Classical Two-Electron Relativistic Dynamics

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IV

ABSTRACT

This is the fourth report on a new research programme investigating the electromagnetic interaction. In contrast to the previous paper in this series, which analyzed the continuous interaction of pairs of charged point particles, this paper focuses on the hypothesis that the inter-electron interaction only occurs discontinuously over time. This new hypothesis is in response to the previous results showing that all continuous interaction (force) theories between point particles that exhibit inertial resistance to changes in their motion are inconsistent with asynchronous forms of action-at-a-distance or equivalently, interactions limited to points 'on their mutual light-cone'. It is shown here that the conventional approach to the special theory of relativity has been based on an implied merger of two distinct but incompatible theories. The continuous electric charge model (now used to develop Maxwell's Equations of classical electromagnetism) leads directly to Relativistic Transformations of the space and time co-ordinates; while Planck's 1906/7 Proposal for redefining an inertial point particle's momentum came to replace classical Newtonian mechanics with its central concept of invariant particle mass. However, both of these theories are fatally flawed: electricity is not continuous but is particulate (point electrons with finite and discrete charge and mass values) while Planck's relativistic derivation relied on a mysterious constant force that contradicts both the inverse square Coulomb force or the Heaviside velocity-sensitive force that are central to electromagnetism. An alternative model is now proposed here for the basic interaction between pairs of electrons that is shown to be consistent with classical electromagnetism and provides an alternative (but now readily understandable) physical explanation for the dynamical results of relativity without requiring the Relativistic transform to redefine the foundations of space and time. Physicists now must make a choice: they can continue to use continuum mathematics (grounded in the traditional calculus used to describe local but mass-less field theories that cover all of space and time, subject to the bizarre interpretations of relativity). Alternatively, theoretical physics can return to the physical models of impulse interactions between point particles (described by the mathematics of finite differences acting within the passive, but common-sense, view of space and time introduced by Newton in the *Principia)* but now acknowledging that the fundamental interaction is asynchronous. This latter choice means that the two interaction times must always be considered in a symmetric manner: the single-time approach can no longer be viewed as a suitable model of reality.

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1. INTRODUCTION & OVERVIEW

1.1 INTRODUCTION

Theoretical physics has lost touch with its roots. For over 200 years physics progressed steadily following the revolutionary innovations of Isaac Newton until around the middle of the 19^{th} century when two related changes altered the course of this fundamental science. These changes were based on the success of mathematicians in pushing natural philosophers onto the sidelines while raising the theoretical perspective over the empirical foundations that distinguished this shared investigation of natural philosophy from the rational speculations of mathematics. These major trends were personified by James Clerk Maxwell, who was the last of the natural philosophers able to conduct his own experiments while excelling in the use of the latest mathematics. It was Maxwell, the natural philosopher, who finally despaired of producing an understandable theory of electromagnetism. Maxwell was convinced that this phenomenon was grounded in a continuous ætherial medium, whose microscopic fluctuations could be represented mathematically by partial differential equations. Experimental scientists soon showed that Maxwell's metaphysical model was fundamentally wrong: electricity was not a stress or a strain in his ætherial medium but existed in the form of tiny, discrete particles that became known as electrons. For about 20 years, around 1900, several theoretical research programmes, described as 'the electrodynamics of moving bodies' focused on mixed models of Maxwell's æther and moving electrons. Most of this theorizing has since been discarded but one reworking of this activity has become a major pillar of modern physics: the Special Theory of Relativity. As Albert Einstein later admitted [1]: "The special theory of relativity grew out of the Maxwell electromagnetic equations." This paper will review this evolution and show that the wrong conclusions were drawn at this time and a fundamental change is now needed to construct a new theory of electromagnetism that centers on the reality of electrons and the invariant nature of their interactions. This paper could take as its epigram a sentence used in one of Einstein's own best-selling books [2]: "… we must first review the physical concepts of *time* and *velocity*."

1.1.1 RESEARCH PROGRAMME

This is the fourth paper in a series that documents a new research programme, which strikes out in a long-forgotten direction in natural philosophy that is constructed around a different theoretical perspective from the one followed over the last 150 years. The motivation, approach and mathematics adopted here are at odds with recent trends in physics but share many of the assumptions and attitudes of earlier theoretical views of natural philosophy. This new research is also grounded in the history of physics because it is often the unstated assumptions (made by earlier scientists), which have set the later course. Since the education of modern physicists includes almost no history of the evolution of physics, these implicit assumptions remain invisible and, therefore, remain unchallenged. In contrast to mathematics, the metaphysical assumptions of physics determine the range of research that is investigated. In the present programme, it is the challenge to the ancient "**Continuum Hypothesis**" that lies at the heart of the new research. This is the key metaphysical assumption (that is almost never made explicit) that reality is continuous so that continuous mathematics can be used to represent this view of the world. A close study of Newton's *Principia* [3] shows that Newton first viewed the world as truly discontinuous with separate interactions occurring between particles in the form of discrete impulses. In a subsequent need to solve his mathematical representations, Newton made the reasonable assumption of 'smallness' (which was valid in the case of gravity) to view these interactions as continuous (this resulted in the introduction of the corresponding concept of 'force'). The resulting new calculus was seized upon by mathematicians like LaPlace and Euler and physics was launched on its course of continuum mechanics ever since. Although physicists have now acknowledged that matter is discrete, theoreticians have persisted in still using the 'field' concept for its description, so that they can continue to use their beloved continuum mathematics – a toolset that has served them well for hundreds of years! The previous paper [4] explored the consequences of moving from the continuum model of electricity (charge density) to one constructed on a point-particle model of electrons. That paper still retained the standard continuous view of interactions between pairs of electrons but showed that this was inconsistent when electrons have inertial mass and only interact when they are 'on the light-cone'. As a result, this paper now removes this restriction of continuous interaction and investigates the effects of allowing the electrons to interact *discontinuously*. It is shown here that this gives a physical explanation for the results usually ascribed to relativity theory, which is now no longer needed. This controversial conclusion, although grounded in a simpler model of reality, will be strongly resisted, as was relativity in its own time.

Conservative Science

Research into human behavior has shown that humans are biased to selectively see evidence supportive of the conclusions they would like to reach, while ignoring evidence that goes against their preferences or subjecting it to special scrutiny. In this regard, scientists are no different from the rest of humanity, in spite of the claims that are sometimes made for being more objective. When it comes to examining the content of any new theory, it is always easier to stay with the crowd and ignore the new: this is especially true whenever the new theory threatens to obsolete the foundations of major intellectual investments. This has meant that the boundaries of **orthodox** science are always expanded in only an evolutionary manner. Revolutionary theoretical suggestions are either ignored or strongly resisted, as Einstein became well aware. Worse, there is an insidious form of self-censorship, which limits most professional scientists from making radical proposals for fear of the negative response of their more conservative colleagues. An example of this effect was quoted in a recent scholarly history of the electron [5] where G. J. Stoney (1826-1911) wrote just before he died, explaining why, although he had named the electron, he had <u>not</u> proposed the electron as an independent particle: "… the limits to allowable heterodoxy in science are soon reached."

Science clings to its Theories

This research programme is well aware of the conservative nature of all human beings to resist change: the rich history of science illustrates that this all too human trait extends to even the best scientists, in spite of all claims to rational objectivity. History shows that popular textbooks play a major role in persuading new generations of scientists of the 'truth' of the latest theories; this effect was illustrated with classical electromagnetism in the second paper [6] in this series. The pressure to 'publish or perish' that characterizes modern academic life means that even new research papers are often only read in a most cursory manner. None-the-less, this programme will continue to place its radical research programme in its historical and philosophical context so that the committed reader can appreciate that the ideas described here did not arise *sui generis*. This is the major justification for the inclusion of so much discussion here of the history and philosophy of relativity theory. It is obvious that orthodox science does not drop its theories, no matter how many anomalies they exhibit, <u>until</u> they can be replaced by better ones. This is the situation today with the three foundational theories of modern physics: Maxwell's EM, Einstein's Relativity and quantum mechanics. All physicists have built their whole careers on these foundations – they will literally resist changing them for other theories "to the death". Accordingly, this new theory must not only show that it can explain the anomalies and predict better agreement with experiment but it must also provide a better explanation for these 'shaky foundations' that the present theories. This will necessitate both historical and philosophical critiques to illustrate where the errors and mistaken assumptions entered in the first place. This is particularly true in the present situation where the new theory deliberately rejects the mathematical techniques and metaphysical assumptions that form the basis for all modern field theories.

Maxwell discovered the 'Truth'

This paper is part of the research programme that challenges the <u>direction</u> of theoretical physics that Maxwell established with his introduction of field theory into his model of electromagnetism. One can judge the difficulty of proposing any new theory of electromagnetism (EM) from the 1999 preface of J. D. Jackson's hugely influential graduate physics textbook [7], where he introduces electrodynamics: "… a subject whose fundamental basis was *completely* established theoretically 134 years ago by Maxwell and experimentally 110 years ago by Hertz." Since Maxwell had developed his theory around the now abandoned concept of the æther and electrons were not to be 'discovered' until 1897 this would seem to be an extreme commitment to the one-time, final discovery of the 'Truth'.

Einstein promoted Independence

A modern scientific 'Menshevik' has quoted Einstein [8] to encourage all scientists to make themselves more aware of their intellectual context: "A knowledge of the historical and philosophical background gives that kind of independence from the prejudices of his own generation from which most scientists suffer." Without this broadening perspective and the exposure of unchallenged assumptions, scientists will simply continue 'to add more bricks to the wall', when the real problem is a leaky roof or, even worse, the palace is being built on the beach.

The Unity of Science

As the polymath, David Berlinski has perceptively pointed out [9]: "modern biology is characterized by no continuous magnitudes, no real numbers and no mathematical analysis." This new research programme tries to help restore the unity of science by also eliminating this class of concepts that have been viewed as a necessary foundation for physics since Newton. In this programme, physics returns to integer arithmetic and combinatorial mathematics, leaving behind the old continuum concepts of force and acceleration and their mathematical representations: calculus and its differential equations that are viewed here only as approximation techniques whenever the number of interactions becomes very large.

Physics is always grounded in Points

Any theory of physics must start with the idea that all quantities are defined at points in space and time. In order for these points to be significant they must be distinguishable from the infinite numbers of points forming the manifolds of space and time. This implies that spatial separations are defined between specialized points: in the present theory, these points are the ones that define the location of each and every electron in the universe. All such distances must then be viewed as ratios, especially when measurements are involved, as they are defined relative to a standard of length. At a minimum, three points must be involved as one point alone is meaningless and two points cannot define a ratio until a third point is introduced. If no points in space were special (all are equal or 'spatial democracy') then the field approach would be appropriate as this is the mathematics of the universal continuum. However, modern experiments (bubble-chamber photographs etc) indicate that at any time some, small finite number of points demonstrate special characteristics from all the remaining, inactive points. These facts are interpreted here to indicate that the particle model is a more fundamental representation of reality.

Reality involves Entities

As was stated in the second paper in this series [6]: "real entities persist, real relationships occur and (real) events happen". Therefore, the universe of existence becomes the totality of real entity occurrences and their transformations and mutual interactions. In the present theory, all electrons are considered as real entities; in other words, each example of this class of objects is considered to have a permanent and unconditional existence, independent of the existence or activities of any other object in the universe. Mathematically, since electrons are also considered here to be 'point' objects with zero spatial extent then their existence is reflected as continuous (zero width) line trajectories across space throughout all of time.

Electrons are Points

The hypothesis that electrons are point objects follows Ockham's *Principle of Simplicity*; zero spatial extent eliminates all discussions of shape (sphere? ellipse? etc), size or sub-components (like electrical 'paint'). Finite sizes also introduce the possibility of rotation (which axis? how fast? why?). The point proposal is the simplest hypothesis that should be needed. This approach is contrasted with the mathematical idealization of the concept of the 'rigid body' that has played such an important role in physics to date; this will be shown in this paper to have introduced major fallacies into modern physics. This paper will limit the motion of an electron to the Newtonian recti-linear simple line, subject to Newton's first law of motion. Later papers will show that slightly more, complex trajectories introduce an explanation for the more intriguing phenomena of quantum physics.

Existence is All Electrons

The ultimate level of physical reality is not the single electron, viewed in isolation, but the **interactions** between pairs of electrons. This viewpoint defines existence as the totality of interacting electrons (and their composites); isolated, single objects are therefore 'meaningless', even though they have often been the focus of much of physics throughout history.

The Fact of the Act

The f*act* of the *act* of inter*act*ion defines existence; in other words, real objects always must interact. The present theory accepts a challenge issued in 1911 by W. F. Magie, Professor of Physics at Princeton, in his presidential address to the American Association for the Advancement of Science, after publicly criticizing the theory of relativity. "Magie concluded that the theory of relativity could not be fundamental because a fundamental theory must be *intelligible* to all people." [10] The present paper submits that the explanation for the various phenomena, that are seen to be the justification for the SRT, is in a simple model of how electrons interact with one another. This interaction appears to make the assumed continuous EM interaction (EM forces) to be speed dependent with drastic implications for the definition of the concept of time. The cause of this fundamental mistake in physics is the universal assumption of the continuity of interaction – the 'force' concept.

1.1.2 THE SECOND PILLAR OF MODERN PHYSICS

As mentioned above, modern physics is constructed upon the three continuum theories of classical EM, special relativity and quantum mechanics. The first paper in this programme [11] showed that a 4D extension of Hamilton's quaternions, referred to here as '*Natural Vectors'*, is a better representation for asynchronous interactions across space than the normal 3D spatial vector representation that Heaviside and Gibbs extracted from Hamilton's pioneering work. This viewpoint was demonstrated in the second paper [6], where classical EM was shown to be readily derived from a *Natural Vector* view of the continuous, charge-density model of electricity. That paper also showed that the limit definitions of velocity, current and charge density were in conflict and were inadequate for even a classical model of EM. The third paper [4] replaced this continuum approximation of electricity with a point model that reflects the experimental evidence for the real nature of the electron. This paper also showed that all continuous interaction (force) theories between point particles that exhibit inertial resistance to changes in their motion, such as electrons, are inconsistent with asynchronous forms of action-at-a-distance or equivalently, interactions limited to points 'on their mutual light-cone'. This paper now focuses on the hypothesis that the inter-electron interaction only occurs **discontinuously over time**. This will topple the second pillar in the temple of modern physics.

It is shown here that Einstein's Special Relativity Theory (SRT) clearly emerged from the late 19th century investigations of 'electrons' in motion that still interacted via Maxwell's EM æther. The implicit continuum model of EM was present in all of these theories that centered on the concept of 'force-density' that was linked to experimental observations through the so-called '*Lorentz force law*' defining the motion of charged point particles. It was Einstein's own attempt to preserve the **form** (covariance) of the partial differential mathematical representation of classical EM (Maxwell's Equations), that resulted in the need to change the very nature of the foundational ideas of space and time that had served physics so well since Newton. It will be shown that the resulting '*Relativistic Transformations*' are a direct consequence of imposing this continuum model on EM while assuming that 'light' is an object that travels across space over time at a constant speed, no matter how light is 'observed', a bizarre feature that corresponds to no other real object in physics. This has since been interpreted to mean that all physics theories must be 'Lorentz invariant'. The present paper shows that this is only a requirement for all continuous field theories, which the present programme rejects *in toto*.

This paper presents a new approach to the analysis of the discontinuous dynamics generated by the exclusive interactions between two electrons. It is necessary to establish the historical context for this area of physics as all earlier efforts have, surprisingly, failed to make much progress with this 'simple' model, even though electrons and their interactions have been investigated theoretically for over 100 years and the classical two-body problem was the archetype of classical mechanics.

It's all about Time

The essence of the present theory of electron interactions is covered by the phrase "It's all in the timing." Mathematically, this focuses attention on the idea of 'phase' indicating that **when** an interaction occurs becomes the most important factor in the new dynamics. In contrast, traditional physics focused only on relative spatial separations as interactions where always viewed as continuous, so that when they occurred became irrelevant, only where was important. Indeed, in the search for 'invariants', the explicit goal has been to eliminate all references to time.

Einstein also began with Time

This research programme shares the same starting point as Einstein: namely, **time**. As he wrote to Michele Besso (one of his oldest friends) in 1905 [12]: "An analysis of the concept of time was my solution. Time cannot be defined absolutely and there is an inseparable relationship between time and signal velocity." However, this new programme explicitly returns to the original Newtonian view of space and time; spatial and temporal *differences* are invariant everywhere, the rate that time 'flows' is universal. The restoration of this 'old fashioned' view is one of the objectives here and will be justified in this paper, where a clear distinction is made between cyclic processes in nature and the frequency of interaction by moving electrons. In keeping with this emphasis on time, many historical contributions to the present research are included. In the present case, with its focus on the special theory of relativity, the cursory modern treatment to this historical context is even more important. This will attempt to correct the usual omission of the important contributions of major physicists whose work in this area preceded Einstein.

The Centrality of Time, not Geometry

One of the principal objectives of this present research programme is to restore the concept of *time* (and its 'twin', *change*) to the center of physics, replacing the centrality of timeless *geometry* and the mathematical concept of the *infinite* that have been the focus for the last 150 years and have resulted in today's exclusive obsession with (continuum) field theories.

Defining Time

Time is defined here as the ordered sequence of interactions across space, where each electron's trajectory through space is the historical record of its interactions with other electrons. Time and existence are always philosophical 'siblings'.

Mass & Energy

The equivalence of *mass* and *energy*, which is widely attributed to Einstein, has brought an esoteric theory in mathematical physics to the broad attention of all educated people throughout the world. The reality of nuclear weapons is taken as the direct proof of Einstein's Special Theory of Relativity. This paper will show that this is a massive simplification of what is actually a major metaphysical but faulty revision of the foundational concepts of natural philosophy. Ironically, these two central concepts are not only difficult to define by non-physicists but have actually always presented a conceptual challenge to professional physicists, as Max Jammer has demonstrated in his prize-winning investigations into these basic concepts [13]. This programme, which follows Newton, takes a totally particulate view of the world, so mass is defined here as each particle's intrinsic ability to resist motional changes generated by all the other particles in the universe, while energy is the capability in any situation to generate changes in the motion of other particles. Logically, the concept of *generation* may be viewed as the complement of *resistance* when the totality of motion is conserved.

Electricity is the Electron

It is now the undisputed view that electricity occurs in the form of electrons. In the present theory, these are posited to exist exclusively in the form of true point particles. Electrons, in order to exist as particles, must retain their identity continuously across space over time, with no two electrons occupying the same spatial point at the same instance. This requirement was shown in a prior paper [6] that representing the space and time parameters of an electron by a specific form of Hamilton's quaternions (referred to in this programme as *Natural Vectors*) was sufficient to ensure that even <u>classical</u> electrons could be treated as anti-symmetric *fermions*, a result that is normally thought to be only associated with quantum mechanics.

Pure Electron Theory

As described in the second paper in this series [6], this research programme is grounded in the metaphysical proposition that the world exists exclusively in the form of electrons, even though the widely accepted Standard Model of Physics views electrons as just one of the several 'fields' from which all forms of matter are constructed. It is the primary objective of this research programme to justify this new view of electrons. Every other electron theory, from Lorentz to Dirac, has been a *hybrid theory* of discrete particle parameters (e, m, etc) and continuous fields ($\underline{E}$ and $\underline{B}$ etc). Any finite theory of electrons must eliminate all reference to fields since these 'objects' are infinite in extent and infinitely divisible in space and time. The logical approach is to acknowledge the experimental fact that electricity always appears at discrete points in space with finite value (e) while continuous charge density concepts have no basis in reality: they are only convenient mathematical fictions in certain approximations. The 'existence' of these mathematical intermediaries is totally problematic and remains completely unjustified. The introduction of a so-called "relativity principle" (preserving just the <u>form</u> of any microscopic equations involving these concepts) should be used to justify the complete overthrow of Newtonian physics is ludicrous.

Interactions cannot be Continuous

The third paper in this series [4] demonstrated that all continuous theories of interactions between point particles that exhibit inertial resistance to changes in their motion (like electrons) are inconsistent with all asynchronous action-at-a-distance forms of interaction (like the EM interaction). In other words, if inertial particles are limited to interactions 'on their mutual light-cone' then **the interaction cannot be continuous**: the 'force' concept must be replaced by a set of discrete impulses that remain always separated in time. This is the opposite of the Continuum Hypothesis, which has motivated physics since Newton introduced the calculus as a computational scheme; physics must now adopt a more suitable discrete mathematics. A simple extension of the calculus of finite differences is introduced later in this paper for this purpose.

1.1.3 OBJECTIVES

The principal objective of this paper is to demonstrate that the non-Newtonian behavior of high-speed, charged point particles can best be explained by a dynamical theory of electrons that only interact discontinuously. In reaching this conclusion, it will be necessary to also show that the traditional relativistic theories of EM and mechanics are deeply flawed theoretical creations that had their origins in older, discarded theories of 19th century electromagnetism. This paper will show that the conventional approach to the special theory of relativity has been based on an implied merger of two distinct but incompatible theories. The continuous electric charge model (now used to develop Maxwell's Equations of classical electromagnetism) leads directly to Relativistic Transformations of the space and time co-ordinates; while Planck's 1906/7 Proposal for redefining an inertial point particle's momentum came to replace classical Newtonian mechanics with its own central concept of invariant particle mass. It will be shown that both of these theories are fatally flawed: electricity is not continuous but is particulate (point electrons with finite and discrete charge and mass values) while Planck's relativistic derivation relied on a mysterious constant force that contradicts the so-called 'Lorentz force law' that is also now central to electromagnetism. It will be shown that it is the implicit metaphysical assumptions concerning the nature of light and the EM interaction that have resulted in theories that are simple in their mathematics but meaningless in their physics.

An alternative EM model for the basic interaction between pairs of electrons will be shown to be consistent with extended forms of both classical mechanics and classical electromagnetism. This new, simple model provides an alternative, but now readily understandable, physical explanation for the dynamical results of relativity without requiring the central Relativistic Transformations used to redefine the foundations of space and time. Theoretical physics can now return to the original physical models of impulse interactions between point particles (described by the mathematics of finite differences acting within the passive, but common-sense, view of space and time introduced by Newton in the *Principia)*.

The second objective is again to remind physicists of the value of studying both philosophy and the history of science. The ongoing use of the Continuum Hypothesis has remained unchallenged to date because it has remained implicit for so long that it has become part of the knowledge base of all professional physicists in the 20th century. Earlier, natural philosophers were aware of this assumption as their education was grounded in both history and philosophy. So, in keeping to the stated methodology of this research programme, many relevant summaries of the historical contributions of major physicists and philosophers will continue to be re-introduced since another lesson learned from the history of science is to challenge the conservative belief that fundamental science evolves incrementally. Whenever a major contributor is mentioned, his life-dates will be included as these temporal milestones indicate how scientific progress has been built on a network of innovation: one that more reflects a Hegelian radical dialectic rather than a Darwinian evolutionary progression.

1.2 OVERVIEW

In this overview, the contents are summarized by including a brief description of each section and the major reasons the particular material has been included. This overview permits the reader to gain a sense of this whole (large) paper without having to make a major time commitment. The paper's 'Summary and Conclusions' focuses on the implications of all this material and the new results obtained. The paper again ends with a brief preview of some of the remaining papers in this new research, which now adds the quantization of action to the constraints on the electron interaction. This begins the next group of papers that focus on quantum electromagnetism (QEM).

1.2.1 A NEW APPROACH TO EM

New EM Theory avoids Relativistic Transforms

The new theory of electromagnetism presented in the current series of papers is deliberately not Lorentz-invariant, as this is an action-at-a-distance theory not a field theory. It is one of the major contentions in this paper that it the internal logic of purely local field theories that demands the imposition of relativistic transformations. As a new theory of EM interactions between pairs of electrons, its mathematical structure is now purely relational, based only on differences of time, position and relative velocity at the 'emission' and 'absorption' times of the electrons involved in each interaction. As such, the equations are invariant with respect to all motion of any frame of reference used to establish all numerical values for such equations. It is also totally independent of the motion of any third-party observer that does not participate in the interaction. The conventional approach to mathematical invariance is rejected here and replaced by one grounded in physical principles.

