacement current in capacitors and dielectric materials, plus Faraday's empirical electromagnetic induction law plus Galilean relativity. This version of electrodynamics is defined in terms of Maxwell's set of differential equations. Maxwell also defined in 1861 a form of the Lorentz force law, which was later published by Lorentz in 1892. The Lorentz electrodynamic force law replaced the separate electric and magnetic force laws when combined with Maxwell's equations.

Maxwell's equations, the Lorentz force law, and Galilean relativity defined electrodynamics for the next 150 years. However, Maxwell's approach to electrodynamics was based upon the well-known approximation or idealization known as the point particle approximation. (See equation 1 where the second term on the right is not zero for finite size particles, but Maxwell dropped it). Also Maxwell's approach did not support Newton's 3^{rd} Law and conservation of energy for magnetic fields.

Point Particle Idealization $$\nabla \times \vec{B}(\vec{r},t) = \frac{4\pi}{c}\vec{J}(\vec{r},t) + \frac{1}{c}\nabla \int \frac{\nabla' \cdot \vec{J}(\vec{r}',t')}{|\vec{r}-\vec{r}'|} d^3r' = \frac{4\pi}{c}\vec{J}(\vec{r},t) \qquad (1)$$

In 1851 the Fizeau experiment was performed. The original analysis of this experiment appeared to indicate that Galilean relativity was inadequate to explain the results. That same year Hertz and Hallwachs [12] discovered that ultraviolet light incident upon crystalline metallic sodium (Na) surfaces caused ejections of negatively charged particles later identified as electrons.

In 1905 Einstein published his Nobel Prize winning paper "**On a Heuristic Viewpoint Concerning the Production and Transformation of Light**" [13] in which he suggested the existence of discrete quanta of light now called photons. Later experiments [14] found that the photoelectric effect using ultraviolet light was significantly reduced on the same metals if they had an amorphous structure versus a crystalline structure (see Figure 1 below). These experiments seemed to suggest that light does not exist as discrete quanta, but as waves. The crystalline lattice serves as an antenna array to receive sufficient energy from the waves to eject an electron from an atom. If the antenna is too small, as in the case of amorphous metals, the photoelectric effect did not occur or occurs much more weakly at the same wavelength as shown in the graph of Figure 1. Conversely if the wavelength of the light is too long for the size of the antenna, little energy is absorbed.

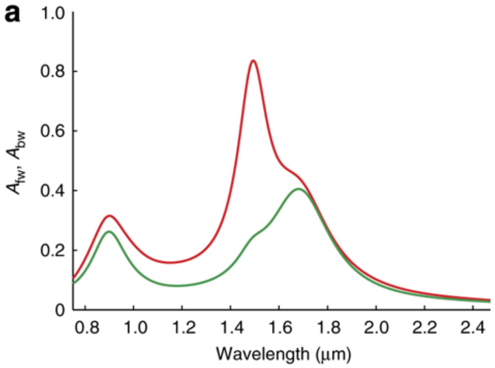


Figure 1 Absorption of light on Optical Antenna Array [14]

Also in 1905 Einstein published his Special Theory of Relativity [15] that appeared to offer a satisfactory explanation of the Fizeau experiment. According to the Theory of Special Relativity it is necessary to correct Maxwell's Equations for the effects of the finite velocity *c* of light. This correction was not based on the discovery of a new force, as Newton required, but on the hypothesis that light is a particle (photon) and that the speed of light is finite and independent of the motion of the source. This correction was made to Maxwell's equations resulting in a relativistic covariant formulation of electrodynamics (see equations 2-5). Equation (5) suggests that mass might be an electrodynamic quantity.

$$\vec{E}(\vec{r},\vec{v}) = \frac{q(1-\beta^2)\vec{r}}{r^3\left(1-\beta^2 sin^2\theta\right)^{3/2}} = \frac{q\left(1-\vec{\beta}^2\right)\vec{r}}{\left[\vec{r}^2 - \frac{\left\{\vec{r}\times\left(\vec{r}\times\vec{\beta}\right)\right\}^2}{\vec{r}^2}\right]^{3/2}} \quad (2)$$

$$\vec{B}_i(\vec{r},\vec{v}) = \frac{\vec{v}}{c}\times\vec{E}(\vec{r},\vec{v}) = \frac{q\left(1-\vec{\beta}^2\right)\vec{\beta}\times\vec{r}}{\left[\vec{r}^2 - \frac{\left\{\vec{r}\times\left(\vec{r}\times\vec{\beta}\right)\right\}^2}{\vec{r}^2}\right]^{3/2}} \quad (3)$$