Philosophy Redux

This paper continues to include major discussions on the philosophical foundations of each of the topics covered in the research that is being reported. This not only reflects the view that physics without philosophy is simply mathematics but contends that it is the philosophical ideas that drive progress in theoretical physics. New ideas are critical to progress and these are not the addition of new terms in old mathematical equations. Since this theory presents a radically new theory of the electromagnetic interaction between electrons that explicitly does **not** comply with the relativistic transforms that have dominated 20th century physics, it is vital to show that it is Einstein's theory of relativity that is the weaker physics theory. The view taken here is that this foundation of modern physics is simply a mathematical theory, which is riddled with weak metaphysical assumptions. Many of Einstein's contemporaries were well aware of this perspective and were not convinced by its mathematical simplicity. Since modern students of physics (and their professors) are now almost completely unaware of the historical controversies that surrounded this subject, these issues have been re-awakened and are summarized herein. This is doubly important, as most of these controversies were **not** resolved – only that Einstein's doubters died off and their challenges died with them. Textbook authors and revisionist historians of science have long since covered up most of these unanswered issues. The mathematicians that now dominate theoretical physics are very uncomfortable with philosophical discussions, even though this was central to the evolution of natural philosophy prior to 1900; they would much rather let 'sleeping dogs lie'. This programme intends to bark very loudly.

Extending Newton's Metaphysics

This research programme views the introduction of field theory techniques by Maxwell as the most serious mistake in the evolution of physics. This was not only incompatible with the solid foundations laid down by Newton but unwittingly laid the trap that Einstein fell into. One of the major methodological principles that has guided this research programme is the idea that concepts that have proven successful in physics should only be modified rather than replaced. Classical physics was based on Newton's concepts of the *particle* and the *interactions* between them. Maxwell rejected this metaphysical perspective (as was described in an earlier paper [6]) and constructed his own EM theory on DesCartes' radically opposed continuum model of the *plenum* that extended everywhere throughout space. As an admirer of Newton, Maxwell still tried to hold onto Newton's dynamical concepts, like force. The heart of this core problem is that Maxwell wanted a continuous medium that would propagate variations (waves) through space with a finite speed whereas Newton's major force concept (gravity) was introduced as crossing unlimited space in zero time between localized particle collections, in other words, with an infinite speed of propagation of the interaction. This programme goes back to Newton's metaphysics but adds finite time delays when electrons interact remotely, as Gauss had suggested.

Newton introduced Dualities

It was Newton, who intuitively realized that fundamental concepts describing reality must be introduced as dualities. Except when concepts are introduced in terms of direct human experience (e.g. *love*), abstract verbal (and mathematical) definitions must be defined in terms of other concepts, as is readily discovered in trying to trace the roots of reality in any dictionary. As such, Newton introduced his key metaphysical concepts of *mass* and *impulse* in terms of each other in his second Law of Motion: the foundation of Classical Mechanics. These particulate concepts remain the bedrock of the present theory and are elaborated explicitly later in this paper.

1.2.2 ELECTRODYNAMICS & MOTION

There are many ways to approach Einstein's Special Relativity Theory (SRT). The approach taken here is to focus on the central role of the so-called 'Lorentz' transformations (LT), as these ultimately appear in every formulation of SRT. This was the view that even Einstein himself eventually took when he wrote in 1935 [1] that: "the Lorentz transformations were the real basis of the special theory of relativity." This paper therefore sets these transforms in their original historical context – electromagnetic research in the late 19th and early years of the 20th Century. It will be shown that the only commonality between Einstein's *kinematical* SRT and Planck's *dynamical* theory of relativistic particle dynamics is the appearance but **not** the use of the LT; this fact is important, as it is only dynamical, physical situations that can be measured experimentally. An analysis of the metaphysical assumptions that are rarely stated within these theories will demonstrate that none of these theories is a suitable basis for describing the real behavior of particulate electricity when high-speed relative velocities are involved.

1.2.2.1 Nineteenth Century EM

Ironically, by 1870, in terms of the metaphysics of electricity, the physicists of Continental Europe and Britain had switched their historical allegiances. Following LaPlace, the Continentalists had become accustomed to applying Newtonian action-at-a-distance mechanics to the study of electricity and this had resulted in the EM theories of Weber and Neumann (see [6]). In England, the Cartesian view of the æther was widely accepted due to Maxwell's EM theory of light. Hertz later merged these two theoretical approaches when he experimentally tried to verify Maxwell's radiation predictions. Hertz created his own hybrid axiomatic theory that incorporated many of Maxwell's equations, especially the wave equation *in vacuo*. This equation did not explicitly include any references to sources (never a strong point in Maxwell's own theory) so Einstein subsequently assumed (incorrectly) that Maxwellian EM waves ('light') were independent of the velocity or acceleration of the electrical sources. Lorenz [14] had already shown that the (optical) electric force vector $\underline{E}$ was due to the net motional activity of all the remote electrical sources. The deep message in these EM theories was that the new universal speed parameter *c* was independent of the motion of all electrical sources and receivers that are interacting across space and time.

In order to focus on the new features of the electron interaction, it will be first necessary to review its appearance and role in classical electromagnetic theory around 1900. This was an especially critical time for theoretical physics, as it was the time when a purely mathematical approach was displacing the older tradition of natural philosophy. More and more equations were being introduced, for mathematical reasons, rather than to represent a model that had first been visualized. This left the classical theories with several major problems that are reviewed in this part of the paper. These problems are grounded in Maxwell's original model of a continuous medium and the introduction of an asynchronous interaction across space. All experimental attempts to demonstrate these features failed but Maxwell's mathematical theory was 'patched up' with bizarre metaphysical suggestions, like FitzGerald's length contraction hypothesis and Lorentz's lacuna-like theory of the electron.

1.2.2.2 Experimental Anomalies

Early experiments, like those of Michelson and Kaufmann, preceded the development of relativity theory and attempts to provide theoretical explanations for each of them were the driving force in this theory's evolution. Although the famous Michelson-Morley experiments are often cited as the 'reason' for the development of the SRT, Einstein himself claimed that he was unaware of them in 1905. Section 2.2 also demonstrates that these optical results were really only a problem for the Maxwellian theory of EM. The more significant results were those published from 1901 by Kaufmann that *seemed* to show that the electron's inertial mass increased with relative velocity. Einstein was very well aware of these results and they were alluded to implicitly in the final section of his famous 1905 paper where they were derived from the kinematical perspective of the Lorentz transformation. Even today, this dramatic phenomenon is used to justify the SRT – an alternative, dynamical explanation forms the central result of the present paper.

1.2.2.3 Relativistic Transformation Theory

The focus of section 2.3 is a critical study of the Relativistic Transformation, from its early introduction by Voigt until its final re-appearance by Einstein, nearly twenty years later. All earlier investigators of this transform viewed it simply as an exercise in mathematics; only Einstein felt that it reflected a metaphysical transformation of the very foundations of physics. Many studies of the history of relativity still fail to mention the active contributions of the British school of electrodynamics, centered on the innovative work of Larmor at Cambridge. Almost all the results that were later published by (and attributed to) Lorentz first appeared in this programme that viewed the FitzGerald contraction as evidence <u>for</u> this theory. Larmor saw his electrons as special points **in** the ætherial medium; his rival, Lorentz saw his own model of the electrons as independent particles **of** electricity that communicated through the æther. Through a series of increasingly complicated hypotheses, Lorentz eventually proposed the same set of space-time transformations as Larmor had done; but soon after, Poincaré chose to name these after Lorentz. The most innovative part of Lorentz's evolutionary process was the step where he defined a new combination of space, time and local velocity into a new concept that he designated as 'local time'. Since Einstein's formulation of SRT was built on two 'postulates', this study presents them again in their historical context, not least because Poincaré had already published the first one (the 'Principle of Relativity') ten years before Einstein, who failed to cite this earlier work (a failure repeated several times in his famous 1905 relativity paper). Poincaré's other major contributions in this area, including the constancy of light signals, are also reviewed to explain why some historians have referred to this as the 'Poincaré-Lorentz Relativity Theory'.

1.2.2.4 Einstein's 1905 Relativity Theory

Section 2.4 draws out some new or little known insights into Einstein's famous 1905 paper on special relativity. This is included because there are several major misunderstandings surrounding this work that continue to distort basic research in contemporary theoretical physics. The most important point here is that only a few studies of relativity have emphasized that the SRT is a *kinematical* theory, not a *dynamical* theory; that is, the relativistic effects are only a consequence of the mathematical transformations of the co-ordinates of space and time (or motion) as calculated from two inertial reference frames in relative, straight-line motion. The present electron theory and the earlier electron theories of Larmor and Lorentz, are all constructed around physical hypotheses proposed to model the interaction between electrons. In contrast, Einstein's theory is applied to an empty world devoid of real material, like electrons - it applies to space-time itself, when viewed as an ontological entity in its own right. The only 'explanation' for these strange effects is the hypothesis that light always moves at the same speed when observed from different reference frames in constant relative motion. There is no explanation for this bizarre behavior of 'light', which would be incomprehensible for any real object. Contrary to the claims made in many modern expositions of relativity, there is <u>no experimental evidence</u> for this behavior: Einstein was truly revolutionary for constructing his theory around this hypothesis, although it was vigorously opposed by most of his contemporaries, who were all committed to an æther model of light. Although Einstein proposed some 'thought' experiments to <u>define</u> these basic parameters these techniques are *never* used in the real world to measure the motion of real objects, especially as his radical methodology was built around the mathematical idealization of a 'rigid body'. This concept was truly central to Einstein's approach but it leads to logical contradictions that are rarely mentioned. The whole issue of <u>changes</u> in the velocity of a particle conflicts with the idea that this is a theory of relative, <u>fixed</u> velocities. Nonetheless, this theory has been applied to dynamical situations ever since: but this is shown in section 3.2 to be due to the widespread use of "Planck's Proposal" for relativistic momentum, not Einstein's SRT. There is no logical connection between these two theories and both are rejected in the present paper, on the basis that they are only mathematical theories that do not correspond to physical reality.

1.2.3 REACTIONS TO SPECIAL RELATIVITY

Section three examines the influential role that Einstein's SRT eventually achieved in modern physics. Again, a historical approach is followed because the lack of historical awareness has given the mistaken impression that this theory exploded on the scene and immediately swept away all its rivals. Historians have shown this was very much *not* the case. Many of the major criticisms of the SRT that were made by Einstein's contemporaries are revived here because they are powerful arguments that have never been rebutted. It was simply the case that all of these critics eventually died, none ever being convinced of the validity of the SRT, so their criticisms disappeared with them. It is time that the area of EM interactions between high-speed particles was put on a firmer foundation, building on known experimental facts.

1.2.3.1 Planck's Role in Relativity

Although in the popular (and often, professional) mind the theory of relativity is associated with the name of Albert Einstein (43 million Google hits) there is little awareness of the critical role played by Max Planck. This omission is corrected here because Planck's dangerous metaphysical position has become the dominant (but implicit) viewpoint in theoretical physics today. This viewpoint has taken on a totalitarian character and now excludes any theory that threatens its own metaphysical assumptions. In addition to supporting Einstein's career, Planck was the first physicist to extend relativity and encouraged his own research team to work in this area. Planck's key role in relativity illustrates the power of cultural forces in science.

In 1905, Einstein (following in his mentor's footsteps) began with the <u>mathematical</u> hypothesis that the (phase) speed of light is always constant in all inertial frames of reference. This immediately resulted in the 'derivation' of the relativistic transformation formulas. As each of these hypotheses was mathematical in origin, it has meant that physicists have since mostly failed to understand the <u>physical</u> meaning of relativity even though these ideas have formed the basis of all 20th Century physics in quantum mechanics and relativistic field theory. Today, since almost all theoretical physicists behave like mathematicians and rarely puzzle over philosophical 'baggage', like physical meaning, this Planckian-approach has become the 'norm', with the search always continuing for a new and more powerful starting equation. It is not surprising that theoretical physics has not progressed beyond astonishingly accurate calculations of the 'simple' hydrogen atom.

1.2.3.2 Planck's Momentum Proposal

As is shown in detail in section 3.2, it was "Planck's Proposal" for redefining Newton's concept of a particle's intrinsic momentum that has actually become the basis for applying a relativistic perspective in modern physics rather than Einstein's kinematical theory. It is shown here that Planck's redefinition is fundamentally flawed and needs replacing; this is achieved in the present paper by demonstrating that the dynamical effects of relative, high-speed motion arise from a reduction in the frequency of interaction with speed, not with the mysterious increase in the inertial mass of the foundational objects in the world. This revised approach returns to Newton's metaphysical model of the world, not Maxwell's incorrect æther theory.

1.2.3.3 Resistance to Relativity

This section summarizes Goldberg's account of the spread of relativity through the major communities of physicists in the first half of the 20th Century. This information is included here as it first documents the misconception prevalent today that Einstein's SRT swept all before it; this account also well illustrates the unflinching resistance that usually greets any radical theory that challenges the metaphysical assumptions of the existing orthodox views of the world. Once again, the crucial role of textbooks in establishing the standard view of the world is demonstrated: culture usually pre-empts evidence.

1.2.3.4 Acceptance of Relativity

Goldberg documents how it was the experimental 'confirmation' of Einstein's prediction of the extra measure of bending of starlight by Arthur Eddington in 1919 that triggered the acceptance process of the special theory of relativity by professional physicists. Major historical texts have shown how the mathematical formalism of SRT was readily adopted but the physical meaning ascribed to the symbols in these equations remained in dispute and was never resolved. Ultimately, it was the new developments in atomic physics that diverted the physics community away from further study of theoretical EM or SRT.

1.2.3.5 Modern Views on Relativity

This section briefly reviews some of the more insightful analyses of SRT since the conventional presentations (mainly just mathematical) are well represented in numerous textbooks. Einstein's approach to relativity is now taught everywhere with little mention of its roots, its philosophical meaning or the criticisms that it has accumulated over the last 100 years. Like most subjects now in theoretical physics, its mathematical content makes it straightforward to teach and to examine. Since it appears to be universally accepted it is professional suicide to criticize this theory in print. Its few critics today are limited to a handful of retired ex-physicists, while the uncensored Internet is flooded with vituperative arguments over its validity.

1.2.3.6 Experimental Confirmation

Einstein was correct to view the 'Constancy of Light Speed' as a postulate when constructing his SRT; contrary to another widespread misconception, this hypothesis is not a fact that has ever been verified experimentally. This section examines the actual experimental evidence for believing that the SRT is a valid description of reality. Particular attention is paid to the decay of high-speed 'elementary' particles as this phenomenon is usually quoted as direct evidence for the temporal component of the relativistic co-ordinate transformations. The evidence for the SRT views of space, mass and energy are also critically reviewed.

1.2.4 METAPHYSICS OF SPECIAL RELATIVITY

The common feature of all the research programmes that have investigated the two-electron problem is the assumption that the EM interaction occurs continuously between the two electrons. Since this assumption had always worked successfully for classical mechanics, it has never appeared necessary to challenge this universal "Continuum Hypothesis". One of the basic perspectives of this research programme is that the microscopic world is fundamentally discrete and, as a result, this discontinuous view is here extended to the nature of the EM interaction itself. In the previous paper [4], it was shown that the continuous interaction model is incompatible with the two requirements that electrons are inertial particles and they only interact when they are "on each other's light-cones". This section investigates the key metaphysical assumptions that form the foundations of Einstein's SRT that are never made explicit, not even by Einstein himself, who was comfortable working within the shared metaphysical tradition of 19th century physics. This section examines these assumptions in light of more recent developments during the 20th century.

1.2.4.1 Continuity in Classical Physics

Ever since Newton, physicists have accepted the concept of 'force' and its implicit continuous interactions with the 'target' particle that is usually the focus of simplistic physical theories. Einstein explicitly adopted Euler's concept of a 'rigid body' to construct his continuous representation of space in three dimensions. Motion through this space (by observers?) is always viewed as continuous, as is any acceleration of inertial particles generated by continuous forces. In Einstein's original 1905 paper, the only motion discussed is between relative observers and the implied motion of light as viewed by these observers. The final section of this famous paper analyzed the change of position of an electrically charged particle, viewed by the two observers, when subjected to a brief EM force that lasted for a "very short instance of time".

The use of real numbers (or their algebraic placeholders) in any theory of physics will always imply the real continuity of interactions, as the difference between any two real numbers representing the same variable can always be made infinitely small. All field theories introduce mathematical variables that are represented by real numbers, which are always defined everywhere throughout space and vary continuously over time. As a result, any theory (like Einstein's SRT) constructed from the prototypical field theory, namely Maxwell's theory of EM, will inevitably smuggle in metaphysical assumptions.

1.2.4.2 Rigid Bodies

The EM interaction has been shown experimentally to act asynchronously (finite delays), which implies that the time at the source is always different from the time at the receiver. None-the-less, physics has persisted in constructing its EM theories around a **single** time parameter, as Newton did for his instantaneous gravitational force. Maxwell's field theory reduced the EM world to a single point in his material æther. Einstein explicitly introduced Euler's rigid rods that could be moved as a single unit, so that its two ends could be defined to have the same time (at least in its own 'rest' frame), no matter how far apart the ends of this rod are apart; when one end moves, so does the whole rod, instantaneously. As an alternative to this 'global' view, several popular relativistic derivations erroneously develop their results using either 'point collisions' or the 'instantaneous' Coulomb electro-static force: results at a single point that are equally fictitious.

1.2.4.3 Light as an Entity

Einstein never acknowledged that he assumed that he viewed light as an entity that propagates independently across space. The reason he never made this assumption explicit is that it is one shared by almost every one of his professional colleagues – they only disagree on whether this 'object' is a wave or a particle. Einstein himself oscillated between these two views, sometimes proposing light as a particle (or 'photon') for explaining the photo-electric effect or as a wave when he created his EM theory of relativity. Today's sophisticated field theorists have rejected the æther as a valid entity but are still happy to talk about EM fields "in space" or "virtual photons" with no directly measurable properties. All of these old metaphysical views of light (theory) are rejected in the present programme which views 'light' as the *interaction between electrons* (fact).

1.2.4.4 The Role of Time

Time is the central concept in physics – which might be called the study of changes in the material world. Since this is a very difficult idea to think about (as Einstein realized) great simplifications are usually assumed: often modeled on analogies with the ideas of space. Even our shared natural languages reflect this technique: many of our temporal prepositions (like 'after') are actually direct spatial analogues (like 'near'). Only our memories give us a sense of time, while vast amounts of human cortex are devoted to real-time, visual (spatial) processing. These spatial analogues have been imported into physics in the mathematical representations of time, sometimes implicitly, as in Newton's fluxions and at other times explicitly, as in Minkowski's four-dimensional 'space'. This new research programme brings *time* back to center-stage and emphasizes its distinct character relative to the three dimensions of space: process and change will not disappear into another geometry. The present theory recognizes that in any symmetric asynchronous interaction between two electrons there is no single privileged time, both times are equally important; the light-cone condition shows that it is the absolute difference between these two times that characterizes all EM interactions. This view is reflected in the *Natural Vector* representation adopted here.

1.2.4.5 The Principle of Relativity

Einstein abstracted from Maxwell's Equations *in vacuo* the idea that the structure of these equations should not change its form when described mathematically from two different inertial reference frames; this has since been raised to a central requirement of any theory of physics, where it is usually called the 'Principle of Relativity'. The history of this evolution from Poincaré's original formulation to Minkowski's final 'covariant' formulation is included here to illustrate how the process of abstraction can strip the physics out of a theory leaving only the bare skeleton of a mathematical injunction.

1.2.4.6 Reference Frames

This small section discusses the artificiality of the concept of a reference frame, as this concept has taken on an increasingly important role in modern physics, particularly as the embarrassment of Einstein's use of rigid-rods to define such frames has grown. This will show that the actual nature of space and time need not comply with the mathematics of SRT.

1.2.5 DISCRETE CLASSICAL MECHANICS

This section presents a new classical theory of particle mechanics constructed around the central idea that electrons interact with each other 'on their mutual light-cones' both asynchronously (finite time differences) and discontinuously over time. The basic approach taken here is to extend Newtonian mechanics with as few explicit hypotheses as possible. The effects of quantizing this interaction will be left to the next paper, as one of the key tenets for presenting this research programme is to introduce each major innovation incrementally with sufficient discussion of each new change to justify the complete theory. This section will follow Newton and focus just on **one** single particle with all the sources of interaction aggregated into a singular 'cause' at any one time. The following section will return to the more natural focus on the complete interaction.

This section first describes why continuum mechanics has been so successful in the history of classical physics and how the momentum of continuum mathematics has powered this older research programme. Next, and fully in keeping with the new programme's view that philosophy must take priority over mathematics in the evolution of fundamental physics, some of the metaphysical characteristics that describe the new theory's views on the centrality of the electron are presented. Since the use of continuum mathematics is precluded in the new approach, the next sub-section first summarizes the standard calculus of finite differences and then extends this branch of mathematics to fit the new view of electrons taken here. This new form of mathematics is then applied to the kinematics and dynamics of the single particle model of physics that was popularized by Newton. The section concludes with a discussion linking this new approach to Newton's original model of "matter in motion".

1.2.5.1 Continuum Physics

The motivation for the present paper is the need to seek an alternative to the conventional approach to theoretical physics, which has been driven by the use of continuum mathematics. This is a consequence of the central result of the previous paper [4]: this proved there could be no continuous forces between inertial particles like electrons when the interactions occur 'on the light-cone'. This result voids not only all continuous theories like classical EM but also all relativistic theories that describe phenomena involving electrons. The continuum model of matter worked well until experimentalists in the 20th century demonstrated that all matter is discrete (or atomic) at the smallest levels of reality.

Field theory has now become the nearly universal norm in theoretical physics: since this is never challenged, its ongoing usage almost never has to be justified. The very rare justifications of field theory today simply repeat Maxwell and restate the universal application of the principle of conservation of energy. This attitude has logically resulted in the assumption (always implicit) that energy itself is a real entity whose independent existence becomes a metaphysical necessity. There is no actual real experimental evidence for this assumption that does not rely on unspoken supportive theories, generating a circular argument that proves its own assumptions. It is one of the contentions of this programme that mathematicians have imposed their own simplifying requirements on physics that has changed the very foundations of the philosophical and empirical investigations of nature.

1.2.5.2 Classical Electron Metaphysics

In order to develop a self-consistent theory of physics, this sub-section begins with a brief discussion of a 'triple-layered' view of reality. This involves distinguishing actual reality from our representations of nature. The central idea here is the critical role of human imagination in constructing models of nature. Experiments then become those manipulations of isolated parts of reality by humans that are interpreted by our imagination. One of the central hypotheses of the present research programme is that the mathematics of *Natural Vectors* is a superior algebraic representation of our 'mental model' of the physical reality of electrons. The principal papers reporting on this research programme will continue to introduce more of the power of this fundamental space-time representation in various ontexts.

Classical EM has replaced Maxwell's original æther model of EM with one that resurrected Helmholtz's failed model of electrical fluid or 'charge density' ρ, as it is now called. This model is presented as a 'distance' perspective on a 'bunch' of electrons that travel close enough together to appear like a continuous fluid at an appropriate distance. Indeed, this view is required to define electric current density $\underline{J}$, where the 'bunch' of electrons share a common, local velocity ($\underline{J} = \rho\, \underline{V}$). Of course, this model needs this charge density to interact 'remotely' but ignores the massive repulsion that such a cluster of electrons would generate that would blow them apart instantaneously, particularly when the use of the differential calculus implies an infinitesimal spatial separation. This new theory dispenses with mathematical intermediaries, like 'EM fields', and directly investigates the interaction between point electrons. As will be shown here, since the new theory does not use continuum concepts, like charge density or differential operators, it has no need to invoke or even comply with any form of relativistic transforms. In this approach, any form of SRT is irrelevant. This section also disposes of the conceit that space, itself, has taken on the role of the æther; this is rarely made explicit in modern field theories but is a logical necessity when 'fields' are viewed as variations in 'something'. The present theory accepts Newton's passive view of space as the stage on which matter performs, with time as the sole author of all changes found therein. The timeless and scale-less nature of one of the greatest creations in the history of human imagination, namely geometry, is next reviewed to show that this branch of continuum mathematics is not suitable as a *complete* foundational representation of reality but Euclidean geometry can form a suitable backdrop for the dynamical interactions of matter over time. The role of real numbers for mapping space and time is viewed here simply as a convenience and implies no infinite division of space or time; there is no confusion here between the sign and the signified (or, in the case of physics, mathematics and reality).

The present theory is a materialist model of reality: only matter forms real 'things'. The ultimate form of matter in this theory is the electron (and only the electron): matter and electricity are viewed here as synonymous. The next sub-section discusses some of the metaphysical characteristics that define the nature of electrons in this theory and how here they are assumed to interact amongst each other. Unlike modern field theories, the present research programme does **not** view energy as an independent entity but follows Newton in viewing energy as an attribute of particles. In the present approach, non-physical assumptions, like light-waves or photons, are dispensed with - thereby eliminating all 'objects' that "move at an invariant speed of light". This sub-section summarizes the replacement of these ancient concepts with the 'light-cone' condition that requires the universal space-time, scaling constant 'c' that was first introduced by Weber. This is followed by an extended analysis of the ideas of existence and velocity that are conjoined into the physical concept of an electron's trajectory. The Continuum Hypothesis has always been extended from the existence of a particle to the continuity of its velocity across time. This is explicitly rejected here with the hypothesis that variable, distinct impulses between electrons lead to the need for discontinuous mathematics to represent the discontinuous changes in the electron's velocity.

1.2.5.3 Finite Difference Mathematics

The use of continuum mathematics has generated both classical and quantum field theories that have each resulted in embarrassing mathematical infinities. The present research programme has deliberately avoided the use of differential operators and integral calculus; this has necessitated the resurrection of the widely ignored finite difference calculus: this will be subsequently combined with the Natural Vector four-dimensional representation introduced in the first paper [11]. This sub-section first summarizes the results found with the mathematics of standard finite differences, which usually focus on equally 'spaced' differences that are not appropriate as a representation for the dynamics of inter-electron interactions. Then some new extensions are introduced, where irregular differences are explored that are more suitable for analyzing discontinuous (non-analytic) functions of a continuous variable, such as time. The simple difference operator is separated into two components – an extended-component that is ideal for representing spatial differences and the point-component that more closely resembles the differential difference operator of traditional calculus.

1.2.5.4 Discrete Classical Physics

This sub-section begins with a definition of the physical situation where classical physics can be expected to apply. In line with the single electron focus of this section, mathematical representations of an electron's kinematic and dynamical motion are first presented, using the discrete mathematical machinery created in this section. An analysis of the electron's trajectory generates an unambiguous definition of the electron's velocity at **all** times. The instantaneous change in velocity at each interaction time $\{T_n\}$ is represented mathematically by the new point-difference operator ◊ applied to the discontinuous, piecewise vector representation of the electron's velocity $\{\underline{V}_n\}$; this replaces the continuum concept of acceleration used in conventional particle dynamics. This section concludes with a historical review of Newton's dynamics, as contrary to the opinion of most physicists, <u>force was treated as a series of *discrete* impulses occurring at *equal* time intervals</u>. This view is used to show how only a very limited form of standard finite difference calculus can be used to reduce to the differential calculus formulation of classical mechanics. It was this implicit restriction that forced Planck to redefine relativistic mass.

1.2.6 TWO-ELECTRON RELATIVISTIC DYNAMICS

Section six is the heart of this paper as it brings together all of the perspectives introduced up to this point to contribute to an analysis of the dynamics of two electrons, defined as truly mathematical point particles, that are interacting discontinuously. In this section, the discontinuous irregularity in each electron's velocity will be seen to provide an explanation of the results of relativistic mechanics and so avoid the bizarre results of special relativity, which requires that space and time must both change their historical invariant characteristics, which have always complied with the common man's intuition.

1.2.6.1 Interactions: Directed & Discrete

This programme views the introduction of the idea of 'force' as artificial and responsible for major, conceptual errors arising in the development of theoretical physics. This section now restores the full symmetry of the situation by returning the focus to the full interaction itself. Since this theory is based on a symmetric view of the interaction between two electrons, neither of which can make a privileged claim on 'universal' time, then this new theory adopts a completely symmetric view of the interaction. Since Newton's original views on impulse are little known today, this section reviews the distinctions between the ideas of force and impulse. In keeping with this programme's methodology, Newton's Laws of Motion are only slightly modified here to accommodate the asynchronous nature of EM interactions. The focus is on Newton's Third Law, which is the only one that explicitly imposed constraints on the <u>two</u> particles involved in an interaction: the emphasis is always on a temporal perspective, rather than the spatial (potential) view of post-Newtonian classical mechanics. As a material theory, the focus here is always <u>only</u> on the two points in space where the two electrons are located at the <u>two</u> times of their mutual interaction. This focus leads to the suggestion that each interaction between the two electrons is only directed between them and not 'broadcast' through the universe, as is the case with all field theories. All electron properties are introduced in terms of the interaction between two electrons – this theory is inherently relational and rejects the 'egotistical' view of the single particle. Einstein's theory has been called 'relative' but the focus was always on the singular field point (on the wave front); it was only relative to abstract 'observers' who sit at the centers of arbitrary inertial frames of reference.

1.2.6.2 Discrete Time Interactions

This theory returns to Newton's original idea of the universal flow of time synchronizing the possible changes between all electrons, no matter where they might be located throughout space. A fundamental unit of time (the *chronon*) is introduced to both scale the world and to create the required degree of temporal correlation. This fundamental time-period becomes the basis for the variable time intervals between consecutive interactions between electrons. The resulting mathematics needed to represent this situation then becomes one involving integer arithmetic and finite differences instead of real numbers and the mathematics of infinitesimal changes. This idea of discontinuity in the interactions between particles lies at the heart of the present theory but will be difficult to accept, as it challenges one of the oldest metaphysical assumptions in all of natural philosophy. This view is an explicit action-at-a-distance theory, requiring no invisible, third-party entities (such as waves or particles) to 'carry' the interaction between the electrons: it unreservedly rejects all those field concepts that have dominated physics now for over 150 years.

1.2.6.3 Digital Two-Electron Mechanics

The focus of this and the next paper will be on the 'isolated' two-electron system, as this will most clearly illustrate the ideas presented so far; in the real world this situation can occur but its frequency is unknown. So here, the kinematics (motion) and dynamics (interactions) of the two (repulsive) electrons are initially examined. A discussion of two complementary viewpoints is offered to clarify the new (two-time) *Interaction View*, in contrast with the traditional, single-point *Historical View*. Momentum exchange between the two electrons is tracked over time in the *Interaction View*, which is presented in the *Symmetric Inertial Reference Frame* (SIRF). It is shown that the *Invariance Hypothesis,* which posits that the total two-electron velocity of the two electrons prior to an interaction is equal to their combined value immediately after, is equivalent to Newton's Conservation of Momentum constraint when every electron is assigned the same universal measure of inertial mass. In contrast, this type of analysis is used to show that total kinetic energy is only conserved <u>after</u> **all** the intermediate interactions are complete. The *Historical View* is used to introduce the mathematical concept of 'potential energy' that is seen to be only meaningful in a single-time perspective; this is used to introduce the concepts of scalar and vector potentials.

1.2.6.4 One-Dimensional Solutions

The most detailed calculations here are performed on a one-dimensional 'thought' experiment, referred to as 'The Terrible Twins' because, embarrassingly, this simple model has never even been solved analytically for classical or quantum electromagnetism and so, it is never discussed. This calculation discusses two possible solutions but only one appears reasonable when the electrons interact many times. This is the 'linear' solution that corresponds to the universal exchange of a standard unit of momentum across each interaction. Closed form solutions for the trajectories of each electron are presented in terms of the (as yet undefined) total number of possible interactions as the electron's velocity goes from c to zero and back again. The model is used to calculate the time intervals between each successive interaction, which are found to be proportional to the electron's local velocity. These results are sufficient to provide a more physical explanation of "Planck's Proposal" for defining a particle's relativistic momentum – the real basis for the dynamical acceptance of special relativity.

1.2.7 CRITIQUE & RE-INTERPRETATION OF RELATIVITY

Section seven brings together the criticisms of SRT that are mentioned in all the earlier sections and merges them with the new insights suggested by the initial investigations of the two electron interaction covered in section six. Einstein's SRT has become accepted as one of the central pillars of modern physics without sufficient critical thought being brought to bear on its weak conceptual foundations. This has become a major problem now that physics has forgone philosophy – as many of the problems associated with this theory are philosophical, especially as it is now taught simply as an exercise in applied mathematics. Most of Einstein's contemporaries, especially those investigating the electrodynamics of moving bodies, were very dissatisfied with Einstein's formulation (reviewed in section two) and these criticisms are recovered here as they were never answered – they usually just disappeared with the deaths of these reputable, but skeptical, scientists.

1.2.7.1 Problems & Paradoxes of Relativity

The discussion here centers on the contradictions and paradoxes arising from Einstein's use of poorly defined concepts. In particular, an analysis is made of the metaphysical assumptions that must be justified before any field theory can be viewed with any confidence. Several paradoxes in SRT are reviewed, as these have never been resolved to everyone's satisfaction – a situation that pure mathematicians would view as completely unacceptable. Problems with the mathematics used in SRT are also examined to show the shaky foundations of this 'fundamental' theory. This sub-section also summarizes Einstein's repeated failed attempts from 1905 through 1907 to derive the famous mass-energy equation in a rigorous manner. It also discusses the danger of using mathematical vocabulary, with words like *true*, *exist* etc, that have been used to smuggle in a Platonic metaphysics into the very foundations of physics – alternative views have been excluded using the spurious argument that physics has evolved beyond philosophy: this paper challenges this totalitarian view.

All of the major late-19th Century theoretical physicists were well versed in natural philosophy; indeed, the actual word 'physicist' was only introduced around 1850. Prior to its introduction, all scientists with a focus on the foundations of the material world would acknowledge that they were participating in the long-established activity of 'natural philosophy'. One of the central thrusts of the present paper is to show the strong historical connections between Maxwell's theory of EM and Einstein's SRT. This is deliberate as this programme views Maxwell's EM theory as significantly flawed, so that later theoretical structures built on its foundations are a poor basis for any fundamental theory of physics, such as SRT has now become. Another major criticism here (of all modern theories) is that they are all based on an exclusive, '**local**' viewpoint, epitomized by all field theories. The alternate perspective adopted here is that the very nature of the EM interaction strongly suggests that refocusing on the interaction <u>between</u> two electrons **at two different times** is a more far-reaching viewpoint. This leads to a new emphasis on the dynamical nature of physics and moves away from the kinematic perspective implicit in Einstein's whole approach. A major criticism is directed at Einstein's explicit use of Euler's concept of the 'rigid body' that is shown here to be absolutely vital to all of Einstein's thinking about 'clock' synchronization; this concept is incompatible with Einstein's own assumptions of how energy (and information) is communicated across remote spatial locations at finite speed. The post-modern, historical approach adopted here also emphasizes how much of SRT is based on purely 'thought' experiments, particularly those that are imagined to occur at a single point in time and space, such as perfect collisions.

1.2.7.2 Relativistic Time

The Michelson-Morley experiment is re-analyzed to show that its famous 'null results' only present a problem for medium-based EM theories, such as Maxwell's EM theory of light. Rather than return to Weber's rival EM theory, which Maxwell had acknowledged describes the phenomena equally well, theoretical physicists around 1900 continued to exercise their hidden metaphysical prejudices against action-at-a-distance and invented more and more bizarre EM theories, like those of Lorentz and Einstein, that ultimately required the foundational concepts of time and space to be re-defined.

1.2.7.3 Challenging Relativistic Mass

It was Kaufmann's experiments on high-speed electrons, beginning in 1901, that generated an acute interest in providing an explanation for the observed, anomalous results. This led to a renewed competition in the attempts to provide a model of the electron, particularly as many believed, at that time, that the electron's inertial mass was purely electromagnetic in origin. An early assumption was made that Kaufmann's results could be explained by assuming that the electron's mass increased with speed since EM effects were velocity-sensitive. This relativistic mass hypothesis has remained unchallenged ever since. As this paper will show, it was actually "Planck's Proposal" in 1906/7 that produced the mathematical derivation of this key <u>dynamical</u> result of relativity that has been used by physicists ever since. This section summarizes the assumptions behind this approach that are never challenged, as this would threaten one of the central pillars of SRT.

1.2.7.4 Inertial Mass is not Energy

The concepts of mass and energy are examined here to illustrate their fundamental differences, which have been confounded by Einstein's famous mass-energy equation. This paper emphasizes that it was "Planck's Proposal" of 1906/7 that really led to the acceptance of this result by the physics community, rather than Einstein's failed attempts in this area. This approach merged Newton's views on accelaration with Einstein's theory of light propagation in vacuo in inertial frames of reference **without** any acceleration, although Einstein did imply in 1905 that "light transfers mass". This paper will show that though the algebra of SRT can be manipulated to show a correspondence between these two key concepts, there is no physical justification for this identification.

1.2.7.5 The Relativistic Transform: Just Mathematics

The present lack of historical exposure in the education of the modern physicist has meant that most professional physicists today believe that Einstein was the sole originator of the theory of relativity. Not only are they totally unaware of the many unresolved controversies that raged around this theory but they are nearly all unaware that the so-called 'Lorentz transform' was derived several times before Einstein. Furthermore, all of these earlier innovators only viewed this as a mathematical transformation, while Einstein (and the modern physicist) interpret this as a revolutionary change in the nature of space and time. The analysis presented here shows that if one adopts Einstein's pseudo-operational definition of time measurement as an accurate model of time itself then the 'clock paradox' can only be resolved by interpreting it in terms of a 'calculational mirage' in a manner similar to Terrell's interpretation of the FitzGerald spatial contraction.

1.2.8 SUMMARY & CONCLUSIONS

The final section summarizes the major points brought out in the earlier parts of this large paper. It also focuses on the new results obtained in section six that analyzed the dynamics resulting from the discrete and discontinuous interaction between two electrons. This section also draws together the many criticisms of Einstein's SRT that are the focus of the early sections and summarizes the alternative view of high-speed dynamics in section seven. This paper has again returned to the history of its primary subject matter – in this case, the theoretical treatments of the electron, especially around 1900, when this new, fundamental particle was mystifying physicists and particularly when the electron was undergoing high-speed motion. It was Einstein's attempt in 1905 to substitute a 'theory of principle' for the failed EM models of the electron that resulted in the special theory of relativity. The history of how this theory was received at the time has been long forgotten and is rarely studied today, except by historians of science. As a result, there is a widespread, but mistaken view that all mathematical theories of physics must now be presented in a relativistic (covariant) manner. One of the objectives of this paper is to demonstrate the limitations of this viewpoint; the solution involves a challenge to one of the oldest traditions in physics.

2. ELECTRODYNAMICS & MOTION

2.1 BACKGROUND

It is the central ontological hypothesis of this research programme that the fundamental substance of reality consists only of electrons that are viewed here as existing at only a finite number of distinct points in space at any instant in time. There is a much shorter history of this viewpoint than the rival claims of the continuum, as is illustrated in the following excerpts.

2.1.1 EM PHYSICS IN THE 19TH CENTURY

Problems with EM Field Theory

Scientists discussing classical physics frequently fall into the philosophical trap of assigning physical reality to **all** the symbols used in the corresponding equations; this metaphysical error has been expanded with the introduction of quantum mechanics, especially where the concepts were derived by analogy with classical electromagnetic field theory. The idea that infinite space (i.e. the modern view of the field) can be related to phenomena arising from a point inevitably lead to infinities not just singularities. As was shown in the previous paper [4], the classical theory of the electron suffered from several fundamental problems, which were never satisfactorily addressed by theoreticians – they were just ignored when atomic and quantum physics became the fashionable center of attention. These problems included:

a) The operational inability to define an electric field as the charge on the test particle *cannot* be reduced to zero.
b) The standard wave equations are *only valid* at points where there is no true charge and never <u>at</u> the electron.
c) The radial solution of the wave equation is always electrostatic and cumulatively *infinite* in all directions.
d) The mysterious advanced solution to the wave equation is as equally valid as the acceptable retarded solution.
e) The total electromagnetic fields of a charge are now defined *without* any supporting medium (or æther).
f) The total energy and momentum of the field around a charged particle diverges without a *finite* particle radius.
g) The mutual electric effect at any one point on a finite electron requires a knowledge of the *entire* history of all the other parts of electron's surface.
h) The acceleration of a charged particle, subject to an electric pulse, is determined by the time-average of the external force over a brief time interval ***after*** the arrival time.
i) A time-symmetric solution cannot be found which absorbs radiated energy from an isolated, accelerated point particle without introducing a set of *complete* absorbers.

Maxwellian Electrodynamics

Maxwell's differential equations must always be mathematically consistent with the macroscopic physical facts as these continuum equations were derived directly from the integral equations that summarized the experimental facts of electromagnetism: differentiation and integration are simply reciprocal mathematical operations. Since these basic experiments are now seen to have been undertaken on gigantic collections of electrons over significant time-scales (at the electronic level), it is an unwarranted assumption that these æther-based microscopic equations reflect the actual physical interactions between electrons, although this is exactly the path that the historical evolution of physics has followed. Maxwell's Equations are now viewed as fundamental rather than simply statistically consistent with macroscopic reality.

Hertzian Electrodynamics

A major confusion surrounds the treatment of time in Maxwell's EM theory, especially in the original approach to Faraday's Law of Magnetic Induction. In his translation from the integral (flux view) of the macroscopic, experimental laws of EM to their 'equivalent' differential equation formulation, Maxwell always used the full derivative symbology of Leibniz e.g. d/dx. This was acceptable for purely spatial variations, as later authors simply replaced these with their partial derivative versions, like ∂/∂x. However, this was <u>not</u> appropriate for the distinctive time dimension as all the phenomena of EM intrinsically introduce finite time differences between the sources of EM activity (cause) and the response of the remote, target charges (effect). Almost all modern authors follow Heaviside and simply replace the full time derivative (d/dt) with the partial time derivative (∂/∂t). This is particularly critical in 'transforming' Faraday's Law, as this is the mathematical origin of SRT. Thus:

$$\oint d\underline{l} \bullet \underline{E} \;=\; -1/c\, d\Phi/dt \;=\; -1/c\, d/dt \iint d\underline{S} \bullet \underline{B} \;\neq -1/c \iint d\underline{S} \bullet \partial/\partial t\, \underline{B}$$

This last step is needed to produce Maxwell's 'electric curl' equation: $\nabla \wedge \underline{E} = -1/c\ \partial/\partial t\ \underline{B}$ – a necessary step to derive the wave equations. The key point here is that the line integral, around a closed circuit, represents the electromotive force generated in the magnetic flux penetrated circuit, when any of the various experimental parameters are changed, including the shape of the circuit itself. Faraday moved a part of the circuit in a magnetic field and observed an induced emf. A shape change cannot occur without accelerated relative motion between parts of the circuit. In this case, there is no inertial frame wherein the circuit as a whole can be considered at rest since changing the shape requires imparting different local velocities to different parts. This major problem was first pointed out by Heinrich Hertz in 1892 [15] and has recently been the starting point for a 'neo-Hertzian' EM field theory proposed by Thomas Phipps [16]. As Phipps emphasizes, only the full time derivative (d/dt) is a first-order Galilean invariant, while the partial time derivative (∂/∂t) is not. The French physicist, E. Mascart had already confirmed experimentally by 1872 that Maxwell's predicted first-order fringe shifts had failed to appear [17]; ironically, this failure of the æther to manifest itself was later used to reject Hertz's 'extended Maxwellian' EM theory but this early result was never held against Maxwell's own theory.

The Æther in 1905

By 1905, Maxwell's theory was the principal explanation for EM. This theory was grounded in the concept of a stationary medium (the æther) that did not impede material bodies. The fact that this was a medium theory implied that the velocity of excitations through this medium (i.e. light) was independent of the speed of the source emitter relative to this medium. The commonly accepted view among physicists was that the Earth moved through the stationary æther without dragging it along or otherwise disturbing it but optical variations should be observable for measurements made in Earth-bound laboratories, such as those made in the Michelson and Morley experiment (MMX). Both Larmor and Lorentz had to use the FitzGerald contraction hypothesis [18] to reconcile the æther concept with their versions of their ETM theories. This was necessary so that they could explain the contradictory experimental results of Airy's experiments with the null results of the MMX. The fact that a water-filled telescope showed no change in stellar aberration compared with an air-filled telescope was explained by Fresnel's æther-dragging model whereas the MMX results were explained by a model of the æther being carried along by the Earth. Einstein rederived all the relevant formulae by adopting an axiomatic, kinematical approach that avoided all explicit references to physical properties (dynamical models) of the æther or of the newly discovered electrons.

2.2 EXPERIMENTAL ANOMALIES

Electrons and Atoms

Calculations of the classical EM model of the electron, particularly those that assigned it a spherical shape, found that it had a radius $\Lambda_0 = e^2/mc^2$ or about 10^{-13} centimeters; experiments provided estimates for the size of atoms to be about 100,000 times larger or about 10^{-8} centimeters [19]. These results will play a major role later in the development of this theory.

2.2.1 KAUFMANN'S EXPERIMENTS

Walter Kaufmann (1871-1947) played a major role in measuring the properties of high-speed electrons soon after their discovery, recognizing that these new particles were destined to play an important role in 20th Century physics. Kaufmann believed, by 1903, that his measurements confirmed Abraham's predictions that the EM mass of the electron (the so-called 'transverse' mass) would increase rapidly as the electron's velocity relative to the equipment approached light-speed. It must be pointed out that these ambiguous results (only 5 data points in 1901) were achieved after extensive (20+ hours) exposures onto tiny photographic film and the data analysis required several arbitrary assumptions.

Voigt 'explains' Kaufmann

Einstein was fortunate that he derived the 'correct' formula for the relativistic change in the electron's transverse mass (M_T) following Abraham ($M_T = \mathcal{L}\ m$, see section 3.2 later), while both Einstein and Abraham got it wrong for the longitudinal mass ($M_L = \mathcal{L}^3\ m$). Kaufmann's experiments of 1903 were the only e/m data for high-speed electrons in 1905. These only measured the transverse mass since the crossed electric and magnetic fields were restricted to planar motion [20]. While the M_T formula could be matched with the data, this result could have been equally explained by the earlier Voigt transform of the dynamic EM force $\underline{F}$ into a transverse, high-velocity equivalent force $\underline{F}_T = \mathcal{V}\ \underline{F} = m\ d\underline{v}/dt$, where $\mathcal{V} = 1/\mathcal{L}$.

2.2.2 THE MICHELSON & MORLEY EXPERIMENTS

It was Maxwell himself in 1878, who first suggested that it might be possible to detect the Earth's orbital motion through the æther by comparing the times of light traveling with and against the Earth's relative motion. Soon after, in the early 1880s, the American experimentalist Albert A. Michelson (1852-1931) proposed a critical test of this possibility with a new optical interferometer. He conducted a series of experiments at Case Western Reserve from 1881 through 1887, working with Edward A. Morley (1838-1923) after 1885, always obtaining a null result. This was quite unexpected for any æther based theory and proved to become one of the crucial experiments in the evolution of EM theory; hereafter these **M**ichelson and **M**orley e**X**periments will be referred to as the 'MMX'. It should be noted that this experiment did not use any 'clocks' as a measure of time intervals but required an implicit theory of EM to interpret and calculate the expected 'fringe shifts' for calculated differences in the travel times of the 'light waves' through the equipment. In this case, the experimentalists were relying on Maxwell's theory of light that relied on the absolute motion of matter (as in the laboratory) to be defined relative to an absolute, stationary æther (the unique and universal reference frame). As Michelson concluded from his results: "the hypothesis of a stationary æther is thus shown to be incorrect." This was the experimental challenge that all proponents of Maxwell's EM theory of light were faced with, as the phase shift was exactly equal if the apparatus was at rest in the æther.