$$\vec{F}(\vec{r},\vec{v}) = q'\left[\vec{E}(\vec{r},\vec{v}) + \frac{\vec{v}}{c}\times\vec{B}_i(\vec{r},\vec{v})\right] \quad (4)$$

$$E = mc^2 \quad (5)$$

Then in 1912 Ewald and in 1915 Oseen [16] discovered the extinction effect. According to the extinction effect light has a very short path length in media, even a man-made vacuum, before it is absorbed on an atom and re-emitted. After re-emission the source has the velocity of the moving absorbing medium. First Fox [17] in 1962 and then Renshaw [18] in 1996 showed that taking into account the extinction effect caused the data in the Fizeau experiment to support Galilean relativity perfectly and was in strong disagreement with Special Relativity Theory as shown in Figure 2.

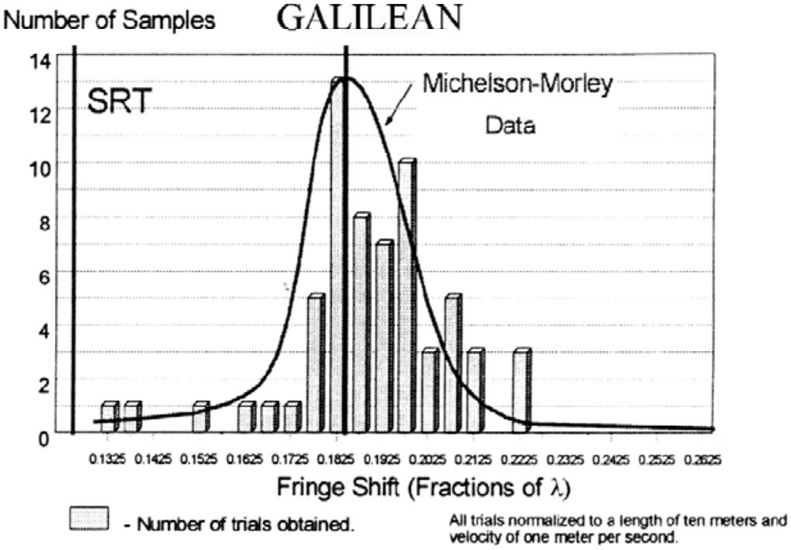


Figure 2 Fizeau Experiment Data Corrected for Extinction Effect [18]

With the advent of accelerators and scattering experiments the size and shape of elementary particles were measured. Elementary particles were not point particles. However, the relativistic equations (2-5) for the fields of charged particles moving near the speed of light were confirmed in accelerator experiments.

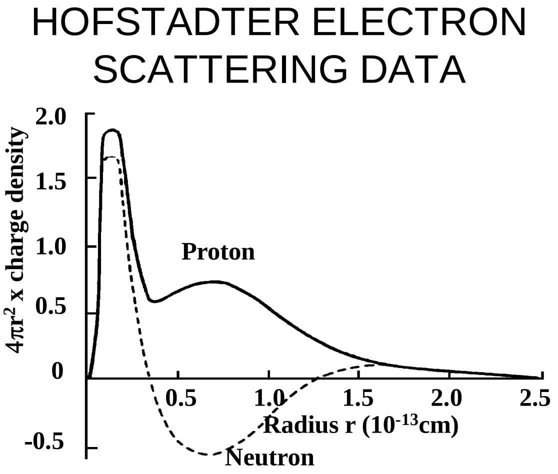


Figure 3 Electron Scattering Data for Proton and Neutron

According to Cullwick [19] and the experiments of Hooper [20] the fields of a moving charge remain "attached" to the moving charge. (See Figure 4 with iron filings showing the fields attached to a magnet). They are modified by the feedback effect according to Lenz's Law and Mach's Principle. Note that the retarded field method for moving charges pretends that the fields are no longer "attached" to the charged particle, but travel through some medium independent of the originating charged particle's motion and the resistance of the rest of the universe as expressed by Lenz's Law and Mach's Principle. The notion of retarded fields is not applicable for contact forces but only **"action-at-a-distance"** type forces. For a charged particle moving at constant velocity there is no radiation or retardation effects. Thus the retarded field methodology is inconsistent with experimental data and causality requiring contact forces.