Polarized Oscillations

In the Michelson-Morley type of experiment, it needs to be emphasized that the only component of the light source, which was expected to contribute to the shift in the interference fringes, lies in the plane that is perpendicular to the plane of the experiment and to the direction of motion. If the first mirror defines the Y-Z plane then all reflected light from this mirror must be polarized somewhere in this plane; similarly, if the second mirror defines the X-Z plane then the recombining light from both mirrors can only be from the Z-plane. This must limit the possible interference effects that ultimately arrive at the observation electrons, as arising only from the oscillations of all the source electrons in the Z-plane, which is perpendicular to the anticipated direction (X) of the motion of the experimental equipment. This leads to the important conclusion: there is *no net relative motion* between all the participating electrons, from those in the source of light, to those in the mirrors, to the target electrons. This could readily be demonstrated with polarized filters. Therefore, the MMX style of experiments should only anticipate an interference effect ***if*** the phenomenon of light involves a ***medium***. So, one conclusion from the observed null results is that such *an ætherial theory is wrong* – a deep embarrassment to supporters of the Maxwellian theory of EM. This failure did not result in a revisiting of Weber's action-at-a-distance theory or even Lorenz's charge-potential theory that were both consistent with this null result – any such giant step would involve admitting that Maxwell's theory was wrong, with all that reversal would entail - demonstrating once again the conservative attachment to well established theories.

Lack of Symmetry

There is no real symmetry in the MMX arrangement. The reference frame ('lab' frame) containing the excited source electrons and the final, receiving electrons (the site of the observed interference) is unique since all these electrons are 'stationary' (they are only oscillating transversely) relative to one another. Any other reference frame, like one defined by the solar system, is irrelevant and is not symmetrically equivalent; indeed, all other frames are irrelevant in the MMX set up.

The FitzGerald Hypothesis

In 1889, Oliver Heaviside wrote to his friend and admirer, George F. Fitzgerald informing him of his private analysis of the null result of the MMX in 1887 [21], which "flatly *contradicted* the expectations of Maxwell's æther-based theory". These calculations, based on Maxwell's theory, showed that the strength of the electric field surrounding a moving charge should be reduced in the charge's direction of motion." FitzGerald then made the intuitive leap that all matter was wholly electrical in nature so that all moving matter <u>must</u> contract to preserve molecular equilibrium. As a result, FitzGerald proposed in the May 1889 issue of the new American journal *Science* [22] that all matter contracted minutely in the direction of motion just sufficient to exactly compensate for the predicted time differences in the two directions of the MMX interferometer, so that a null result would always occur. This was not the ridiculous *ad-hoc* hypothesis that is often presented to modern readers. Rather, FitzGerald knew from Heaviside's analysis that the reduction in the strength of the electric field surrounding a moving charge would be reduced in the charge's direction of motion through the æther precisely by the factor required by his hypothesis. FitzGerald's article in this little-known (at that time) publication was not referred to in print until his friend Oliver Lodge mentioned it in an article on EM in the major British journal *Nature* in 1892. Lorentz read this article and incorporated this idea into his own electron-theory of matter in his 1895 *Versuch*, with FitzGerald's priority only meriting a footnote. It was only after 1897, when Larmor had published his own electronic theory of matter did Cambridge physicists accept that FitzGerald had proposed a correct explanation for the MMX null result. In fact, the MMX result was then used by the Cambridge School to justify Larmor's ETM theory.

Implicit Assumptions

The MMX situation is always viewed in terms of several important assumptions that are almost never made explicit. These center on the metaphysical assumption that the phenomenon of light is evidence that light itself is an entity – an exemplar of reality that exists independently of all other aspects of reality. At the time that Michelson and Morley began their famous experiments light was viewed as an oscillation in the æther, even today, light is still viewed as 'something' (an EM wave) that moves across space over time. This optical entity (light wave or photon) is also assumed to be dividable by the optical splitter (usually a partially-silvered mirror) at the heart of the MMX, so that one part moves through the apparatus along a different optical path before recombining at the final observation point. It is this model that generates all the paradoxes.

Null Result surprises Ætherists

Maxwell developed the final version of his theory [23] around the concept of EM energy. He proposed two equivalent expressions for the local energy density: one based on local EM fields (E and B) and the other based on remote action-at-a-distance potentials (ϕ and A). Maxwell and his followers, all obsessed with the metaphysical concept of the æther, chose only to develop the version involving fields traveling through the æther. This led to the MMX experiment to measure the impact of motion relative to this æther. The null results shocked the ætherists, who were expecting measurable results. Rather than give up the idea of the æther and, worse, adopt the Continentalists' action-at-a-distance theory [6], Lorentz and then Einstein modified the very foundations of physics. The dramatic metaphysical changes to our well-established ideas of space and time were unnecessary, as the action-at-a-distance theories required none of these changes while still correctly predicting null results for the MMX.

O'Rahilly lists the Alternatives

The Irish physicist Alfred O'Rahilly (1884-1969) summarized the impact of the null result in the Michelson-Morley experiment from the viewpoint of many older physicists in 1930 when he wrote [24]: "this experiment disproves the hypothesis of a stationary æther. Lorentz being eliminated, we have a choice between Stokes and Ritz: either the æther is earth-convected or there is no æther at all." O'Rahilly's choice was to go with the 'ballistic' theory of the Swiss theoretical physicist and long-time critic of Einstein, Walter Ritz (1878-1909). This asynchronous theory, which proposed that 'light-particles' left the emitter always with relative velocity c, has failed to generate much support since it was first proposed in 1908 [25], perhaps because of Ritz's early death (at 31 from lung disease). Surprisingly, O'Rahilly was not prepared to consider a Weber-like action-at-a-distance alternative even though he was a great admirer of Weber's EM contributions. There appears to have been little discussion by scientists then or now that this famous experiment can be immediately explained by action-at-a-distance theories, where relative motion of observers is irrelevant.

2.3 RELATIVISTIC TRANSFORMATION THEORY

2.3.1 EARLY HISTORY

The Voigt Transform

A few modern authors, such as Miller [26] and Pais [27], still remember that Woldemar Voigt (1850-1919) was the first scientist to investigate the invariance of the form of the D'Alembertian (Wave) Equation in 1887 [28]. His analysis focused on the differential equations characterizing vibrations through an elastic, incompressible medium. Voigt's final form of the transformation equations associated with the space and time parameters, invoking an *invariant speed of propagation c* were:

$$x' = x - v\,t\,,\;\; t' = t - v\,x / c^2\;;\; y' = \mathcal{V} y,\; z' = \mathcal{V} z \qquad \text{where} \quad \mathcal{V} = \sqrt{(1 - v^2/c^2)}.$$

These equations retain the Galilean transformation in the direction of motion (x) and preserve the universality of the time dimension. They introduce a 'shortening' in the transverse y and z directions, which appears like a spiral transform with respect to the speed. Although Lorentz would later claim that he was unaware of Voigt's transform, Lorentz was in private communication with Voigt soon after the publication of this result, which preceded the actual proposal of Lorentz's "own" transform in 1895, both preceding Einstein's 1905 derivation of the Relativistic transform in 1905 [29]. As Voigt pointed out, his transform was purely an exercise in mathematics (as Lorentz always viewed his own efforts) and had nothing to do with moving media or observers in relative motion.

Voigt transforms the Transverse Amplitudes

The Voigt transform [30] is not a kinematical transformation of the space and time co-ordinates, like the Relativistic transform. Rather it is simply a reduction of the amplitude of the **transverse** components of the propagating wave-like displacements, like the electric and magnetic force intensities (E and B) on the wave front. In contrast to the Relativistic transform, the Voigt transform is not a 'rotation' from the spatial direction of motion into the time dimension and vice-versa. Notice that as the 'speed' parameter 'v' approaches the medium's invariant speed constant 'c', these transverse amplitudes reduce to zero, implying that the wave vanishes and would be unable to communicate energy or information: a point that is rarely made. The (inverse) relativistic transform generates infinities when v reaches c and this is used to limit the velocity.

Heaviside rediscovers the Voigt Transform

Oliver Heaviside was the first to exactly solve Maxwell's Equations in 1888 for the special case of two massive, charged point particles that continue to move at a fixed, relative constant velocity [31]. Heaviside discovered that the electric force is everywhere radial with magnitude: $\mathcal{E} = e^2 (1 - v^2 / c^2) / r^2 (1 - v^2 \sin^2\theta / c^2)^{3/2}$, with θ as the axial angle, while the lines of magnetic force are circles, centered on the relative line of motion with magnitude: $\mathcal{B} = \mathcal{E} \sin\theta \, (v / c)$. Almost no physicist has commented on these results, which both go to zero as the speed v goes to c, again implying that all high-speed EM effects (e.g. light signaling) vanish at light-speed, as the Voigt transform predicts. This contrasts with Planck's 1906/7 Relativistic Momentum Proposal that predicted that non-zero inertial mass always becoming infinite in such circumstances.

2.3.2 LARMOR'S ELECTRONIC THEORY OF MATTER

Most histories of the theory of relativity touch on the contributions of Lorentz and Poincaré but most fail to mention that there was an alternative research programme investigating EM phenomena in relative motion already underway in England under the leadership of Joseph Larmor. Surprisingly, the very detailed history of the emergence and early interpretation of the SRT by Einstein historian Arthur I. Miller [26] makes absolutely no mention of Larmor's contributions. Many of the results of this programme preceded the relativistic pronouncements arising on the Continent – an ironical nationalistic reversal of the earlier Maxwell-Weber rivalry associated with the fundamentals of EM theory.

It is difficult for the modern reader to realize that in 1900 Joseph Larmor (1857-1942) was one of the leading physicists in the world, in the same league as Poincaré, Lorentz and Planck; today he is remembered only for his work on diamagnetism. As the leading mathematical physicist at Cambridge from 1885, he was widely viewed as Maxwell's very worthy successor. He was appointed Lucasian Professor (Newton's old chair) on the strength of his researches into EM phenomena involving relative motion. Based on the application of the *Principle of Least Action* he proposed a new dynamical foundation for EM. In a series of papers published by The Royal Society between 1894 and 1897, he eventually (due to the strong persuasion of FitzGerald) focused on J. J. Thomson's concept of a microscopic body of electricity that became known as the 'electron'.

Larmor's Electron Theory of Matter

Larmor's final form of his theory proposed that matter consisted only of positive and negative electrons; these interacted via a continuum (the EM æther) that propagated effects between these particles. He viewed these electrons as mechanical point centers of radial strain **in** the æther thus solving the problem of the interaction between matter and the EM æther while also suggesting that all inertial mass was electromagnetic as the electrons were accelerated relative to the stationary æther. The whole universe could thus be viewed as electro-magnetic – a major unification in its metaphysical foundations [33] . In contrast to the widely-accepted view today that EM was in crisis in 1900 due to the 'paradoxes' incurred by relative motion (exemplified by the MMX), the Cambridge programme constructed a dynamical model of EM that fully explained the null result; furthermore, they viewed the MMX as a justification of their own theory. The introduction of the 'electron' concept (discussed in more detail in the third paper in this series [4]) meant that all material interactions involving EM in the ETM became a problem in the electrodynamics of moving bodies. By 1895, Larmor had shown that moving matter formed from electrons would contract slightly in the direction of its motion. Larmor used his theory to construct a new theoretical model of the MMX interferometer that explained all of the null result when he introduced his new space and time transformations relating the EM variables defined in the stationary æther to similar variables defined in the rest-frame of the interferometer. These transforms would subsequently be 'rediscovered' by Poincaré and named the 'Lorentz' transforms (see 2.2). When the constant speed of the interferometer is v (defining the x-direction) relative to the fixed æther then the space and time variables in the moving-frame ($\underline{x}'$, t') relative to the æther's rest-frame ($\underline{x}$, t) are related by [34]:

$$x' = \mathcal{L}\,(x - v\,t), \quad y' = y, \quad z' = z, \quad t' = \mathcal{L}\,(t - v\,x / c^2) \quad \text{where} \quad \mathcal{L} = (1 - v^2/c^2)^{-1/2} = 1 / \mathcal{V}$$

Larmor also found that Maxwell's electric (E) and magnetic (B) variables had also to transform according to the scheme:

$$E_x' = E_x , \quad E_y' = \mathcal{L}(E_y - v B_z) , \quad E_z' = \mathcal{L}(E_z + v B_y) ; \quad B_x' = B_x , \quad B_y' = \mathcal{L}(B_y + v E_z/c^2) , \quad B_z' = \mathcal{L}(B_z - v E_y/c^2)$$

Initially, he found that these EM field transforms preserved the form of Maxwell's Equation up to the second order (v^2/c^2). In 1904, Larmor also realized that this invariance was valid to all orders under these transforms i.e. they were covariant. He explained this similarity in form as being due to the measured fields in the moving frame (the laboratory) being generated from the original fields **in** the fixed æther and the effects of motion **through** the æther. In 1897, Larmor also derived the equation for the potential **around** a moving electron. This indicated that the potential surfaces around the electron would contract in the direction of motion by exactly the amount predicted by FitzGerald. All of these results were eventually republished in Larmor's best-selling book *Æther and Matter* in 1900 [35]. From a physical perspective, Larmor viewed the stationary frame of the æther as privileged (as did Maxwell and all who believed in the æther model of EM); compared to this frame, all moving bodies actually became shorter and moving clocks actually ran slower. Larmor's transforms should therefore be viewed **in** space and time, in contrast to Einstein, who saw them as transformations **of** space-time.

2.3.3 LORENTZ'S ELECTRON & ÆTHER THEORY

Always convinced of the continuum nature of the æther as the medium 'carrying' the EM interaction, in 1892 Hendrik A. Lorentz (1853-1928) combined the ideas of the action-at-a-distance 'EM Continentalists' with Maxwell's æther theory by adding the hypothesis that the sources of the EM disturbances were microscopic charged particles that moved in the all-pervasive æther that was absolutely at rest. In contrast to Larmor's æther-model of the electron, Lorentz viewed his new electron **as** an independent entity that interacted through the EM æther.

Lorentz adopts Weber's Æther

As early as 1852 Wilhelm Weber (1804-1891) had considered the æther to consist only of positive and negative particles of equal charge orbiting around each other [36]. This view contributed to the development of Lorentz's electron theory with electrical particles that were distinct from the æther (in contrast to Larmor), which supported retarded fluctuations in the EM fields.

Lorentz's Transformation Theory

In 1895 Lorentz examined bulk matter from its own reference frame where his 'ions' were always at rest, behaving like a rigid body. Without any attribution, he now introduced Lorenz's 4-potential that satisfied the "Lorenz" equation: $c\,\underline{A} = \underline{v}\,\phi$ with the bulk matter moving at a constant velocity $\underline{v}$ relative to the fixed æther. This enabled Lorentz to calculate the EM force $\underline{F}$ on another ion q in the bulk medium due to a source ion q′ in the æther that was responsible for generating the static potential ϕ:

$$\underline{F} = - q\,\nabla\Phi \quad \text{where} \quad \Phi = (1 - v^2/c^2)\,\phi \quad \text{using Searle's "convective" potential, } \Phi$$

After using a Galilean transformation, Lorentz then repeated Thomson's 1889 co-ordinate 'stretching' transform along the direction of motion (again without attribution) while still retaining the unchangeable time dimension. These transformed his EM equations to an equivalent Poisson (static) form of the 'stretched' scalar potential ϕ'' in terms of the 'stretched' charge density ρ'', where the 'stretching' invoked the Voigt factor, $\mathcal{V} = \sqrt{(1 - v^2/c^2)}$; in other words, $\phi'' = \mathcal{V}\,\phi$ & $\rho'' = \mathcal{V}\,\rho$. Lorentz had effectively re-established Heaviside's 1889 result for the electric field of a uniformly moving point charge based on the equivalent potential $\psi = q'\,(1 - v^2/c^2) / \sqrt{(x^2 + y^2 + z^2)}$; that is, Voigt-like transforms. Lorentz , now analyzing the motion of his ions, next introduced a new independent variable τ, which he called the "**local time**" (so as to distinguish it from the universal, Newtonian time variable 't') by the definition: $\tau = t - \underline{v} \bullet (\underline{r} - \underline{v}\,t) / c^2$. As a result of all these special transforms "Lorentz found that only in charge-free space, i.e. the free æther, did the EM field equations have the same form" and even this conclusion was only valid for "bulk matter that was non-magnetic, non-dielectric, non-conducting and neutral" indeed, a rare form of matter [37]. Effectively, Lorentz was switching backwards and forwards between the 'fixed' view, as seen from the target electron's perspective, and the laboratory view, where the target electron was being buffeted by the EM fields.

Lorentz includes 'Solid' Electrons

In 1904, Lorentz formally extended his theory to include free, 'finite' electrons [38]. Lorentz was motivated to respond to Poincaré's criticism that he was inventing too many arbitrary hypotheses just to explain the Michelson-Morley experimental results. When trying to explain "second order" phenomena in the optics of moving bodies, Lorentz now had to explicitly introduce ten (10) new and fundamental hypotheses – but these were acceptable to Poincaré! Lorentz now proposed several consecutive sets of space-time co-ordinate transformations applied to the charge density ρ, the electron's velocity v and to his E and B fields, so that together they preserved the form of his earlier "Maxwell-Lorentz" equations. These equations were similar to Voigt's 1887 wave-preserving transforms and equivalent to Larmor's 1900 equations, with neither set being attributed to these earlier innovators. In this theory, Lorentz had to allow his initially spherical electron to deform elliptically in the reference frame of the real, solid medium [39]; this was typical of the type of EM 'solutions' around 1900.

2.3.4 POINCARÉ'S RELATIVITY VIEWS

It is difficult to believe today, with all its hypotheses, but in 1902 in his best-selling book *Science and Hypothesis* [40], France's leading scientist, Henri Poincaré (1854-1912) declared that Lorentz's theory "was the most satisfactory of all the current microscopic theories of EM and matter because it best explains the known facts". Poincaré was prepared to make this statement although in 1900 he had already pointed out that Lorentz's model of the fixed EM æther violated Newton's Third Law of Motion. Even after Poincaré was able to soon "patch up" this problem by adding further hypotheses, Lorentz himself was unconvinced by all this 'help', responding with the comment that: "in an æther-based theory the action of an emitter of unidirectional radiation could not be simultaneously compensated for by the reaction of the absorber and Poincaré had 'dodged' this point." In addition, Lorentz also showed that whenever Poynting's energy current varied with time then the æther was no longer in equilibrium. In 1904, Poincaré finally admitted defeat in this area, acknowledging Lorentz's observation of the non-simultaneity of action and reaction in any EM field theory [41].

Poincaré's Relativistic Contributions

Poincaré had already enunciated the "*Principle of Relativity"* in 1895 and, by 1900, believed that this had been confirmed experimentally. He had published on the synchronization of clocks using light in 1898, 1900 and 1905. From 1895 to his early death (after a botched operation) in 1912, Poincaré continually supported Lorentz's electron-æther theory.

Poincaré & the Transformation of "Lorentz"

Poincaré's 1905 paper on electron dynamics [42] eliminated both the foundational Galilean transformations from the fixed æther system (S) to the constant velocity (inertial) reference frame (S_r) of Lorentz's bulk matter (the 'lab' frame) along with any reference to Lorentz's convective derivative. Additionally, he retained Lorentz's key transformation to a third reference frame (S″) that had been introduced only, "as an act of the imagination", to achieve preservation ("covariance") of the new Maxwell-Lorentz EM equations in S″. In his more extended 1906 version [43] Poincaré inverted these final transformation equations back to the æther frame. He viewed this step as only invoking mathematical symmetry and not having physical meaning, since he viewed the æther frame as always fixed. This gave Poincaré a set of transformations (which he named after Lorentz) of the EM fields, charge density ρ and force density f ; equivalently, he had proposed that the imaginary frame S″ was an inertial frame, not the real frame S_r. This confirmed Lorentz's 1904 results (and Larmor's in 1895) that the equations of the EM medium are unaltered by the Relativistic transformations. As Poincaré later wrote to Lorentz, these new transformations "form a group"; this has impressed physicists of a mathematical predilection ever since.

In this same paper, Poincaré was also the first to generate 4-vectors for the EM pairs (ϕ ; A), (ρ ; ρv/c) and (f • v/c; f) that all relativistically transformed like the basic co-ordinates (ct; x). He also introduced the imaginary time co-ordinate (i c t) so he could use a positive-definite 4D metric. Using the standard least-action approach based on the EM field Lagrangian density ($B^2 - E^2$), to the spherical model of the electron (as usual, filled with electrical charge-density), Poincaré had to add an extra term (now called the Poincaré stress) to cancel the self-stress generated by the electron's own Coulomb field. This extra term was needed to prevent the deformable electron from exploding in its own 'rest system' when subject to the internal Lorentz-force density.

Poincaré dismissed Larmor

Poincaré only briefly mentioned Larmor's EM theory in his own 1902 best-seller [44], for which Larmor wrote a 10 page preface to the English translation that appeared in 1905. Poincaré was obviously familiar with Larmor's work but dismissed it as a "failure" without any form of justification, even claiming that Larmor had only provided a "mechanical explanation" by building upon H. A. Lorentz's electron theory (again without providing any evidence). Larmor had published the full set of transformations (including those for the EM field variables) in 1895, the same year that Lorentz first proposed his own transformations for only the space and time co-ordinates. Although it was to be another nine years (1904) before Lorentz first published the same complete set, Poincaré still named these transform after Lorentz and not Larmor. Perhaps, Poincaré was being ironical (a French speciality) when he named the final version of the relativistic transforms after Lorentz. In order to correct this historical injustice, this programme will henceforth refer to them as the "L-transforms" (or **LT**s), reflecting the ambiguous contributions of both Larmor and Lorentz. Miller's term "Relativistic Transforms" will also be used, as this is a more generic attribution.

2.3.5 SUMMARY OF THE RELATIVISTIC TRANSFORMATIONS

Jefimenko has summarized the history of the 'Lorentz' transformation in a series of footnotes in his EM text on Retardation [45]. He begins with the spatial transform for the transverse directions, first published by Woldemar Voigt in 1887. The full set of co-ordinate transforms (including the longitudinal direction of motion and the temporal) was first published by Joseph John (J J) Thomson (1856-1940) in 1889 [46]. Joseph Larmor, England's leading theoretician in Maxwellian EM, was the first to derive this full set of basic co-ordinate transforms to Maxwell's Equations from his own electron theory. All of these results, along with the new transforms of the EM field variables, were published in his famous book *Æther and Matter* in 1900 [35]. H. A. Lorentz only <u>proposed</u> these equations for transforming the space and time co-ordinates (but only for t = 0) in his 1895 investigations into the electrical and optical properties of moving bodies [47]. All of this work would have been known to H. A. Lorentz before he first used them for transforming Maxwell's Equations in 1904 when he first published these extended results (again without citations) [38].

Poincaré's Contributions to Einstein's SRT

The relativistic formula for the addition of <u>rectilinear</u> velocities followed directly from the 1904 demonstration of France's leading theoretician, Henri Poincaré that these transforms form a group. In 1898, Poincaré had already pointed out that light always travels at a constant speed c, so that the concept of simultaneity was only a convention; this was followed by the statement in 1902 that the æther was not subject to measurements i.e. it was a metaphysical concept. Finally, in 1904 he was the first to write on the Principle of Relativity, which proclaimed that the laws of all physical phenomena must be the same for all observers in uniform relative motion. These latter two insights became Einstein's initial postulates in his SRT.

Modern Derivations

In 1976, Levy-Leblond provided a general derivation of the L-Transformation [48] explicitly trying to avoid the standard use of the 'constant velocity of light' hypothesis so that this transformation could be seen as universal across all major forces in physics. He proposed using general properties of "the structure of space-time", such as homogeneity and isotropy of space plus linearity (group transforms) and causality for different inertial observations of the "same event". He found that only the Relativistic and Galilean transforms satisfied all of these constraints. The Relativistic transform also required a velocity-like parameter *c*, "which is a universal constant associated with the very structure of space-time." This approach was based on a <u>single-time</u> 'event' (as seen from a common origin of the two inertial reference frames) so it had implicitly smuggled in the outward, propagating spherical wave model that was the foundation of Einstein's approach in 1905. It was therefore not surprising to find that when *c* was finite it also ended up with the Relativistic transform. Since this approach ignored the physical situation of EM interactions between <u>two</u> electrons, neither of which can be 'pinned' to the origin, it becomes no more than another mathematical solution of the spherical wave equation viewed from two separating centers.

The Poincaré Group

The addition of the standard 3D spatial translations to the L-Transformation group is now known as the *Poincaré group*. Pais has made an interesting observation, when describing the anomalous factor of '2' in the gyro-magnetic ratio [49]: "At the heart of the Thomas precession is the result that if one LT with a velocity $\underline{v}_1$ is followed by another LT with a velocity $\underline{v}_2$, in a <u>different</u> direction, the combination does **not** lead to the same inertial frame as one single LT with velocity $\underline{v}_1 + \underline{v}_2$." This means that these are each <u>only a group for linear additions</u> of velocity in the **<u>same</u>** direction. As space is 3D, this is a very limited result, especially as EM always introduces transverse forces for charges in motion (the 'Lorentz' force).

2.4 EINSTEIN'S SPECIAL RELATIVITY THEORY

A Crisis in Maxwellian EM

Albert Einstein (1879-1955) worked within the Continental tradition of EM that centered on the work of H. A. Lorentz and H. Poincaré. Both of these senior scientists were investigating the electrodynamics of moving bodies when viewed from the theoretical perspective of Maxwell's EM. The most puzzling challenge was the optical experiments of Michelson that failed to show the expected effects of motion relative to Maxwell's fixed æther.

The rigid retention of the older metaphysical models implicit in Maxwell's theory of EM resulted in physicists constructing bizarre theories to comply with the irrefutable evidence of experiments. Ultimately, Einstein had to change the definitions of space and time so that he could retain (implicitly) Maxwell's model of the æther although he explicitly claimed that he had dispensed with it. The null results of Michelson and Morley and then later, Trouton and Noble, were only a problem for the Maxwellian theory of light. These anomalies should have been the trigger that prompted physicists to re-examine their assumptions and return to a deeper examination of the rival action-at-a-distance EM theories that had no problems with 'the electrodynamics of moving bodies'.

The 'unusual' features of SRT arise directly from two features that distinguish the EM interaction from Newton's simple model of gravity; namely, EM involves delayed action-at-a-distance and a 'force' that depends on the relative velocity of the pair of charged particles. In contrast, the gravitational interaction was treated as a simple, line-of-centers, instantaneous force that was independent of the relative velocity of the attracting bodies. These distinctions imply that EM measurements will appear "odd" when viewed by a third participant (optical observer) with his own independent but fixed relative velocity.

2.4.1 EINSTEIN'S 1905 SRT PAPER

Very Little Electrodynamics

At age 26, Einstein published his most famous paper, *On the Electrodynamics of Moving Bodies* in the September 1905 issue of Germany's leading physics journal, *Annalen der Physik* [29]. Einstein's explicit intent (described near the end of his introduction) clearly stated that he wished to derive a "simple and consistent theory of the electrodynamics of moving bodies, taking as a basis Maxwell's theory for bodies at rest." In other words, how would EM appear from the viewpoint of the moving electron? This ignored the fact that any electron subject to EM forces would be accelerated and cannot form the basis for any equivalent inertial frame of reference. As will been seen later, this paper contained little electro-dynamics but did incorporate Maxwell's view that light was a propagating EM wave; in this case, playing the central role of a universal synchronization and signaling device. Indeed, it might have attracted more attention when first published if it had used a title like: *On the Relative Optics of Constantly Moving Massive Objects*. It would have been more accurate if the title had stated *On Maxwell's Theory in Moving Co-ordinate Systems*. While talking about semantics, Einstein did not use the term 'relativity' in this paper and he only used the expression 'relativity theory' after 1911; until then (confusingly), he would speak of 'the principle of relativity' when he was referring to the principles, arguments and techniques introduced in his SRT paper. It was only towards the end of 1915 that he introduced the phrase 'special theory of relativity' to distinguish this earlier work from his latest theory on gravity and acceleration, which he wished to call the 'general theory of relativity'.

Einstein's Innovations

The science historian, Stanley Goldberg, who undertook the first study of the early international reception of SRT, described how Einstein approached the problem of electrodynamics in an original manner [50]. Firstly, Einstein derived his theory based on an axiomatic approach (the two postulates), secondly, he created a kinematical theory (not a dynamical model) and thirdly (relating to the second point), this theory was not dependent on any explicit properties of the EM æther. Einstein knew that Newton's kinematics (theory of constant motion) was in conflict with Maxwell's EM theory, especially the by-then famous set of field equations that resulted in wave-like motion in empty space. In order to preserve the EM theory, Einstein was forced to sacrifice the simplicity of the kinematics that had served physics for over 200 years.

Einstein's Two Postulates

Einstein introduced the second section of this paper with his two postulates, or 'principles', from which he would construct his theory. The first was the *Principle of Relativity*, which he defined as: "The laws by which the states of physical systems undergo changes are independent of whether these changes of state are referred to one or the other of two co-ordinate systems moving relatively to each other in uniform translational motion." The second was the *Principle of the Constancy of the Speed of Light*, defined as: "Any ray of light moves in the 'resting' co-ordinate system with the definite velocity *c*, which is independent of whether the ray was emitted by a resting or a moving body." Critics of Einstein's approach, from the very beginning, have focused on these two postulates as unsuitable for forming the foundations of such a universal theory: they will also be commented on extensively herein. At this point, it will prove useful to notice that in his version of the *Principle of Relativity*, Einstein refers to 'states', which in the case of inertial particles are characterized by their momentum. This concept is ignored in the remainder of the paper that ends with a discussion, in terms of Newton's Second Law of Motion, of an 'electron' subject to a static electric field and the impact this has on the definition of mass only. This avoidance of any discussion of **velocity** in mechanics is significant, especially changes in this quantity, in a theory that purports to be about constant velocity, refraining from discussing acceleration until the later, 'General Theory' of relativity. The *Light-Speed* postulate was a far more radical departure by Einstein and was vigorously criticized by many of his contemporaries. The major reason for rejecting this postulate was that it implied the rejection of Maxwell's æther, which was viewed as the necessary medium for supporting EM vibrations that were viewed to be the metaphysical basis of the phenomenon of light.

Two-Way Synchronization

Throughout the SRT paper Einstein always used the term 'event' to mean an occurrence at a particular location (measured relative to an inertial reference frame by a rigid measuring rod) and at a time that was registered by a stationary clock at that **same** point in space. In Einstein's scheme, each inertial reference frame had a master clock at the origin that was used to synchronize all (?) the other clocks throughout this reference frame. He dismissed one-way master-clock synchronization as "inconvenient". Instead, he proposed (§1, 33-46) two-way (reflective) synchronization between any two remote locations. As Miller describes this process: "an inertial system composed of rigid rods and an associated isotropic and homogenous space was a logical inconsistency" [51]. Lengths of objects moving through an inertial frame are **defined** by an observer moving with the rod comparing the locations of the ends of the object at two fixed locations when their fixed clocks at these two locations 'read' the same time. This does not appear to be a very 'convenient' method of measuring moving objects. In case it might be thought that Einstein's use of the concept of 'rigid rods' was a youthful mistake that he later realized was incorrect, it would appear that he clung to this viewpoint until the end of his life. In the fifth edition of his best-selling book *The Meaning of Relativity*, which Einstein revised for the last time only two years before his death he still claimed [2]: "co-ordinates with respect to an inertial system are **physically** defined by means of measurements and constructions with the aid of *rigid bodies*."

Einstein's SRT Velocity Contradictions

Many critics (see [52]) have pointed out that Einstein's SRT paper contains a major internal contradiction. In section two, line 50 [26], when analyzing the reflection of light between two ends of a rigid rod in motion, Einstein calculated the light-speed to be $c \pm v$. Later in section five, after deriving the addition of relativistic velocities, he then proved (line 18) that the velocity of light is always c: the result he needed to confirm, in order to be consistent with his postulate that light always travels at light-speed in a vacuum. In effect, Einstein was implicitly following Lorentz's approach of switching from the laboratory frame of reference to one that moved with the field point, which was moving through the laboratory at a constant speed v. This field point, especially when it tracked the location of a real 'target' electron (as in section ten), always appears stationary to the moving frame of reference. This could no longer be true whenever the target electron was subject to real accelerative effects, as is always the case in any EM theory. In this case, there is no equivalent inertial reference frame 'riding on the electron' – so Einstein had to resort to Zeno's 'trick' of introducing fictitious 'instants of time' for an infinite set of 'equivalent' inertial reference frames. Einstein realized this was not an acceptable style of solution for the study of dynamics, which is the reason he moved on from the 'special' theory to his later 'general' theory to include acceleration.

2.4.2 RELATIVISTIC MASS CALCULATIONS

The key innovation underlying Newton's physics was his technique for introducing the concept of 'number' into the study of natural philosophy. In particular, Newton defined the concept of 'mass' as the measure of the amount of matter existing in a physical body. This allowed a *physical experiment* to be proposed that could *assign numbers to qualities* of the natural world. When combined with Newton's algebraic approach to multiplying qualities, as in his definition of momentum, he had a complete metrical scheme that justified the title of his world-changing masterpiece *The Mathematical Principles of Natural Philosophy*. It was the implicit idea of instantaneous interactions that converted Newton's conservation of total momentum principle (the direct consequence of his Third Law of Reaction) into an equivalent stationary center-of-mass theorem; this linkage was subsequently broken by the asynchronous nature of the EM interaction.

Longitudinal & Transverse Mass

Einstein had followed Lorentz and recreated Max Abraham's 1902 results which indicated that a high-speed particle reacted differently to an isotropic force in its direction of motion or at right-angles to this motion; this was summarized as both a longitudinal and transverse mass [53] – a significant deviation from Newton's invariant mass concept. SRT can be seen as a philosophical attempt to replace the unchanging foundations of our common view of the world with concepts that change their significance, with the relative points of view of every different observer. This, along with his apparent rejection of the foundation of Maxwell's EM theory (i.e. the æther), were probably the main reasons that Einstein's new perspective was so vigorously rejected by his scientific peers, who were well-grounded in both electromagnetism and natural philosophy.

2.4.3 EINSTEIN'S MASS-ENERGY APPROACH

In 1884, John Poynting analyzed Maxwell's Equations in empty space to show that EM radiation conveys an energy density $\varepsilon = E^2 / 4\pi$ when the local electric field vector has a maximum strength of E [54]. He also showed that this radiation exerted a pressure by conveying a momentum density $\eta = E^2 / 4\pi c$. These two forms have the obvious relationship: $\varepsilon = \eta c$. As Lewis later pointed out (section 3.4) one only has to introduce the idea that this momentum, traveling at light-speed c, is due to an equivalent moving mass density μ (or $\eta = \mu c$) to arrive at the 'Maxwellian' version of that famous equation: $\varepsilon = \mu c^2$.

The Inertia & Energy Papers

Later in 1905, Einstein wrote to his friend Habicht [55]: "the principle of relativity in conjunction with Maxwell's fundamental equations requires that the mass of a body is a direct measure of its energy content – that light transfers mass." This resulted in Einstein's final paper in his 'Annalen Quartet', where he first derived the most famous equation in physics: $E = mc^2$. This equation never actually appeared at this time; he actually wrote in this paper: "If a body gives off the energy L in the form of radiation, its mass diminishes by L/c^2." Of course, this view of mass is quite contrary to Newton's original conception of mass as the measure of the quantity of matter. In Einstein's model, mass would have to first disappear at the source (or multiple sources) and then to magically re-appear later within the existing receiving matter upon absorption.

Miller provides a signal duty by reminding the modern reader that Einstein was never happy with his attempts to derive the 'mass-energy' equivalence, contrary to the widespread assumption this had all been accomplished in the final paper of 1905. In 1906, Einstein demonstrated [56] that, at least to first order (in v/c), the validity of the principle of the conservation of center-of-mass momentum depended on the mass-energy equivalence. This approach is frequently used in undergraduate texts. Although Einstein commented that this was similar to Poincaré's result of 1900, he failed to mention that Poincaré had neither attributed any decrease in mass to an EM emitter nor did he propose that mass was equivalent to energy as he never assigned any mass to radiation. Thomson had explicitly introduced this equivalence first in 1881 [57]. Einstein tried again twice in 1907, first with two analyses of charged bodies, beginning with a rigid macroscopic charged body and then for a collection of mass points [58]. Einstein's next attempt to ground this important result was included in his 1907 review in the radioactivity yearbook [59]. This approach used a magical deformable envelope (that was impermeable to radiation) containing charged bodies that acted like a "material point". Despite all of these logical failures and the absence of any experimental confirmation, by the end of 1907 Einstein was convinced of the universality of the mass-energy equivalence. Ironically, one of Einstein's last technical papers was a final attempt to justify the equivalence of mass and energy. This was published, appropriately for a mathematical theory, in the Bulletin of the American Mathematical Society in 1935 [1]. This final attempt appealed to 'plausibility' arguments based on elastic collisions of two identical particles and an appeal to the 'Lorentz' transformations of the space and time co-ordinates, while invoking the conservation principles of energy and momentum (repeatedly referred to, incorrectly, as 'impulse'). Here, too, Einstein was still invoking his model of the 'rigid body' to move from mathematical points to measurable objects.

2.4.4 EINSTEIN & THE ÆTHER

Maxwell's EM Fields need an Æther

Maxwell's EM theory, like all field theories, implies a medium (like the æther) to 'carry' (or at least, 'define') the fields. Attempts to define the EM fields as simply 'fields of force' are both circular and tautological; they are simply extra words that convey no new meaning. Finite speed field theories must be affected by the relative speed of the target field point if it is in relative motion to the medium. Any hypothesis introduced to impose a constant speed of field variations through the medium then implies that either the Relativistic transform is needed or field theories do not correspond to reality and action-at-a-distance theories are needed instead. As a natural philosopher, Maxwell was completely aware of the need for a carrier of energy across space. As he wrote critically in his *Treatise* [60]: "If the action of a remote electrical system on another system does in reality take place by direct action-at-a-distance, without the intervention of any medium, we must consider these quantities (EM energy, tension and pressure) as mere abbreviated forms for certain symbolic expressions, and as having no physical significance." Maxwell knew that without the metaphysical necessity of an æther, he was just proposing a mathematical theory, which was his primary criticism of the action-at-a-distance theories of his Continental rivals.

Comparing Einstein and Lorentz

In their different approaches to electrodynamics, Lorentz was more consistent than Einstein. Lorentz acknowledged that their theories were both based on Maxwell's EM theory that was grounded in a model of the æther as the carrier of the EM fields. It was completely consistent to use Galilean invariance for Maxwell's theory as this was created on the assumption of the independence of space and time. Thus, Lorentz could consistently view absolute time as being defined relative to the universal, stationary æther, even though this could not be detected. He resolved this problem by introducing invariant *local time*, centered on the moving electron, with 'calculational' time being defined in the 'lab' frame, as every point (moving or not) defined its own frame of reference, especially for its own set of Lorentz transforms [61]. In contrast, Einstein had to redefine relative simultaneity using two-way light signaling, based on a non-measurable view of the 'speed of light'. In fact, use of the Lorentz transformation is, in general, very complicated except when both observers are on the same translational radial vector between the common event and the common origin.

Ignoring the Æther in 1905

Einstein did not dispose of Maxwell's æther in his SRT paper. As he wrote [62]: "The introduction of a 'luminiferous æther' will prove to be superfluous because the view here to be developed will introduce neither an 'absolute resting space' provided with special properties, nor associate a velocity-vector with a point of empty space in which electromagnetic processes occur." In this statement, Einstein was going beyond Mach, who had never rejected the idea of a physical æther but was waiting for further experimental evidence to confirm the status of its real existence. This dismissal also challenged Poincaré's metaphysics that viewed the æther, like Maxwell, as necessary to support the EM disturbance in transit and as a continuum, so that EM phenomena may be described by differential equations. However, Einstein never explained in what medium the EM fields were to be found, even though he had absolutely, no doubt that such EM fields were completely real. Indeed, in his short 1935 paper [1], Einstein confessed that his SRT "grew out of Maxwell's electromagnetic equations."

Einstein has problems with the Æther

Kostro has documented Einstein's fluctuating views on the reality of the æther, showing how Einstein only denied the existence of the æther for only eleven years, from 1905 until 1916. He notes that all 19th Century models of the EM æther favored one specific reference frame. He quotes Einstein's letter of 1912 to his friend, Paul Ehrenfest: "You are one of the few theoreticians who have not been deprived of their native intelligence by the mathematical epidemic." [63] In 1920, in one of his public lectures on relativity at the University of Leyden, Einstein contradicted his dismissal of the EM æther earlier in 1905 so as to preserve the wider impact of his General Theory of 1916. He wrote [64]: "More careful reflection teaches us, however, that the special theory of relativity does not compel us to deny the æther." Six pages later he writes: "The æther of the general theory of relativity is a medium which is itself devoid of all mechanical and kinematical qualities but helps to determine mechanical (and electromagnetic) events." In order to play this key intermediary but physical role between the real material of the universe (with ponderomotive mass), Einstein also had to say (page 16): "To deny the æther is ultimately to assume that empty space has no physical qualities whatever." This is actually the view of empty space that is explicitly taken in the present research programme, contrary to Einstein's final viewpoint, which he states on page 23 as: "According to the general theory of relativity space is endowed with physical qualities; in this sense, therefore, there exists an æther – space without æther is unthinkable."

3. REACTIONS TO SPECIAL RELATIVITY

3.1 PLANCK'S ROLE IN RELATIVITY

Planck's Support for Einstein

In 1905, Max K. L. Planck (1858-1947) was Professor of Theoretical Physics at Berlin University, which was Germany's leading institute for physics. Goldberg has described how, from this position of prestige and authority, Planck promoted Einstein's career and revolutionary ideas. Einstein's colleague and scientific biographer, the theoretical physicist Abraham Pais (1919-2000) has also confirmed that Max Planck was the first and most vigorous promoter of Einstein [65], possibly because of the intense nationalism that was sweeping Europe prior to the Great War. Planck was also the first physicist to subsequently write on relativity [66] with his 'Proposal' for redefining relativistic momentum (see section 3.2). He was also the first scientist to coin the phrase *relativity theory* in 1906 [67]. Ironically, although Planck was Einstein's greatest supporter, unlike Einstein, he always insisted on the necessity for an ætherial medium to support Maxwell's EM fields, as did Einstein's other two heroes, Lorentz and Poincaré; indeed, so did almost every other physicist around 1900.

Eminence Grise

In exercising decisive power behind the scenes, Max Planck was acting as the 'Cardinal Richelieu' of late 19th Century German physics. In his role as chief advisor for theoretical physics to *Annalen der Physik,* he acted as the invisible censor of new ideas. As private advisor to the Prussian educational bureaucracy, his confidential recommendations played a key role in filling critical professional appointments in an authoritarian, hierarchical, conservative culture [68]. In his public role as Director of the Imperial Science Institute in Berlin from 1889 to 1927, he was able to make his own Platonic viewpoint the official orthodoxy of the next generation of German theoretical physicists, so that the eternal, immutable laws of thought could be discovered by pure thought alone; in other words, by mathematics.

Planck's Coterie

The second earliest supporter of Einstein's SRT was Max von Laue (1879-1960), who was Planck's personal assistant in 1905 (and until 1908). He wrote the first monograph [69] on relativity (*The Relativity Principle*) in 1911, where he proved that the classical concept of a *rigid body* had no place in relativity since such an object would be capable of instantaneously transmitting information throughout its dimensions no matter how far apart, i.e. both ends moving together at the same time. He did <u>not</u> point out that this was integral to Einstein's theory where Goldberg quotes Einstein's claim [70] that relativity "is only founded on the ideas of <u>rigid</u> rods, perfect clocks and light signals." This internal contradiction surrounding the key idea of rigid bodies also did not seem to bother any of the other members of Planck's coterie that were promoting Einstein's SRT nor does it seem to have presented any problem to supporters of Einstein's SRT ever since.

3.1.1 PLANCK & *ANNALEN*

Planck referees 'Annalen'

Planck was co-editor in 1905 and from 1906 the sole editor of Germany's leading academic physics journal (*Annalen der Physik*), where Einstein's first professional papers were published. As theoretical co-editor (i.e. 'referee') Max Planck must have personally reviewed Einstein's first publication in this journal in 1901 as it was the custom at that time, that the adviser would confirm the suitability of an unknown author's first contribution before acceptance for publication. Once published, further submissions were rarely reviewed thereafter once the new author had passed this initial test. It is therefore possible that Einstein's SRT paper [29] was not refereed prior to publication – this would explain why there were no citations and no references to any earlier investigations into the electrodynamics of moving bodies: a field that had been actively researched by then for at least ten years, as Planck well knew. In this regard, Max Planck failed in his responsibilities as co-editor of *Annalen der Physik* in 1905 when he allowed a paper to be published that had no references or citations to earlier work in the same area (electrodynamics and moving bodies) – especially the major contributions of Germany's rivals: Larmor, Lorentz and Poincaré.

3.1.2 PLANCK'S METAPHYSICS

Planck's Philosophical Idealism

A major reason for Planck's early patronage of Einstein was Planck's own rationalist approach to physics research [71]. This was exemplified by his own early papers on thermo-chemistry written during the period 1887 through 1894 where he used only the general laws of thermodynamics together with 'ideal processes' (*gedanken* experiments), which avoided all hypotheses about molecular motion, which was still a controversial idea at that time.

Planck's Platonism

Goldberg claims that Max Planck's support for the theory of relativity [72]: "can be traced to his own philosophical and ethical convictions about the ultimate laws of reality." Planck viewed physics as supremely objective, like mathematics, and SRT demonstrated "laws and variables that are absolute and invariant – the same for all observers." Pais has also speculated on Planck's vigorous support for Einstein, claiming that Planck's admitted Platonic obsession ('the search for the Absolute' had found a new focus in Einstein's formulation of the '*Relativity Principle*'). Planck and Einstein, like Poincaré, believed sincerely that physics had entered its 'second phase', where the laws of physics should be based on general 'principles'.

Planck's Technique

A major problem in physics first appeared in the 19^{th} Century when German universities started to recruit mathematicians to teach the more mathematical components of physics to undergraduates. Like most mathematicians, these men were quite content to manipulate symbols that had no meaningful significance – they found the 'rules of the game' were sufficient. In contrast, natural philosophers have always needed to understand their symbolic representations of reality. Indeed, the main tradition in natural philosophy, following Newton, was to develop a **visual** model of a situation that was the first step that preceded attempts to describe the model in mathematical terms. Planck was one of the first 'theoretical physicists' to work only in formal terms. He seems to have developed the useful technique of 'working backwards' from an experimentally derived equation to a logically prior point where he could introduce an *ad-hoc* mathematical hypothesis. He would then work forward again to 'derive' the original equation so that it could be claimed that the facts had now been 'explained'. He used this technique first in 1901 with Pringsheim's black-body radiation curve which was then 'derived' from Planck's now famous quantum hypothesis. He repeated this process in 1907 when he started with Kaufmann's measurements of the e/m ratio of high-speed electrons subject to transverse EM forces. He worked backwards again to the plausible hypothesis that the electron's mass varied with speed when accelerated by a constant force; he then worked forward again to 'derive' the relativistic mass formula, which immediately results in the 'proof' of the mass-energy formula. This variable mass exposition is the one usually reproduced in today's textbooks on relativity. It will be the focus of the present paper.