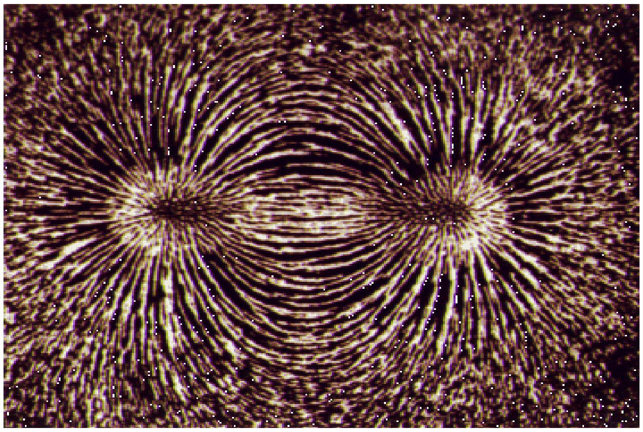


Figure 4 Iron Filings Showing Pattern of Magnetic Fields Attached to a Magnet

In 1977 Dr. Thomas Barnes of the Physics Department of the University of Texas at El Paso made the first attempt [21] to see what could be done to correct Maxwell's Equations for these approximations. Dr. Charles Lucas Jr. of Common Sense Science perfected the approach of Barnes [22]. In his papers Lucas removed the point particle approximation and added Lenz's law which supported Newton's 3rd Law and conservation of energy for magnetic fields to obtain a new and improved axiomatically derived electrodynamic force law. The Lorentz Force Law was derived as a consequence of the Galilean transformation. The resulting equations for the electric and magnetic fields (see equations 2-4) in the new force law were identical in the limit of constant velocity to the relativistic covariant Maxwell field equations that had been confirmed in particle accelerator experiments [23 p. 555 and 24 p. 560]. Thus there were no longer any significant electrodynamic experiments uniquely supporting Special Relativity Theory.

According to Newton's empirical scientific method with his Rules for Natural Philosophy, the simpler explanation for the relativistic type velocity field effects being due to finite size effects combined with Lenz's Law supporting conservation of energy for magnetic fields and Newton's 3rd Law, was preferred over having a second additional theory of relativity. Furthermore the problems that Special Relativity Theory had with the Fizeau experiment and the photo-electric experiment were solved. There was now no role for Special Relativity Theory in electrodynamics. Since relativity theory was presented as a universal theory by Einstein, it appears to be invalid everywhere if it is invalid in any one area, such as electrodynamics.

By defining an electrodynamic potential for the electrodynamic force for constant velocity, Lucas was able to extend the electrodynamic force to include acceleration a effects [18] (see equations 6-8). Thus he was able to predict radiation directly from the electrodynamic force law which was not possible to do directly from the relativistic covariant version of the electrodynamic force law, because Maxwell's electrodynamics did not conserve energy for magnetic fields. Thus for Maxwell's electrodynamics and the covariant version of electrodynamics built upon it one can not legitimately define a potential.

$$\boldsymbol{U(\vec{r},\vec{v}) = \frac{qq'}{r}\frac{\left(1-\frac{v^2}{c^2}\right)}{\left(1-\frac{v^2}{c^2}sin^2\theta\right)^{1/2}} = \frac{qq'\left(1-\frac{\vec{v}^2}{c^2}\right)}{\left[\vec{r}^2-\frac{\{\vec{r}\times\left(\vec{r}\times\frac{\vec{v}}{c}\right)\}^2}{\vec{r}^2}\right]^{1/2}}} \quad \textbf{(6)}$$

$$\boldsymbol{\frac{dU(\vec{r},\vec{v})}{dt} = -\vec{F}(\vec{r},\vec{v},\vec{a})\cdot\vec{v}} \quad \textbf{(7)}$$

$$\boldsymbol{\vec{F}(\vec{r},\vec{v},\vec{a}) = \frac{qq'}{\vec{r}^2}\frac{\left(1-\vec{\beta}^2\right)\vec{r}+\frac{2\vec{r}^2\vec{a}}{c^2}}{\left[\vec{r}^2-\frac{\{\vec{r}\times\left(\vec{r}\times\frac{\vec{v}}{c}\right)\}^2}{\vec{r}^2}\right]^{1/2}} - \frac{qq'\left(1-\vec{\beta}^2\right)}{\vec{r}^2}\frac{\left\{\left(\vec{r}\cdot\frac{\vec{v}}{c}\right)\vec{r}\times\left(\vec{r}\times\frac{\vec{v}}{c}\right)-(\vec{r}\cdot\vec{r})\vec{r}\times\left(\vec{r}\times\frac{\vec{a}}{c^2}\right)\right\}}{\left[\vec{r}^2-\frac{\left\{\vec{r}\times\left(\vec{r}\times\frac{\vec{v}}{c}\right)\right\}^2}{\vec{r}^2}\right]^{\frac{3}{2}}}} \quad \textbf{(8)}$$