3.2 PLANCK'S PROPOSAL

Planck redefines Momentum

Planck, as advisor to the theoretical section of *Annalen der Physik*, was probably the first person to read Einstein's famous SRT paper [29]. He quickly realized that Einstein had made an error in simply assuming Newton's simplified force law (force = mass * acceleration) and using his usual trick of 'back-tracking' discovered he could make the necessary change in Newton's definition of momentum. So, in 1907 [66] Planck introduced his own quite arbitrary change in this definition by assuming that the 'observed' mass M of a particle with intrinsic, inertial mass m, when seen to be moving at speed v, was speed-dependent; in other words, Planck made the proposal:

$$M[v] \neq m \quad \text{when } v \neq 0$$

This revised definition of a particle's mass was to be used with Newton's original definition of momentum $\underline{P}$, as the product of mass and velocity along with the continuous form of Newton's Second Law of Motion, namely the instantaneous force $\underline{F}$ equals the continuous rate of change of momentum.

$$\underline{P}[t] = M[v]\,\underline{v}[t] \qquad \text{and} \qquad \underline{F}[t] = d\,\underline{P}[t] / dt$$

This set of assumptions and definitions (referred to hereafter as "Planck's Proposal") has become the standard form ever since of what is now known as 'relativistic mechanics', in contrast with 'classical' (or Newtonian) mechanics where every particle's mass is independent of its observed speed.

3.2.1 THE DERIVATION

Using Euler's Metaphysics

The Swiss savant, Leonhard Euler (1707-1783), widely regarded as one of the greatest mathematicians of the 18th Century, attempted to develop a Natural Philosophy based on continuum models of solid bodies and continuous fluids, in contrast to Newton's model of microscopic point particles. Like DesCartes, Euler's view of 'matter' was based on the idea of extension and impenetrability (which implied coherent mobility), hence Euler's proposition that the interaction between bodies is due to elastic collisions. Euler's focus was on a single body's state of motion, that is to say, *velocity*, rather than Newton's truly revolutionary idea of *inertial mass* and, therefore, momentum. Since Euler was obsessed with infinitesimals, he viewed all changes in a body's state as due to external forces whereas Newton's Second Law of Motion focused on the idea of impulse. Euler's force law actually anticipated Planck's Proposal of 1906/7 for a variable velocity-sensitive momentum:

$$\underline{P}[v] = m[v]\,\underline{v} = m_0\, f[v]\,\underline{v}\ ; \quad \text{So,}\quad d\{\,\underline{v}\, f[v]\,\} = \{\,\underline{F}/ m_0\,\}\, dt \quad \text{(Euler's Force Law)}$$

Unlike Newton, Euler's emphasis was only on the single ('target') body, that was subject to 'external' and internal forces, whereas the real genius of Newton's Third Law of Motion emphasizes the mutual interaction between the source and target particles, including action-at-a-distance: the philosophy followed in this research programme. Peter Enders describes this Eulerian approach in his 2005 paper [73] on classical and quantum mechanics.

Planck's Proposal

In 1906 and 1907, Planck wrote two papers on the relativistic effects on a high-speed particle's motion. The first paper [74] (and most frequently cited, possibly because its title promised to address the foundations of mechanics – and it was only five pages long!) was based on the observation that a single, vector version of a modified 'law of motion' that incorporated the 'Lorentz' force could unify both Einstein's and Lorentz's transverse and longitudinal mass equations. This new form was:

$$d/dt\{\, m_0\, \underline{v}\, (\,1 - v^2/c^2)^{-½}\,\} = e\,\{\underline{E} + \underline{v} \wedge \underline{B}\, / \,c\}$$

This intuitive suggestion, based on covariance arguments, enabled Planck to suggest a relativistic Lagrangian L for a 'mass-point' so that he could define the 'impulse co-ordinate' $\underline{P}$ from the standard Lagrangian definition:

$$\underline{P} = \partial L / \partial \underline{v} = m_0\, \underline{v}\, (\,1 - v^2/c^2)^{-½} \quad \text{with} \quad L = m_0\, c^2\, (\,1 - v^2/c^2)^{½}$$

In his 1907 paper [66] Max Planck 'derived' this desirable result by introducing a fictional (constant) force $\underline{F}_0$ which was parallel to the accelerating particle's velocity at all times. This force transferred energy E from the unspecified source of this force to accelerate the target point particle continuously from rest to a velocity $\underline{V}$. Planck identified this new dynamic energy, denoted E with the kinetic energy of his relativistic particle through the classical, continuous kinetic energy equation relating the mechanical work done W by the external force in the direction of motion: $dE = dW = (\underline{V} \bullet \underline{F}_0)\, dt = \underline{F}_0 \bullet d\underline{X}$

The most important step in Planck's derivation was the assumption that Newton's definition of a particle's momentum $\underline{P}$ was still valid but that the inertial mass was now a function of speed M[V], which could be used in an extended version of Newton's Second Law of Motion relating force to the change in momentum. Note, in the following how critical is the assumption that all vectors are collinear. Each of Planck's assumptions (usually made implicitly *) is introduced in turn.

#1. The particle's inertial mass becomes a scalar function M increasing with speed V from a rest-mass m: M[V].
#2. The mass variation is a function of the speed, relative to 'light-speed' c: $M[V] = m\, \mathcal{L}[\beta]$ & $\beta = V/c$.
*3. The particle's momentum $\underline{P}$ is always parallel to its velocity $\underline{V}$: $\underline{P} = P\, \underline{U}$ where $\underline{U} = \underline{V} / V$ & $\underline{U} \bullet \underline{U} = 1$.
*4. The change in momentum $d\underline{P}$ is always parallel to its velocity: $d\underline{P} = \underline{U}\, dP$.
*5. The change in velocity $d\underline{V}$ is always parallel to its velocity: $d\underline{V} = \underline{U}\, dV$.
#6. The particle's momentum is proportional to its velocity ("Plank's Proposal"): $\underline{P}[V] = M[V]\, \underline{V}$.
*7. The external force is always parallel to the change in momentum (Newton's II): $d\underline{P} = \underline{F}_0\, dt$.
#8. The change in the particle's dynamic energy equals the external work done: $dE = dW = \underline{F}_0 \bullet d\underline{X}$.
#9. The cumulative work (up to speed V) is proportional (via parameter c^2) to the relativistic mass: $W = c^2 M$.

The following algebraic steps then follow mathematically from these assumptions.

A. $d\underline{P} = M\, d\underline{V} + \underline{V}\, dM \qquad \underline{U}\, dP = \underline{U}\, M\, dV + \underline{U}\, V\, dM$ (using #6,4,5)

B. $dP = M\, dV + V\, dM$ (now only a scalar relationship)

C. $dW = \underline{F}_0 \bullet d\underline{X} = d\underline{X} \bullet d\underline{P}/dt = d\underline{P} \bullet d\underline{X}/dt = d\underline{P} \bullet \underline{V} = dP\, (\underline{U}\bullet\underline{U})\, V = V\, dP$ (using #8,7,4,5,3)

D. $dW = M\, V\, dV + V^2\, dM$ (using B & C)

E. $dW = c^2\, dM$ (using #9)

F. $dM = M\, V\, dV / (c^2 - V^2) = m\, \mathcal{L}\, V\, dV / (c^2 - V^2)$ (using #2)

G. $dM = m\, d\mathcal{L} = m\, dV\, (\, d\mathcal{L} / dV)$ (using #2)

H. $d\mathcal{L} / dV = V\, \mathcal{L} / (c^2 - V^2)$ so $d\mathcal{L} / \mathcal{L} = V\, dV / (c^2 - V^2)$ (using F & G)

Integrating this differential equation from zero to V and remembering that $\mathcal{L}[0] = 1$ gives: $\mathcal{L}[V] = (1 - V^2/c^2)^{-½}$

It is worth drawing attention to several key moves in this derivation. Firstly, this derivation assumes a result it desires (&8). Secondly, the reduction from 3D vectors to scalars (assumptions *3, 4, 5 & 7). It is not at all obvious that the Lorentz force, the only known EM force on electrons, tracks the direction of the change in momentum at all times, especially as relativistic acceleration is not parallel to the instantaneous force, as can readily be shown.

$$d\mathcal{L}/dt = 1/c^2\, V\mathcal{L}^3\, dV/dt \quad \therefore\ \underline{F} = d\underline{P}/dt = d(m\mathcal{L}\, V)/dt = m\, \underline{V}\, d\mathcal{L}/dt + m\, \mathcal{L}\, d\underline{V}/dt = 1/c^2\, M\underline{V}\mathcal{L}^2\, dV/dt + M\, d\underline{V}/dt$$

$$\therefore\ \underline{V}\bullet \underline{F} = m\, \mathcal{L}^2\, \underline{V}\bullet d\underline{V}/dt \qquad M\, d\underline{V}/dt = \underline{F} - (\underline{V}\bullet \underline{F})\, \underline{V} / c^2 = (1 - V^2/c^2)\, \underline{F} \text{ if \& only if } \underline{F} = F\, \underline{U}$$

$$\text{Also:} \quad m\, d\mathcal{L}/dt = 1/c^2\, MV\mathcal{L}^2\, dV/dt = (\underline{V}\bullet \underline{F}) / c^2 = 1/c^2\, dE/dt \quad \therefore\ dE = mc^2\, dL = c^2\, dM \quad \therefore\ E = M\, c^2$$

Newton 'anticipates' Planck

The mass-energy equation can be readily derived from Newton's views of the impulsive interaction between two particles if Newton had assumed that interactions required a finite time to cross the spatial separation (X) between the particles and the speed 'c' of this energy exchange is constant. Newton's Second Law of Motion was actually formulated in terms of discrete impulses $d\underline{I}$ causing changes in momentum $d\underline{P}$ and energy dE between the particles.

$$dE = \underline{V} \bullet d\underline{I} = \underline{V}\bullet d\underline{P} = \underline{V}\bullet d(\, M\, \underline{V}\,) = \underline{V}\bullet (\underline{V}\, dM + M\, d\underline{V}) \qquad \text{but if } V = c \text{ then } dV = 0 \quad \therefore\ dE = c^2\, dM$$

$M\, c^2\, dM = M\, dE = M\, \underline{V}\bullet d\underline{P} = P\, dP$ Assuming $\underline{P}$ and $d\underline{P}$ are parallel; then integrating from M(o) = m to M:

$$c^2 \int M\, dM = \int P\, dP \qquad \therefore\ c^2(\, M^2 - m^2) = P^2 = M^2\, V^2 \qquad \therefore\ M[V] = m\, (1 - V^2/c^2)^{-½} = m\, \mathcal{L}[V]$$

The Implications of Planck's Proposal

The square of Planck's Proposal: $\underline{P} = M\, \underline{V}$ leads (as Planck had well realized) to the identity: $P^2 + m^2\, c^2 = M^2\, c^2$

In terms of differences (or differentials): $\Delta(P^2) = c^2\, \Delta(M^2)$ leading to: $c^2\, \Delta M = v\, \Delta P = \Delta x\ \Delta P / \Delta t = F\, \Delta x = \Delta E$

a) For an electron with finite mass: $E = M\, c^2$ Substituting back into the squares identity: $E^2 = P^2\, c^2 + m^2\, c^4$

b) For a photon with zero inertial mass (m = 0): $P = M\, c$ and $E = P\, c$

3.3 RESISTANCE TO RELATIVITY

Contrary to the modern viewpoint (which has been created by revisionist historians), that portrays Einstein's special theory as changing the very nature of physics from the moment it was published, Einstein's SRT paper was almost totally ignored for several years after its publication. When it was brought eventually to the attention of contemporary physicists it was first rejected and only very slowly and reluctantly accepted. This almost forgotten process has been thoroughly described by the Einstein scholar and Harvard historian Stanley Goldberg in his text *Understanding Relativity – the Origin and Impact of a Revolution,* a book that deserves a much wider audience [75]. The ongoing arguments around this controversial subject resulted in no scientist ever being awarded the Nobel Prize in physics for either of the theories of relativity. In describing the reaction to relativity, Goldberg emphasizes the critical fact (that is now almost never acknowledged) that the nature of the explanation of any radical theory which individuals respond to is more related to the individual's prior commitments than to disagreements about the evidence. This is possible because any one of numerous theoretical structures can explain the empirical evidence. Moreover, metaphysical assumptions have often been associated with national differences.

Cultural Influences

The heart of Goldberg's book is the central section spanning four chapters (almost 100 pages) where the response of the four major national physics communities (German, English, French and American) to specifically Einstein's approach to the SRT is described. Initially, rejection was universal in all countries but for widely different cultural reasons. He points out that it is the social organization of science that preserves the status quo from new ideas thought to be heretical and threatening [76] "belief in science, as in all human activity, is a cultural phenomenon and is subject to intellectual fashion." Pais has also observed that at first the European scientists usually preferred Lorentz's theory to that of Einstein because it was constructed around physical hypotheses. In contrast, most American scientists who first looked at relativity preferred Einstein's more axiomatic approach, perhaps (like the modern theoretical physicist) because they were primarily mathematicians, while the more empirical experimentalists rejected both theories as being insufficiently grounded in experimental evidence. Goldberg also demonstrates that it was not experimental evidence that led to today's near-universal acceptance of this revolutionary theory but the powerful role of textbooks in the next generation's acquisition of knowledge that plays the key role – a subject that was described in the adoption of Maxwell's EM theory [77] and is particularly powerful in the American physics tradition.

Nationalistic Science

Scientists have long viewed themselves as above the mundane concerns of mere mortals but as one historian of science has acutely observed [78]: "Enlightenment men of science often claimed they were engaged in a collaborative, internationalist project to uncover the truths of nature. In practice, natural philosophy was riven with national interests: the intellectual debates between the supporters of such rivals as DesCartes, Newton and Leibniz were strongly colored by their chauvinist loyalties. From around 1700, most English experimentalists were opposed, as a matter of principle, to the ideas of Descartes. French resistance towards Newtonianism was fueled by Jesuit educators on religious grounds." Ironically, the central Law of Electrostatics, proposed by the French scientist Charles Coulomb (1736-1806), was directly modeled on the universal Law of Gravitation proposed by England's most famous scientist, Isaac Newton. Even algebra, at least until 1800, was seen in England, as an essentially French innovation, so preference nearly always was given in England to timeless geometric methods when applying mathematical techniques to the study of electricity. These rivalries continued to grow throughout the 19th Century coming literally to an explosive conclusion with the two world wars when almost all scientists strongly supported their own governments, with most contributing directly to their own government's war effort. The following examples will illustrate how this nationalistic impulse was played out in the study of electro-dynamics and relativity.

3.3.1 GERMANY

In Germany, despite Planck's powerful role in Berlin, Einstein's approach to the SRT was restricted for several years to a "handful of individuals". This was in spite of this new theory being vigorously debated across various research schools.

Von Laue's Deadly Analysis

Max von Laue's analysis in 1911 of Minkowski's world-tensor proved that the concept of the mass-point was inconsistent with the SRT [79] since a finite body needed internal stresses to invoke relativistic invariance and a moving object's spatial volume is a function of its relative velocity, a result that lies at the heart of relativity and electromagnetism. Von Laue also confirmed a pre-relativistic result of Abraham, that a body's momentum need not be collinear with its velocity; in effect, to move a body in the x-direction requires forces in the 'y' and 'z' directions: a result directly contradicting Planck's Proposal.

SRT was not Empirical

In von Laue's 1911 text on relativity he commented that Einstein's SRT was still being rejected by many researchers [80] who "maintain that the theory's empirical basis is not sufficient. Much greater however are the number of scientists who cannot satisfy themselves with the intellectual content; in particular, the relativity of time, with its many seemingly paradoxical consequences, appears unacceptable." This is a conclusion that fails to rankle today's mathematical physicists.

Einstein caught in a Contradiction

Kostro describes [63] how Philipp Lenard (1862-1947), winner of the 1905 Nobel Prize for cathode ray research, charged Einstein, in a public meeting held in 1920 to debate the theories of relativity, with trying to 'eat his cake and have it too'. Einstein re-introduced the concept of the æther in 1916 to support his model of the gravitational field but rejected the EM æther as 'logically' unnecessary in his special theory in 1905. It is, therefore, not a surprise that Einstein failed to integrate both electric and gravitational fields into one unified theory in the last 40 years of his life.

3.3.2 UK

In Einstein's first job at the Swiss Patent Office, he would have both access to all contemporary scientific literature and the paid time to read this material. None of these sources was cited in the SRT paper (in fact, there are no citations at all). The mathematical core (and largest section) of Einstein's famous SRT paper is a dubious (see 4.7.2) derivation of the Relativistic transforms. It is also highly probable that Einstein had already read the 1904 first edition of the now famous text on electromagnetism [81] of Max Abraham (1875-1922) since Einstein recreated Abraham's results for the longitudinal and transverse variations in electron mass with velocity using the same set of symbols. Given all of this well-published earlier work, it is not surprising that many of Einstein's British contemporaries, who were expert in EM, were not impressed with Einstein's claims to originality. Indeed, the British astronomer, Edmund T. Whittaker (1873-1956) went so far as to title his 50 page chapter on relativity as "The Relativity Theory of Poincaré and Lorentz", reducing Einstein's famous contribution to a three page summary of the relativistic Doppler effect [82]. Another respected historian of science, Helge Kragh has written [83] that Einstein was <u>not</u> justified in extending the general applicability beyond Maxwell's Equations. He quotes Einstein, who wrote [84]: "these results as to the mass are also valid for ponderable material points, because such a point can be made into an electron by the addition of an electric charge, *no matter how small*". This claim ignores the <u>finite</u> mass and charge of the electron, two facts that were already well-known to physicists in 1905.

Cambridge Incomprehension

George F. C. Searle (1864-1954), a lecturer at the Cavendish Laboratory in Cambridge, was the only British physicist to correspond with Einstein prior to 1919 [85]. He was an expert in electrodynamics and had visited Germany several times. In May 1909, he wrote to Einstein (who was still at the Swiss Patent Office) thanking him for sending a copy of his 1907 review paper on the principle of relativity. "I have not been able to gain any really clear idea as to the principles involved or as to their meaning and those to whom I have spoken in England about the subject seem to have the same feeling." Andrew Warwick, a Historian of Science, relates this story to illustrate how Einstein's papers on relativity were received in Britain by his contemporaries "with a mixture of indifference and incomprehension." Indeed, the second generation of Cambridge Maxwellians (Larmor, Cunningham, Bateman, Liven, Nicholson, Hasse, McLaren) "did not regard Einstein as the author of an essentially new theory. Rather, they viewed Einstein as raising an analytical result that originated in Larmor's earlier ETM theory to the status of a postulate of nature (the constancy of light's speed) – an extremely dubious step that was not empirically justified." [86] This generation of Cambridge mathematical physicists continued throughout their professional careers to view the principle of relativity as a theorem in Larmor's electron theory rather than as a foundational basis for a wholly new kinematics and mechanics. Einstein's work was initially ignored, re-interpreted, rejected and finally accepted and taught to undergraduates at Cambridge during the period 1905-1920.

Cambridge continues with the Æther

Until about 1920, most theoretical physicists who accepted Maxwell's theory of EM would view the concept of the æther as a necessary explanation for the existence of electric and magnetic fields and the propagation of energy through empty space by an EM wave. The Cambridge supporters of the ETM theory would also see the existence of the EM æther as necessary, even though Larmor had introduced in 1887 the idea that electrons were the carriers of electricity rather than Maxwell's displacement in the æther. Einstein's failure to construct a dynamical theory around these concepts was viewed as a major weakness of his approach to electrodynamics [41].

Whittaker credits Poincaré & Lorentz

Edmund T. Whittaker (1873-1956), one of England's leading mathematical astronomers in the first half of the 20th Century, credited the development of the theory of special relativity to Poincaré and Lorentz in the second volume of his magisterial history of the æther and electricity [87]. As a contemporary of all the major contributors to this theory he recognized that these two scientists had not only provided the first theoretical analysis between 1895 and 1904 but they correctly saw that this theory was directly linked to the interaction of light and electrons. Perhaps, he was also influenced by their lifelong belief in the reality of the EM æther, a belief he shared throughout his own life. In over 50 pages devoted to this subject, he mentioned Einstein's contributions only once where Einstein's SRT paper was described as "adding some amplifications to the relativity theory of Poincaré and Lorentz which attracted much attention". Whittaker explicitly credited Einstein with high-speed modifications to the formulae for the aberration of light and the Doppler effect.

3.3.3 FRANCE

Poincaré ignores Einstein's SRT

In contrast to Germany, there was no response in France to Einstein's SRT from 1905 through 1911. The highly centralized French education system and the influence of Henri Poincaré (the leader of France's physics community) saw developments in the motional effects of EM entirely in terms defined by Poincaré, who was building on the foundations laid by Lorentz. Indeed, Poincaré never mentioned Einstein's SRT from its publication in 1905 until his own, early death in 1912 from post-operative complications [88]; as Goldberg reports [89]: "few French physicists spoke of it either." This was not due to petty politics, Poincaré was universally seen as a man of integrity and one not subject to professional jealousy or the pursuit of fame. It is possible that he viewed SRT as too theoretical and lacking in empirical foundations, while he also may have thought that the second postulate of the invariance of the speed of light was too artificial and unjustified. A broad survey of French scientists in the 1920s demonstrated almost no support for Einstein's SRT (except by Paul Langevin, who was a close friend of Einstein), on the grounds that the theory rejected the need for an EM æther and lacked a "firm basis". Furthermore, almost no French scientists supported Einstein's SRT before 1940.

3.3.4 USA & CANADA

America rejects SRT

The USA is the principal focus for Goldberg's analysis of the response to Einstein's SRT. He writes [90]: "In the United States, where the theory of relativity was largely ignored, the emphasis had been not only on the lack of empirical content to the theory but on its impracticality. American physicists, more than most others, were not only skeptical, they were derisive and outraged that such utter nonsense could get a serious hearing in some quarters." The respected American experimental physicist Herbert E. Ives (1882-1953) analyzed Einstein's original derivation of this famous equation in 1952 [91] where he showed that by concentrating only on the emitting particle alone then Einstein had to assume that the emitted light energy had to come from the particle which must therefore lose mass. In other words, Einstein's derivation was fallacious since one of his intermediate assumptions implicitly assumed the answer he was trying to prove. This paper was also widely publicized by Max Jammer in his award-winning study of the concept of mass [92] but these critical conclusions were even more widely ignored, perhaps because they originated from a philosopher of science.

Bridgman's Skepticism

Percy Williams (P. W.) Bridgman (1882-1961) was one of America's most honored physicists, including winning the Nobel Prize for Physics in 1946 for his life-long work at Harvard on extreme pressure measurements. He wrote extensively on the philosophy of science, including his advocacy for his preferred scientific method, known as 'operationism'. This was the method where a scientific concept, such as 'length' was defined by the scientific operations that could be used to <u>measure</u> the concept; when different scales were needed (e.g. microscopic versus human-scale lengths) then different concepts were needed. He wrote an influential book [93] on relativity (a subject that had fascinated him for 40 years of his life) that was published after he shot himself, ending his battle with terminal cancer. Bridgman was particularly impressed with Einstein's approach in his SRT paper to explicitly defining techniques for defining 'time' between separate, moving observers, or as he described it "spreading time over space". Harvard science historian, Stanley Goldberg, who had access to his papers, writes extensively on Bridgman's views in his history of relativity [94]. In 1928, he had written that: "it would be a great mistake to think of Einstein's theory as a logically consistent structure; it is lousy with implicit physical <u>assumptions</u>." Goldberg reports that Bridgman's "intellectual distress" with special relativity had returned by 1959. He remained convinced that there was no way to operationalize the one-way speed of light.

3.4 ACCEPTANCE OF RELATIVITY

Limited Support until General Relativity

Goldberg describes [90] how almost no physicists accepted Einstein's kinematical approach to Special Relativity before 1919 when the announcement of the experimental 'confirmation' of General Relativity began to impact the profession. In those first 15 years, the mathematical 'formalism' of relativity theory (i.e. the relativistic transforms and the relativistic mass formula) was increasingly adopted for predicting the results of experiments with high-speed electrons but the interpretation was usually based on Lorentz's second-order electron-æther theory. SRT was largely ignored in France until the 1950s.

The irony of this situation was that Einstein was compelled by the problems of introducing ideas of acceleration into his special theory to predict the dynamical behavior of high-speed electrons subject to EM fields to create a general theory of accelaration that he identified with gravitation. Rather than solve the problems of the special theory (as many of his fellow physicists believed) he had created two parallel theories for the two major forces measurable in the macroscopic world. He then attempted to unify these two field theories throughout the remainder of his life. His failure here has not discouraged two generations of field theorists from attempting the same goal. Their ongoing failure is reminiscent of the attempts of the physicists 100 years earlier, who failed to grasp the significance of the MMX null results – perhaps the theory is wrong!

3.4.1 GERMANY

Germany (and its German-speaking neighbors) had the most extensive university and research network in 1900. The more than 30 physics research centers competed with each other vigorously. The theory of relativity was eventually (after about 1908) debated until it became the accepted solution, beginning with Planck and then spreading outwards until by 1911 it had a degree of acceptance. Unfortunately, some of the anti-relativity disputations in this "old boys' club" were motivated by the widespread and long-standing anti-Semitism in Germany, where the growing number of Jewish theoretical physicists were seen to be 'pushing' Einstein's SRT. Even with Planck's patronage, Einstein remained employed in the Swiss Patent Office until 1909 when he was invited to become a professor at the Swiss ETH (his alma mater). In 1913, Planck invited Einstein to join him in Berlin where he stayed until he fled to Princeton in 1933 to escape the political situation in Germany.

3.4.2 UK

Cunningham's EM Field Transforms

Ebenezer Cunningham (1881-1977), a staunch Maxwellian and colleague of Searle, was the first British physicist to comment on Einstein's 1905 relativity paper [95] and the first to write a treatise in English on Special Relativity [50]. Cunningham, in his 1907 paper on electrodynamics [96], was also the first to point out that the Relativistic transforms of the space and time dimensions preserve the outward <u>spherical</u> wave form traveling at constant speed c in both inertial frames of reference. He was also the first author to show (by transforming the differential derivative operators, div and curl) that the <u>form</u> of Maxwell's Equations could be preserved across inertial frames if and only if, Larmor's EM field transforms are applied to the electric and magnetic field intensities. Ironically (*vide* Einstein), these free-space field transforms were based on Larmor's conception of the fields as physical states of a <u>stationary æther</u> and are directly related to the 'Lorentz' force on a charged body being separated into a velocity-sensitive part (<u>H</u>) and a non-velocity part (<u>E</u>). This derivation was based on assuming that the solutions of the wave equation were both spherical in each reference frame: an assumption that has never been verified experimentally.

Cambridge Rejection wanes

The effective stalemate between the Cambridge support of the ETM and the Einsteinian promoters over the <u>interpretation</u> of the *Principle of Relativity* was <u>never</u> explicitly resolved. The support for Larmor's ETM declined, especially after 1919 due to several factors [97], including the 1909 reform of the Cambridge mathematical Tripos examination that subsequently emphasized pure mathematics, rather than "water, gas and electrical" subjects, depriving Cambridge of the steady stream of physicists with very good math skills. At the same time, Larmor's central ETM text [35] was not required reading any more for the best undergraduates with a strong mathematical talent, while only Larmor and Cunningham of the Maxwellians were still teaching at Cambridge. Most experimental physicists (even in Britain) would not accept the metaphysical basis of the ETM, namely, that matter only consisted of positive and negative electrons. Finally, Eddington's 'proof' of Einstein's GTR was (mistakenly) believed to have validated Einstein's STR because "both were about relativity".

Demise of the ETM

The contemporary lack of interest in Larmor's ETM theory might be interpreted as evidence that this theory had been totally refuted, leaving the victory alone to the Einstein view of the world. This was not the case, as has been detailed by Warwick in his history of mathematical physics at Cambridge [98]. Ironically, Warwick believes that a major factor contributing to the ETM "petering out around 1915" was that this new electrodynamics never appeared on the Tripos examination papers, so it found no new supporters among wranglers (the top scoring mathematical students) after 1909, when the syllabus was radically revised in favor of pure mathematics and lecturing was substituted for small-group coaching. This situation was exacerbated by the departure of every young ETM researcher for junior teaching positions at provincial universities. Only Cunningham returned in 1912 and he had to vacate Cambridge in 1915 as punishment for being a conscientious objector. On his return after the war, he never again published a research article in mathematical physics; indeed, he declined to take on new research students, such as Dirac in 1923. Ultimately, Warwick attributes the growing lack of interest in the ETM to the fact that this was a highly mathematical theory that found little practical application in the new, exciting areas of atomic physics. This was compounded by the growing skepticism among experimental physicists that matter only consisted of positive and negative electrons. Experimentalists could not find any positive electrons while the positive part of every atom was showing characteristics quite different from the negative electron. As Warwick summarized: "The effective stalemate between the Cambridge and Einsteinian interpretations of the relativity principle <u>was never explicitly resolved</u>. The matter could not be decided experimentally."

Eddington champions Relativity

There was growing awareness in England after 1916 that Einstein had changed 'the rules of the game' by extending the theory of relativity from simply an EM theory to one that encompassed gravitation and cosmology; this was compounded by the rise of a new champion of general relativity at Cambridge, the astrophysicist Arthur S. Eddington (1882-1944).

3.4.3 USA

As Goldberg describes it [99], the small but pragmatic American academic physics community initially totally ignored the publication of Einstein's SRT paper – attention was still focused on improving the accuracy of the MMX. D. F. Comstock was a recent post-doc who had studied EM in Berlin and Cambridge; he returned to the USA in 1907 to take up a teaching post at M.I.T. Although he later claimed he knew nothing of Einstein's work until 1910, he did publish a paper in 1907 on the relation of mass and energy. The first two American scientists to publish studies directly related to Einstein's approach to relativity were two physical chemists, Gilbert H. Lewis (1875-1946) and Richard C. Tolman (1881-1948), both at M.I.T. Lewis actually wrote the first paper in 1908, this was soon followed by their joint paper in 1909. Lewis soon lost interest in relativity but Tolman continued alone, becoming Professor of Physical Chemistry and Mathematical Physics at Cal Tech from 1922 to 1948 – his personal influence in changing the attitude in America to relativity cannot be under-estimated.

Lewis defines the Mass Formula

Lewis derived the famous mass-energy formula in 1908 [100] by simply defining the ratio of the change in EM energy (ΔE) to the amount of transferred momentum ($\Delta\mathcal{Q}$) as the constant speed of light, $\Delta\mathcal{E}/\Delta\mathcal{Q} = c$. This result was suggested from a result of Poynting's analysis of the flow of energy and momentum in Maxwell's EM theory [101]. Lewis then proposed that this momentum was due to a real mass exchange ($\Delta\mathcal{M}$) that was transferred at light-speed ($\Delta\mathcal{Q} = c\,\Delta\mathcal{M}$), this immediately gives the result: $\Delta\mathcal{E} = c^2\,\Delta\mathcal{M}$. Lewis did not suggest that any of these intermediate quantities were observable but their effects on the target electron's kinetic energy ΔK and real change in momentum ΔP might be, as: $\Delta K = \Delta\mathcal{E}$ and $\Delta P = \Delta\mathcal{Q}$. Lewis claimed that his goal was to produce a mechanics in which energy, mass and momentum were all conserved at <u>every</u> instant in every process. The formal nature of the approach taken by Lewis was heavily criticized as it lacked any physical meaning and reminded his fellow American scientists of the excessive theoretical approach becoming popular in Europe.

Lewis & Tolman introduce SRT to the USA

Lewis and Tolman read their joint paper on Einstein's new theory of relativity at the meeting of the American Physical Society in December 1908 [102]. This paper derived the mass-velocity formula from a consideration of the conservation of momentum of two colliding perfectly elastic spheres (see section 3.2.4). This paper generated interest in not only Einstein's work but brought the two authors significant attention: a phenomenon that has occurred on more than one occasion.

Tolman rejects Ritz in MMX

In 1912, Tolman conducted a theoretical investigation of the MMX interferometer that used light from the sun instead of a fixed laboratory lamp [103]. The aim of this study was to identify any measurable differences between the optical theories of Einstein's SRT and Ritz's emission theory, where light retained the component of velocity obtained from its original source throughout its whole optical path. In the Ritz theory, all optical phenomena occur as though light were propagating through an æther, which was stationary with respect to the original source. In contrast, in Einstein's theory, all light is effectively propagated through an æther, which is stationary with respect to the observer. Einstein had assumed that light is isotropic, moving with the same speed in all directions. This implies that the speed of light is also independent of the speed of the observer relative to the original light source, so that the speed of light is the same in all directions with respect to any and all observers. Tolman's analysis concluded that the MMX would show **no** fringe shifts from the 'moving' sun in Einstein's theory but detectable (second order) shifts **would** be observed in Ritz's theory when the interferometer is rotated 90°; these have never been observed.

'New York Times' promotes Einstein

Einstein's worldwide fame can be traced directly [104] to the ongoing efforts of *The New York Times*. This began with its initial full column announcement of the Eddington eclipse expedition on November 10, 1919, through sponsored articles by the American mathematician, R. D. Carmichael, and by many of its editorials, including the one following Einstein's death on August 19, 1955. This ongoing publicity defined Einstein as the model for the academic genius throughout America.

3.5 MODERN VIEWS ON RELATIVITY

Most modern presentations of classical electromagnetism (CEM) include at least one chapter on special relativity, an approach that recognizes the intimate connection between these two theories. Some authors, like Rosser [105], even go so far as to develop Maxwell's Equations starting with the formulae for the EM fields of a 'point' charge moving with uniform velocity, as first developed by Heaviside (from his version of Maxwell's Equations). In this case, Rosser simply applied the Relativistic transformation to Coulomb's Law of electrostatics (based on quasi-static experimental evidence) without any justification that these techniques can be applied to accelerated charges.

Accepting the Formalism

Goldberg concludes his insightful study on relativity with his considered opinion [106] that within the scientific community, the 'formalism' of SRT has become widely adopted (see above 3.4) but the meaning of this formalism has remained quite ambiguous. "Even now, in most physics books, the interpretation of the formalism is more representative of Lorentz's or Poincaré's outlook than Einstein's. The American interpretation of the meaning of the theory is based on the belief that the theory is correct because both the postulates and the predictions of the theory are in full agreement with measurement and observation." As philosophers never fail to point out: agreement with experiment is not proof that a theory is either 'true' or exclusively validated: only that a theory is consistent with experiment.

Relativistic Hamiltonians

Relativistic mechanics is a direct consequence of assuming that the EM interaction can be described by a velocity-dependent potential [107] with two invariant parameters (charge e and speed c); this is equivalent to proposing an interaction term H_I in the Hamiltonian formulation involving the EM vector potential $\underline{A}$, where $H_I = (e/c)\, \underline{V} \bullet \underline{A}$. The standard derivation of H_I indicates that this is only valid if the electron's velocity $\underline{V}$ is only a function of its time parameter and is always independent of its location and also that the scalar and vector potentials are also independent of the electron's velocity. Since all these assumptions center on the idea of velocity (which is a function of the motion of the frame of reference) then the velocity-dependent 'Lorentz' force and the relativistic space-time transforms must both be introduced to accommodate the 'flowing' magnetic field (or its vector potential) representing this interaction.

Mathematics, not Physics

There is very little explicit physics, and as reviewed above, almost no electrodynamics, in Einstein's SRT paper. This may be why so many of his contemporaries totally ignored it when it was first published. However, the simple (many might say, 'elegant') mathematics used in SRT has always appealed to mathematicians, including most later theoretical physicists. The early adoption and promotion of this theory was nearly always by mathematicians or those theoretical physicists with a very powerful bias towards mathematics. Today, it is taught (and examined) as a topic in applied mathematics to all students of physics.

The New Orthodoxy

It is nearly impossible today to challenge either of Einstein's theories in a reputable physics journal. It is not only 'the kiss of death' for any professional academic but impossible to get past the universal (and anonymous) peer-review process. One or two 'fringe' journals still publish serious critiques but most of the criticism is now conducted on the Internet, especially in the Google news group on relativity, where a vociferous 'discussion' continues on a daily basis. In fact, googling the words "Einstein, relativity, wrong" will provide the curious with access to over 80,000 entries!

Dingle commits professional Suicide

Herbert Dingle (1890-1978) was another British professional physicist and natural philosopher, who specialized in, wrote about and taught on Einstein's SRT. After taking retirement, he announced his apostasy as he had eventually concluded that this theory was illogical and non-physical. He published a series of papers describing his concerns, mainly in the leading UK scientific journal *Nature*. Eventually, he could not get his criticisms answered in the scientific journals although he claimed much support privately from leading scientists. He finally published a book, *Science at the Crossroads* [108] that detailed his criticisms of special relativity and described this period of his life, expressing publicly his dissatisfaction with the timidity of reputable scientists to acknowledge their concerns. He described how leading experimentalists would rather confess privately that they considered themselves fools who could not understand relativity than admit publicly that they doubted the validity of this theory; they consoled themselves with the view that "at least, the mathematicians understood it." Dingle's temerity to take on the orthodoxy of theoretical science and raise the possibility that one of its foundational pillars might be wrong led to his public ostracism and the destruction of his well-earned professional reputation.

Burniston Brown rejects SRT

Skepticism towards Einstein's SRT seems to be a British tradition, summarized by a famous remark by Ernest Rutherford, *apropos* their negative attitude to this theory, when he replied that "the British have too much common-sense." The British academic G. Burniston-Brown was able to get his views printed in the official bulletin of the Institute of Physics as late as 1967 [52]. His article began with a historical review that emphasized the contributions of Poincaré and highlighted the logical contradiction between a theory constructed around uniform velocities and the derivation of relationships between dynamical quantities, like mass and energy. He concluded that: "Special relativity is untenable as a <u>physical</u> theory."

Marmet's Velocity Critique

Paul Marmet (1932-2005) was one of the increasingly rare professional physicists who publicly challenged Einstein's SRT in recent times. Marmet was professor of physics at Laval University for over 20 years; he authored over 100 papers in low-energy electron microscopy, was president of the Canadian Association of Physicists and was awarded the Order of Canada. In a series of self-published books and articles [109] he pointed out that Einstein's model of EM could be equally derived from the algebraic identity: $c^2 = \{ \tfrac{1}{2} (c - v) + \tfrac{1}{2} (c + v) \}^2$. An equation that indicated an averaging of the outward and inward 'ballistic' speeds of the light waves (or particles) relative to the emitter. This suggestion was not well received by Marmet's colleagues; indeed, this became a 'career-limiting' move that forced his early retirement when he declined to stop publishing such heretical material.

3.6 EXPERIMENTAL CONFIRMATION

Philosophical Primitives

It takes a historian and philosopher of science, like Stanley Goldberg [110] to remind physicists that: "We **never** measure speeds or changes in speeds (acceleration). Speed is an abstract, defined quantity. It is <u>defined</u> as the (instantaneous) time rate of change in position. We can only measure distances and times because these are conceptual primitives in our system of physics." He also points out that the one-way speed of light has never been 'measured' in two frames of reference that are moving at high-speed relative to each other. Obviously, humans would need 'star-ships' before we were capable of this feat. It is a great pity that most textbook authors (and, as a result, many thousands of students) have come to believe that Einstein's light-speed postulate is based on experimental evidence – it is **not**; this is just a much-repeated assumption that has been passed down through several generations to become one of the 'myths of science'.

3.6.1 TIME

High-Speed Particle Decay

The only physical evidence for the time-dilation effect predicted by SRT is the extended decay time of particles found in cosmic rays. However, particle decay is a quantum mechanical phenomenon that is inherently statistical and is not clearly understood. As such there may well be better explanations to be found that reflect the actual dynamics occurring within these unstable particles, such as the 'raising of the height of the potential well' due to statistical fluctuations of kinetic and potential energy. In other words, particle decay is more likely to be the consequence of dynamic two-particle interactions and not simply intrinsic (kinematic) time phenomena within a single, unstable particle. The experiments that measure the average life-times of high-speed mesons (and compares them with 'stationary' situations) are not a validation of the time-slowing predictions of SRT since these high-speed situations involve either decelerations or massive circular acceleration in particle accelerators [200], whereas SRT is only appropriate in inertial reference frames where there are no accelerations. Indeed, without a dynamical theory of particle decay (be it cosmic rays or mesons), it is simply unwarranted to claim that this phenomenon is evidence for relativistic time dilation: relativity is a quick but empty (mathematical) explanation.

Variable Nuclear Decay Rates

The investigations by Kofman and Kurizki [111] demonstrated that the spontaneous decay of unstable nuclei can be accelerated by heavy exposure to EM radiation; this result contradicted the expected (but theoretical) Quantum Zeno Effect, which predicted that frequent observations would inhibit the decays. This research would suggest that 'environmental' interactions are a better explanation than relativistic time dilation for the extended life times of all high-speed, unstable particles.

Transverse Doppler Effect

In his contribution to the 1907 edition of the *German Yearbook on Radioactivity* [112] Einstein made the claim that any consistently periodic phenomenon constituted a 'clock'. This led him to propose that the time dilation formula could be observed in any direction of relative travel between two moving inertial observers; so that if the 'clock' oscillated with frequency f_0 in the stationary reference frame then it would appear to have an observed frequency f in the reference frame moving with relative speed V, where $f = f_0 (1 - V^2/c^2)^{½} = f_0 /\mathcal{L}$. This was a Doppler shift, which was independent of direction, so that relative movement would show this effect in the transverse direction as well as in the direction of motion. This 'transverse' Doppler effect was a unique prediction by Einstein as Lorentz's theory only predicted a longitudinal effect.

Ives & Stilwell

This transverse Doppler effect was tested successfully by the American experimentalist, Herbert Ives at Bell Labs with his colleague George Stilwell in 1938 [113]. Their experiment observed the high-speed motion of excited ions (canal rays) with known stationary frequencies by averaging the transverse observations in the forward and reverse directions. Tucked away in one of hundreds of footnotes, Einstein scholar, Arthur I. Miller, makes the remarkable claim that [114]: "To this day the Ives-Stillwell experiment is **the only positive proof for Einstein's prediction of time dilation**. Ives and Stilwell claimed only that they had verified the "Larmor-Lorentz" theory since Ives was committed to an æther-based theory of EM. The various experiments utilizing elementary particles (do *not prove* SRT) as they involve a vicious circle because their data analyses depend on special relativity; consequently these experiments test only the *consistency* of the special theory of relativity." (Miller's emphasis). In spite of this sole claim to validating Einstein's SRT, Burniston-Brown has published a detailed analysis of this experiment indicating that Ives and Stillwell claimed that the results needed an extra second-order term in the radial Doppler formula and the results were ambiguous as they were achieved at the very limits of experimental accuracy [115].

Global Positioning System

Many people today quote the Global Positioning System (GPS) as evidence for the SRT time dilation prediction. These satellites are in fixed, synchronous orbits so there is no radial movement between the satellite clocks and the Earth clocks; worse, there is no common inertial reference frame between the two sets of atomic clocks, with the standard being set from a theoretical point at the center of the earth. GPS may be viewed as evidence for the general theory of relativity but satellite experiments are irrelevant for demonstrating the 'truth' of SRT, as was admitted in a recent paper [201].

Hafele-Keating Experiment

In the famous Hafele-Keating experiment [202] atomic clocks were flown around the world in opposite directions: small changes were calculated and these effects were compared with predictions from a combination of Einstein's two theories of relativity to accommodate height variations (gravitity) and velocity/Sagnac effects. The raw data has been re-evaluated by several independent investigators (A. G. Kelly, D. E. Spencer & L. Essen) who did not agree this experiment confirmed SRT or GRT. This is sometimes presented (erroneaously) as proof of the reality of the 'Twins' paradox.

3.6.2 LENGTH

In 1932, Kennedy and Thorndike repeated the MMX but using an interferometer with sides of unequal length [116]. They claimed that the observed null result could not be explained by the FitzGerald length contraction but only by the relativistic time dilation effect. Ives challenged this analysis, claiming that the time dilation effect needed a positive demonstration on its own terms: these he was able to do with Stilwell in 1938 (see above).

In 1959 James Terrell published a short paper [117] that contradicted the long-held assumption, typically stated by Lorentz, that the high-speed length contraction was not merely an 'appearance' but was real and could be observed and even recorded on photographs. Terrell's neat analysis indicated that a finite body would be seen (even on a photograph) as rotated and not contracted, not the result Lorentz predicted for his high-speed sphere that was expected to be elongated. Even more bizarre, Terrell showed that stereoscopic viewing head-on (if the moving object subtends a finite solid angle) would correct for the rotation but would still reveal an elongation in the direction of motion but **not** one predicted by the FitzGerald contraction.

Surprisingly, despite the FitzGerald length contraction being a major prediction of relativistic theories, there has never been any experimental confirmation of this effect. This is often said to be because "measuring the length of a moving object to the precision required has never been feasible"; however, it is more likely that Terrell's explanation of an 'optical illusion' is closer to the truth.

3.6.3 MASS

There have been no direct tests of 'relativistic' mass effects between two high-speed inertial viewpoints. Experiments like Kaufmann's famous experiments involve either circular motion or other forms of acceleration. They always invoke extra theories (like Classical EM) to compute the 'forces' that these particles are deemed to experience, completing the circular arguments usually used to justify SRT. The modern view usually refers only to rest mass: the corresponding high-speed phenomenon of 'relativistic mass' is now absorbed into a vague definition of 'energy'.

3.6.4 ENERGY

The conversion of mass to energy is seen by the general populace to have been demonstrated beyond doubt by atomic weapons. Scientists confirm this theoretically by computing how much (little?) uranium or plutonium disappears after the explosion. A stronger view is derived from measuring nuclear binding energies but here (once again) a physical theory of nuclear mass is absent so that a 'book-keeping' explanation is thought to be sufficient. There has been some direct evidence [203] of the extra (relativistic) energy predicted to be available from very high-energy (20 GeV) electrons by measuring the rise in temperature when these beams are absorbed in water (to about 30% accuracy) but these observations still lack any adequate explanation for the energy transfer mechanisms between individual electrons and water molecules.

Overall, the direct, unequivocal experimental evidence for the special theory of relativity after 100 years is underwhelming.

4. METAPHYSICS OF SPECIAL RELATIVITY

The common feature of all the research programmes that have investigated the two-electron problem is the assumption that the EM interaction occurs continuously between the two electrons. Since this assumption had always worked successfully for classical mechanics, it has never appeared necessary to challenge this universal "**Continuum Hypothesis**". One of the basic perspectives of this research programme is that the microscopic world is fundamentally discrete and, as a result, this discontinuous view is here extended to the nature of the EM interaction itself. In the previous paper [4], it was shown that the continuous interaction model is incompatible with the two requirements that electrons are inertial particles and they only interact when they are "on each other's light-cones". This section investigates the key metaphysical assumptions that form the foundations of Einstein's SRT that are never made explicit, not even by Einstein himself, who was comfortable working within the shared metaphysical tradition of 19th century physics. This section examines these assumptions in light of more recent developments during the 20th Century, which continue to confirm the discrete nature of reality.

4.1 CONTINUITY IN CLASSICAL PHYSICS

This research programme views electricity simply as collections of discrete point particles, which have been experimentally identified as electrons. These electrons are viewed here as interacting cyclically only over a universal, non-zero time-rate in pair-wise combinations. Both electrons, in every individual interaction, are treated symmetrically across space at two distinct points in time, each with a history (and future) and each mutually influencing the other asynchronously. This is a very different view of electricity than those that have characterized EM research from Maxwell to Einstein.

4.1.1 CONTINUOUS SPACE & TIME

Einstein views Space as the Base

In 1905, while claiming to be a follower of the early Positivist philosopher, Ernst Mach (1838-1916), Einstein's views of space and time presented in his famous paper [29] were completely contrary to Mach's *Reality Principle* that was grounded in human measurements. Einstein always viewed space as being defined by an orthogonal frame of 'rigid rods' – a totally, idealized fiction that had been introduced into physics in the 18th century and remains an 'invisible scaffolding', even today.