Assuming that the charge in a finite-size elementary particle flows in closed loops [25-27], then the average work done on the particle by the electrodynamic force in emitting radiation is the negative of the power integrated over one period from τ_1 to τ_2

$$\boldsymbol{\int_{\tau_1}^{\tau_2}\vec{F}_{Rad}\cdot\vec{v}dt = \int_{\tau_1}^{\tau_2}-Pdt = -\int_{\tau_1}^{\tau_2}\frac{\mu_0 q^2\vec{a}^2}{6\pi c}dt = -\int_{\tau_1}^{\tau_2}\frac{\mu_0 q^2}{6\pi c}\frac{d\vec{v}}{dt}\cdot\frac{d\vec{v}}{dt}dt} \qquad \textbf{(9)}$$

Notice that we can integrate the above expression by parts. If we assume that there is periodicity in the charged particle structure, the boundary term in the integral by parts disappears to give

$$\int_{\tau_1}^{\tau_2} \vec{F}_{Rad} \cdot \vec{v}dt = -\frac{\mu_0 q^2}{6\pi c}\frac{d\vec{v}}{dt} \cdot \vec{v}|_{\tau_2} + \frac{\mu_0 q^2}{6\pi c}\frac{d\vec{v}}{dt} \cdot \vec{v}|_{\tau_1} + \int_{\tau_1}^{\tau_2} \frac{\mu_0 q^2}{6\pi c}\frac{d^2\vec{v}}{dt^2} \cdot \vec{v}dt$$

$$= 0 + \int_{\tau_1}^{\tau_2} \frac{\mu_0 q^2}{6\pi c}\frac{d\vec{a}}{dt} \cdot \vec{v}dt \qquad (10)$$

Thus we can identify the experimentally confirmed radiation reaction force [24, p. 748] as

$$\vec{F}_{Rad} = \frac{\mu_0 q^2}{6\pi c}\frac{d\vec{a}}{dt} \quad (11)$$

Albert Einstein said in his Nobel Prize award address:

> A theory is the more impressive the greater the simplicity of its premises, the more different kinds of things it relates, and the more extended is its area of applicability [28].

Thus Einstein would be the first to discard his theory of Special Relativity in favor of an improved electrodynamics.

Conclusion. Maxwell's axiomatic method for obtaining "Maxwell's Equations of Electrodynamics" by using the empirical electric and magnetic laws of Gauss, Ampere, and Faraday as the axioms or postulates has been improved by removing the point particle approximation and adding Lenz's Law as an additional axiom to support conservation of energy and Newton's 3rd Law for magnetic phenomena. This improved version of electrodynamics gives rise to the so-called "relativistic effects" in electrodynamics due to finite-size particle effects, conservation of energy, and Newton's 3rd Law. Following Newton's rule that no more causes of natural things are to be allowed than such as are both true and sufficient to explain the experimental data, we are forced to reject Einstein's Theory of Special Relativity. Also we are to reject it, because it is not in agreement with the Fizeau experiment and the photoelectric experiment. Furthermore, this improved version of electrodynamics is able to describe radiation and radiation reaction directly which the covariant version of electrodynamics fails to do properly, because of the inherent limitation of constant velocity in Einstein's Special Relativity Theory and Maxwell's electrodynamics.

References.

1. Isaac Newton, **The Principia, Mathematical Principles of Natural Philosophy: A New Translation**, translators I Bernard Cohen and Anne Whitman (University of California Press, Berkeley, 1999) p. 382.

2. **Ibid.** p. 943.

3. Isaac Newton, "An Account of the Book Entitled Commercium Epistolicum", reprinted in A. Rupert Hall, **Philosophers at War: The Quarrel between Newton and Leibniz** (Cambridge University Press, Cambridge, 1980), p. 312.

4. Christiaan Huygens, “Traite de la Lumiere”, in **Oeuvres completes de Christiaan Huygens, vol. 19** (The Hague: Martinus Nijhoff, 1937), p. 454.

5. Newton, **Principia**, p. 588.

6. **Ibid.** p. 588f.

7. Rene Descartes, **Principles of Philosophy**, trans. Valentine Rodger Miller and Reese P. Miller (D. Reidel, Dordrecht, 1983) , gravity in Propositions 20 – 27 and magnetism in Propositions 133-183 in Part 4.

8. Newton, **Principia**, p. 588.

9. A. Rupert Hall and Marie Boas Hall (editors) **Unpublished Scientific Papers of Isaac Newton** (Cambridge University Press, Cambridge, 1962), p. 307.

10. Curtis Wilson, “Predictive Astronomy in the Century after Kepler” in Rene Taton and Curtis Wilson editors **Planetary Astronomy from the Renaissance to the Rise of Astrophysics, Part A: Tycho Brahe to Newton** (Cambridge University Press, Cambridge, 1989), pp. 172-185.

11. Isaac Newton, **Opticks: or A Treatise of the Reflections, Refractions, Inflections and Colours of Light** (Dover, New York, 1952) p. 404.

12. Report of the Board of Regents By Smithsonian Institution. Board of Regents, United States National Museum, Smithsonian Institution, p. 293 (1913). http://books.google.com/books?id=ic0rAQAAIAAJ&pg=PA239#v=onepage&q&f=false

13. Albert Einstein, "Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt", **Ann. Phys. 17** (6): 132–148 (1915).

14. Daniel Dregely, et al., “3D Optical Yagi-Uda Nanoantenna Array” **Nature Communications 2, Article 267**, April 5, 2011.

15. Albert Einstein, "On the Electrodynamics of Moving Bodies", *Annalen der Physik* **17**: 891–921 (1905).

16. C. W. Oseen, “uber die Wechselwirkung Zwischen Zwei Elektischen Dipolen der Polarisationsebene in Kristallen und Flussigkeiten”, **Ann. Phys. 48**, 1-56 (1915).

17. J. G. Fox, “Experimental Evidence for the Second Postulate of Special Relativity”, Am. J. Phys., 30, p. 297-300 (1962).

18. Curt Renshaw, “Fresnel, Fizeau, Hoek, Michelson-Morley, Michelson-Gale and Sagnac in Aetherless Galilean Space”, **Galilean Electrodynamics, 7**, 103-108 (1996).

19. E. G. Cullwick, **Electromagnetism and Relativity** (Longsman Green and Co., 1957) p. 245.

20. W. J. Hooper, **New Horizons in Electric, Magnetic, and Gravitational Field Theory** (Electrodynamic Gravity, Inc., 543 Broad Blvd., Cuyahoga Falls, OH 44221, 1974), preface.

21. Thomas G. Barnes, **Foundations of Electricity and Magnetism – Third Edition** (Thomas G. Barnes publisher, 2115 North Kansas St., El Paso, TX 79902, 1977), pp. 368-384.

22. Charles W. Lucas, Jr., "The Universal Electrodynamic Force", **Proceedings of the Natural Philosophy Alliance Volume 8, 18th Annual Conference of the NPA, 6-9 July 2011 at the University of Maryland**, College Park, USA, pp. 387-396 (2011).

23. J. D. Jackson, **Classical Electrodynamics-Second Edition** (John Wiley and Sons, Inc., New York, 1975).

24. J. D. Jackson, **Classical Electrodynamics-Third Edition** (John Wiley and Sons, Inc., New York, 1999).

25. Charles W. Lucas, Jr., "Derivation of a Universal Electromagnetic Force Law for Finite-Size Elastic Charged Particles" **Proceedings of the Natural Philosophy Alliance Volume 2, No. 1, 12th Annual Conference of the NPA at the University of Connecticut,** Storrs, CT May 23-27, pp. 85-108 (2005).

26. Charles W. Lucas, Jr., "Derivation of the Classical Universal Electrodynamic Force Law", "The Electrodynamic Origin of the Force of Inertia", "The Electrodynamic Origin of the Force of Gravity", "A Classical Electrodynamic Theory of the Atom", "A Classical Electrodynamic Theory of the Nucleus", "A Classical Electrodynamic String Theory of Elementary Particles", "The Electrodynamic Origin of Life in Organic Molecules Such as DNA and Proteins" **13th Annual Conference of the Natural Philosophy Alliance (NPA), Volume 3,** University of Tulsa at Tulsa, OK April 3-7, 2006.

27. Charles W. Lucas, Jr., "A Classical Electromagnetic Theory of Elementary Particles" **Journal of New Energy, Vol. 6, No. 4**, **Proceedings of "Physics as a Science" International Workshop**, Arrecife, Lanzarote, Canary Islands July 1-5, 2002, pp. 81-109 (2002).

28. Albert Einstein, Nobel Prize in Physics Award Address, 1921.