Continuous Space-Time

In 1921, Einstein gave a series of four lectures at Princeton University that constituted an overview of his still controversial theories of relativity. These lectures were published soon after and appeared in five best-selling editions [118]. These lectures began with the assumption that there exist devices called 'clocks' which "provides a series of events which can be counted" and this event series "is formed of elements all of which can be regarded as equal." No discussion is offered of what these clocks consist of and how we are to interact with them – the assumption being that these are nothing special. Einstein, almost at the same time, also introduces the concept of a 'rigid body' with no more definition than "a relatively constant complex of sense perceptions." These vague ideas are presented as sufficient to introduce the concept of a three dimensional frame of reference spanning all of space involving the purely mathematical concepts of continuous Euclidean geometry using the idealized concepts of lines and points. In other words, this theory begins with the implicit assumption that reality maps to our intuitive ideas of geometry married to an infinite 'sea' of point-like clocks, even though a few pages earlier he had just lambasted philosophers from moving our concepts from the empiricism of experience to the abstract 'world' of the *a priori*. This preamble was needed to introduce spatial intervals defined on a rigid body and to anticipate the use of the Pythagoras theorem in 3D space. Einstein also added the explicit assumption that "one can move an ideal rigid body in an arbitrary manner" and that the intervals defined by such rigid bodies "can be brought into coincidence always and everywhere."

Einstein concluded that no real object could exceed the speed of light (relative to any inertial observer) purely on the mathematical consequence of the Lorentz factor that becomes infinite at this speed and imaginary at higher speeds [119]. Einstein concluded his section on Special Relativity with the demonstration that Maxwell's Equations of electromagnetism satisfy the Relativistic transformation, which should be no surprise in a theory constructed completely (although often implicitly) around Maxwell's theory of light.

Continuous 'Light' needs a Medium

It is only the metaphysical view that 'light' is an entity (particle-like photons or EM ætherial waves) that results in the illogical conflict arising from the additional metaphysical proposition that 'light always travels at a constant speed in a vacuum'. There are no conceptual difficulties with viewing the phenomena of light in terms of Newton's concept of action-at-a-distance extended to include asynchronous interactions. In this view, variations in motion of the electrical sources may affect other electrified matter simply based on their absolute separation in time. Space is then the measure of how far apart these objects were at the times of their interaction, with the parameter *c* being the universal conversion factor between space and time. This must remain logically independent of the velocities of real objects as any velocity dependence would only introduce a further recursive element into the definition of this ratio, which needs to be grounded in our basic metaphysical ideas of space and time.

SRT built on Maxwell's Æther

Einstein's claim that he did not use any properties of the æther in his development of the SRT is, at best, disingenuous. Einstein's whole theory is grounded in Maxwell's EM theory of light – both implicitly through his focus on light-signaling and explicitly in the final section of his 1905 paper [29] where he transformed Maxwell's Equations for the electric and magnetic fields between stationary and moving reference frames. Einstein chose to ignore Maxwell's stated metaphysics that his theory was based on the reality of the æther as the medium that transmits the EM vibrations, i.e. a real wave that moves through space over time. It is rarely mentioned that Einstein's second postulate on the invariance of light-speed is <u>not</u> based on any experimental evidence (there was none in 1905 and there is still none in 2008). In fact, this would be an exceedingly difficult experiment since it concerns the <u>phase</u> velocity of infinite, sinusoidal EM 'vibrations'. Implicit in this postulate is the hidden hypothesis that the parameter *c* in Maxwell's theory is a universal constant that is invariant between linear transforms across two different inertial reference frames – this is a metaphysical proposition. However, this hidden interpretation would, at the very least, limit Einstein's SRT to EM interactions and not be seen as a universal characteristic.

4.1.2 CONTINUOUS ACCELERATION

Change varies with Time

Traditional physics (classical, relativistic and quantum mechanical) is founded on the universal assumption of physical continuity: the **Continuum Hypothesis**. This is directly reflected in the use of the differential calculus applied to smoothly continuous functions. Generically, the difference between any two states of the world $\Delta S(t)$ at any one time 't' that are close together in time become identical as the time difference between them becomes vanishingly small, so that the difference $\Delta S(t)$ becomes proportional to the time difference Δt as this goes to zero. At the microscopic level, this assumption is no longer true, when experimentally discontinuous changes in state are directly observable, e.g. the phenomenon of electron 'spin flipping'. This discontinuity in the interaction itself is viewed here as fundamental to even the classical view of EM.

Noether's Theorem only applies to Velocity

Amalie Emmy Noether (1882-1935) was one of the first women to break through the European barrier against women in academia and earned her doctorate in mathematics. She is immortalized due to her symmetry theorem, which states that for every **continuous** symmetry in the action there results a quantity that is **conserved** at **all** times [120]. There is no reason why this powerful theorem should apply to discrete action theories, such as impulse theories. Even for continuum field theories, this does <u>not</u> mean that spatial continuity implies momentum conservation but only velocity conservation; it requires the further assumption of continuous interactions to extend this result to momentum. The principle of momentum conservation for interacting particles is grounded in collision experiments where the asymptotic values are measured both before and after the actual short-range collisions. The argument that momentum conservation is based on infinitesimal spatial displacements (Noether's theorem) assumes that all changes in the motion of <u>inertial</u> particles in the real world actually evolve continuously, not that space is mathematically homogenous.

4.1.3 CONTINUOUS FORCE DENSITIES

Faraday's Lines-of-Force

Faraday's 'lines-of-force' were the conceptual starting point for Maxwell when he developed his various theories of EM [6]. Although Maxwell gave them a mathematical representation that has become the basis of the classical EM theory they were never more than a visual aid to help physicists and engineers link electric and magnetic sources to targets. Both Maxwell and Faraday believed explicitly in the reality of these 'invisible chords' (on religious grounds) but they have no more reality than Ptolemy's epicycles – all are simply visualizations of calculational techniques. These concepts only had a possible physical meaning when electricity and magnetism were viewed as continuous real substances that could be influenced, at the infinitesimal limit, by the electric and magnetic force densities. Since the discovery of the electron, these hopes have been dashed forever.

Fields need Real Numbers

All field theories have no scaling and always assume continuous interactions so that proposed real physical properties (like 'force densities') must be assigned to every point in empty space (an infinite number) across an infinite number of instants of time. It is not surprising then that such theories must represent these mathematical intermediaries with 'real' numbers, each containing an infinite number of decimal digits. The concepts of fields and infinity are intimately bound together.

Einstein tries to avoid Forces

In a short paper published in 1935 [1], Einstein attempted his final approach to developing the Mass-Energy equivalence relationship by applying conservation rules to elastic point collisions, like Lewis in 1908 (unfortunately Einstein never used the term 'momentum' and always uses the term 'impulse' although this idea is limited to the change in momentum). At the conclusion of the article, Einstein wrote: "In classical mechanics force is a function of the co-ordinates of all the particles, which is obviously not possible in the relativity theory. Therefore, I have avoided introducing the force concept." This seems unusual as he introduced this article with the declaration that: "The SRT grew out of Maxwell's EM equations." This statement ignores the fact that these famous EM equations are all about forces, albeit electrical and magnetic.

4.1.4 CONTINUOUS INTERACTIONS

Detached Radiation Field

Advanced classical electromagnetic theory predicts [121] "the radiation field detaches itself from the charge which is its source and leads an independent existence; it is endowed with energy and momentum. … So that a charge emits radiation relative to a Lorentz observer, if and only if, it is accelerated. … This radiation is emitted only in a direction orthogonal to a non-vanishing component of acceleration." This is a bizarre conclusion: the existence of the observer (in a remote Lorentz frame) even outside the 'light-cone' can cause (?) the emission of radiation from another charged particle. This viewpoint illustrates the danger of developing a theory of EM that does not take into account the interaction between the source and target electrons. Such theories are filled with daunting mathematics but the real physics has disappeared in the equations.

Mechanical Acceleration

The problem of radiation damping has been around ever since Abraham and Lorentz (independently) studied the theoretical problem of accelerating an electron by an external mechanical force, when the electron then radiates away EM energy. Once again, this illustrates the danger of applying mechanical analogies to EM phenomena (a trap that Maxwell often fell into). This fails to recognize that an electron can only be accelerated by the EM interaction with another electron – there are no external mechanical forces (contra Planck) that can be applied to electrons, which only participate in the EM interaction.

Ritz proposed diminished Force

Walter Ritz anticipated the results of this paper in 1908 when he proposed that instead of the electron's inertial mass becoming infinite as electrons approach light-speed, the EM effect ('force') goes to zero [25], as predicted by the Voigt transform (see 2.3.1). This was not investigated further by Ritz, who died unexpectedly the following year. Surprisingly, this somewhat obvious alternative has not been investigated in the last 100 years. Physicists now bet on 'the winners'.

4.1.5 CONTINUOUS ELECTRICITY

The electron is the central metaphysical subject of this research programme so a brief biographical history was provided in section 4 of the previous paper [4]. This emphasized that, in contrast to the other 'stable' components of gross matter (the proton and neutron), the electron has remained throughout its entire history as a truly elementary particle; its universality confirmed by the discovery of beta decays emerging from the nucleus.

EM needs a special 'Test' Particle

The concept of a vanishingly small 'test particle' is another mathematical idealization that is needed to define field theories. There is no experimental evidence of infinite regress: quite the contrary, electric charge manifests itself at the smallest level as equal to the charge '*e*' on a single electron while inertial mass also appears finitely at its smallest value '*m*' of the electron. Despite the theory of quarks, there has never been any experimental evidence of charges smaller than this value.

Jackson revives Lorentz Electron Model

The convoluted state of classical EM may be gauged by Jackson's book [7] that is widely used for graduate courses in this subject. In the final chapter, Jackson divides electrodynamics into two separable 'classes', firstly: calculated fields from known sources of charge and current, secondly: the calculated motions of the electrified target particles when external EM fields are specified. He confesses that: "this can only be of approximate validity" as this separation neglects the (spherical) emission of the target charges when they are accelerated and therefore the corresponding reaction of the radiation on the motion of the sources. He tries to wriggle out of this flawed model (valid for large collections of electrons) by stating that electrons are elementary particles and the problem has been solved by QED. He also claims that reactive effects are small (not for electrons) so that they can mostly be ignored. Rather than challenge the basic assumptions of classical EM theory (especially the *Continuum Hypothesis*) or re-open Weber's action-at-a-distance model, Jackson redevelops the hundred-year old Abraham-Lorentz model of the finite electron filled with electrical fluid (without mentioning any of the several, bizarre assumptions of this approach, see section 2 of [4]). He further revives Larmor's æther-based model of radiation (without using that forbidden word in a modern text) to then redevelop the Abraham-Lorentz equation of motion as a time-averaged approximation.

Invariant Electron Charge

The interaction between two electrons is always asynchronous, such that if electron #2 'receives' an impulse at time t_2 from electron #1 which 'sent' it at time t_1, then either $t_2 = t_1 + R_{12}/c$ (retarded) or $t_2 = t_1 - R_{12}/c$ (advanced), where R_{12} is the (positive) spatial difference between the locations of the two electrons at the times of the emission and absorption. If this is repetitive, then the next pair of events between these two electrons occurs at t_1' and t_2' when the spatial separation is R_{12}'. All continuum (field) theories always assume that both t_1' and t_2' approach t_1 and t_2 respectively as the time between the two interactions (Δt) goes to zero; the previous paper [4] in this series demonstrated that Δt must always remain finite for real, inertial particles, like electrons. In all fields theories that only focus on a single 'field' point, the source electron is always ignored, which is equivalent to setting $\underline{x}_1 = 0$ throughout all of the interaction – an impossibility except for an infinitely massive source particle (these have yet to be discovered). Since the emitting (source) electron recoils from the interaction, it is only the relative motion of the two electrons that is inertial, not the target electron alone. By ignoring the real source of the interaction, local field theories (i.e. those constructed around a single space-time point) **need** to introduce relativistic transformations between different inertial frames of reference to compensate for the use of artificial, non-inertial frames. All the classical electron models (and also the modern approach to classical EM using charge density, see [6]) could only be matched to the invariant, finite electric charge, *e* of real electrons by introducing an invariant charge in an infinitesimal spatial cube. This tiny cube was filled with this electric fluid with charge density $\rho(\underline{x}, t)$, centered at the location designated by $\underline{x}$ at time t. Since these theories need this electron charge in the second frame e' to be invariant ($e' = e$) then this requires the transformed density $\rho' = \mathcal{L}\,\rho$ to compensate for the 'FitzGerald contraction' in the direction of motion: $dx' = dx / \mathcal{L}$; this then requires $dt' = \mathcal{L}\,dt$ and all the other consequences of the relativistic transformations.

Jefimenko identifies the Source of SRT

EM phenomena are ultimately traceable to the motion of remote electrical sources as Lorenz first showed in 1867 [14] and Jefimenko recreates in exquisite detail in his under-appreciated study of classical EM [122], where he proves that "the EM fields are associated with inhomogeneities in the distribution of charges and currents." He demonstrates that the need for the Relativistic transform arises directly from the fact that both the electric and magnetic fields are derived from the retarded electric currents, whose values will obviously change in different inertial frames of reference.

Jefimenko tries to save Maxwell

Only Jefimenko seems to have adopted a coherent and consistent view of Maxwell's Equations. Metaphysically, Jefimenko proposes only retarded interactions (like Lorenz) between differential volumes filled with continuous electrical fluid [123]. Fluctuations in remote charge then induce variations in electric displacement and magnetic flux in the EM æther that cause remote but synchronized changes in the ubiquitous electric and magnetic force field densities.

Jefimenko distorts the 3D Cell

Jefimenko [123] has shown how in EM situations involving continuous charge-densities in constant relative motion the delayed effects generated by the finite time for interactions to reach the 'field' point (i.e. asynchronicity) create the well-known equations involving Relativistic transformations in electromagnetic quantities. Jefimenko consistently rejects a point model of electricity so that he can generate the effects of Special Relativity directly from one-dimensional changes in the differential cell's dimensions to maintain constant electricity per unit volume, independent of relative motion. Since this text appears to be little known his important arguments will be summarized here.

Jefimenko's Derivation

Jefimenko has developed a completely relativistic approach to deriving Maxwell's Equations [124] solely on the basis of EM retardation combined with the Galilean *Principle of Relativity* without any additional postulates or hypotheses. He develops the relativistic transforms from an analysis of the retarded integrals of a stationary electric charge density ρ as viewed from a frame of reference moving at a constant velocity $\underline{V}$ with the key invariant condition: $d\rho/dt = 0$. He writes: "the region of space from which the field signals are sent is not equal to the region of space, or volume, occupied by the charge distribution when it is at rest." These transforms are applied simultaneously to the electric charge and current ($\underline{J}$) densities and to the differential 3D spatial volume $d^3\underline{X}$, leading to the most important scalar identity: $\rho' \, dx' = \rho \, dx$. The transformed form of the moving charge density becomes: $\rho' = \mathcal{L} \, (\rho + \underline{V} \bullet \underline{J} / c^2)$. This approach **fails** for point-charge electrons, which have been traditionally modeled using Dirac's delta 'function', as in: $\rho[\underline{X}] = e \, \delta^3[\underline{X}]$. This has been confirmed by Jefimenko in a private communication, hence his consistent rejection of the point model of electricity (the point electron). Although he assigns no reality to the relativistic transforms, Jefimenko reluctantly accepts the necessity for their use. He writes (using words that could easily have been written by Larmor or Lorentz): "Relativistic transformation equations must be regarded as *prescriptions* for replacing one **set** of quantities by another **set** in order to obtain relations between quantities pertaining to one inertial frame of reference from the corresponding relations between similar quantities evaluated in another inertial reference frame." Like Maxwell, Jefimenko accepts the reality of all EM field quantities when, for example, he resolves the Lewis and Tolman's "L-shaped lever paradox" by demonstrating that the magnetic angular momentum (in the lab frame) balances out the mechanical angular momentum, when equal electric charges are the source of the forces on the two rigid arms of the supporting structure.

Cullwick analyzes Relativity

Geoffrey Cullwick was a respected Scottish Professor of Electrical Engineering who wrote several books on EM during his long career. One of his last texts emphasized the role of moving media in the study of EM [125]. He regarded this viewpoint as central, reminding readers that Maxwell introduced his concept of the EM field as a physical state in a material medium (the æther) while electric currents are now seen as moving through conducting media: relative motion is therefore intrinsic to the phenomena of electromagnetism. As an EM engineer and scholar, Cullwick always insisted that SRT should be only limited to EM phenomena. He pointed out that: "Maxwell's theory of the EM field is based on a treatment of the theory of current circuits by means of the general dynamical equations of Lagrange." This emphasizes that Maxwell's continuous microscopic (differential) theory was a mathematical extrapolation from macroscopic EM laws (such as those of Oersted and Faraday) developed before there was any appreciation of the complexity of electron activity in conductors or magnetic material. Obviously, Maxwell's theory will be mathematically consistent with the macroscopic physical facts as this is the area were it originated: differentiation and integration are simply reciprocal mathematical operations. It is an unwarranted assumption that the resulting microscopic laws reflect the actual physical interactions between electrons, although this is exactly the path that the historical evolution of physics has followed: Maxwell's Equations are now viewed as fundamental rather than statistically consistent with macroscopic reality.

Einstein rejects Relational Mechanics

When Einstein rejected the idea of a purely relational mechanics, it was not, as he claimed, because this was "impractical" [126] but because this view would mean giving up on the field concept that was at the heart of his metaphysical view of the world. A relational mechanics requires that all quantities in the theory are only introduced in terms of differences between the values associated with each of the interacting objects, such as the difference in positions or differences in velocity of two interacting particles. It is the fact that local field theories only use parameters at the single field point that make a relational approach impossible and not, as Einstein wrote, because "scientific development has not confirmed this conjecture." A relational mechanics would refocus the whole analysis on the relationship between the source charges and the target charge – an action-at-a-distance approach that was pioneered by Lorenz in 1867 [14] and is now the focus of the present research.

4.2 RIGID BODIES

Einstein built his whole theory of special relativity around two fictitious concepts: the **rigid body** and the **point-clock**. His original supporters saw this approach as an attempt to construct a Machian operational philosophy, as Einstein may himself have been attempting in 1905. However, by 1921, in a series of four lectures given to the Prussian Academy of Sciences entitled *Geometry and Experience* [127], he admitted that these did not find their "exact correspondence in the real world" – a confession that showed Einstein had been constructing a Pythagorean mythology all along with his *gedanken* experiments. Nevertheless, Einstein still claimed that the ideal of rigid measuring rods was a good approximation to the solid objects in the world of sense perceptions. In contrast, Poincaré thought that giving an interpretation to physical space was meaningless since "the objects of Euclidean geometry and those of the world of sense perceptions had no correspondence". It was this weak link surrounding the use of the concept of rigid bodies that Einstein later acknowledged as the reason he viewed his General Theory of Relativity as superior to his special theory and not because it incorporated acceleration. Indeed, Einstein, throughout the rest of his life, could find no special situation that would show that the SRT was a limiting case of the GRT.

Holonomic Constraints

Imposing constraints on a mechanical system is another way of saying that there are forces present in the problem that cannot be specified directly but are known in terms of their effect on the motion of the system. When the constraints on the motion of a set of mass points { $\underline{r}_j(t)$ } can be expressed as equations connecting the spatial co-ordinates with a single time t (e.g. $f[\underline{r}_1, \underline{r}_2, \ldots, \underline{r}_n; t] = 0$) then the constraints are said to be 'holonomic' [128]. Classical mechanics was created around the time-independent, pair-wise constraints $(\underline{r}_j[t] - \underline{r}_k[t])^2 = d_{jk}^2$; this is a mathematical technique to describe *rigid bodies* and leads to the idea of generalized co-ordinates. An alternative approach defines a rigid body as one where the internal potential energy is always constant over time, where the internal forces do no work. It should be pointed out that both of these approaches use the concept of a single time parameter spanning the whole system – a situation that does not describe the EM interaction with its finite times of propagation. The present system rejects this approach and only recognizes the '*light-cone*' constraint (see 5.2.4) **relating two times to two locations in space**.

Collisions need Rigid Bodies

The analysis of particle collisions either assumes the mechanical contact of point particles or a direct collision between finite rigid bodies, with instantaneous propagation of the impact from the surface point of contact to every part of the two bodies. In reality, no two electrons can approach each other to achieve a zero spatial separation, as the traditional 'Coulomb' force would become infinite.

SRT needs Rigid Bodies

In the introductory section of Einstein's SRT paper [26] Einstein almost immediately brings in the concept of a rigid body on which he will construct his theory. He wrote (line 37): "The theory to be developed is based – like all electrodynamics – on the kinematics of the rigid body, since the assertions of any such theory concern the relationships between rigid bodies (co-ordinate systems), clocks and electromagnetic processes." The concept of a rigid body is that of a real object of finite and constant spatial extent wherein all its parts, including both of its ends, can move simultaneously. In this SRT paper, at the beginning of section one (*Definition of Simultaneity*), Einstein constructed his theory on the concept of rigid bodies: writing (line 7): "If a material point is at rest relative to this co-ordinate system, its position can be defined relative to it by rigid measuring rods employing the methods of Euclidean geometry and can be expressed in Cartesian co-ordinates." It is the use of such imaginary tools that allowed Einstein to construct his 'thought' experiments, where changes in spatial separation could be 'measured' without any passage of time. Physical rigid rods were isomorphic with co-ordinate frames.

Milne's Impossibilities

E. Arthur Milne (1896-1950) emphasized in his book *Relativity, Gravitation & World Structure* (1935) that the concept of 'rigid rods' is not only theoretically unrealizable as physical entities but cannot, even in principle, be defined. [129]

No Rigid Bodies

Due to our macroscopically perceived sense of touch and the high density of pressure-nerve endings in our fingers, mankind has believed that all matter is 'solid', that is, continuous and extended between well-defined boundaries. The new theory instead views 'matter' as the manifestation of interactions between point electrons, separated by purely empty space. This means that Euler's concept of a 'rigid body' is a mathematical idealization, introduced to simplify calculations and does not exist in reality. Furthermore, in the new theory, all objects, beyond the single electron, are viewed as composite objects or dynamical collections of electrons that are stable over significant (to be defined later) timeframes. Einstein's use of the concept of rigid-rods to define a Cartesian reference frame is rejected. All real measurements of single 'object' locations in space are always explicit differences between pairs of electrons, including the electronic 'observer' at the 'origin'.

4.3 LIGHT AS AN ENTITY

'Let there be Light'

Einstein always made two fundamental metaphysical assumptions in all his theories; in every case, these remained implicit and were only rarely discussed. The first was the assumption that light was an entity – an independent object that came into existence at the time of emission and disappeared when it was absorbed (and as an wave, this might only occur at infinity). In most cases, Einstein assumed that the major object of interest was a real 'field' that too had its own independent existence (although in what medium, that supported these variations in value, was almost never defined). The most popular solution seems to have been 'something' that exists everywhere and always, in terms of infinitely divisible space and time. Today, space itself has taken on the role of the æther that scientists hypothesized earlier as the foundation for all wave-like activity.

Light as a Moving Object

Since almost all physicists have assumed that light is an 'object' (either wave or particle) then they logically assume that this 'object' travels from its source to its destination, like all real objects. Einstein and his followers therefore always assume that an observer will see the 'lightening flash' sooner when moving towards the flash than when moving away from them or not even moving at all, thus Goldberg writes [130]: "The (lightening) strokes were not simultaneous". This is just simply another 'thought' experiment, as this situation has never been measured in reality. This 'light as object' assumption is the implicit metaphysical foundation for all of relativity theory, especially when combined with the explicit hypothesis that this 'light object' always travels at the same speed, no matter what the speed of the observer; hence the need to redefine the units of length and time in the two reference frames using the relativistic transforms.

Light is not a Thing

It is indisputable that light is a real phenomenon (fact) but it is only a theory that light is a 'real thing'. It is a metaphysical statement that light is an entity with fundamental ontological existence. Einstein's SRT is a direct consequence of believing that light is an **entity** that *travels* across space at a constant speed in all inertial reference frames. Bridgman put the realistic position well when he wrote that [131]: "light as a thing traveling must be recognized to be a pure invention".

Treating Light like Phlogiston

There is a long tradition in philosophy, going back to Ancient Greece, that explanations for material differences are due to differences in material. This leads to the "chocolate cake" fallacy, which extrapolates from the correct analysis that such a cake contains chocolate to the idea that all differences in nature are due to the addition or subtraction of 'secret ingredients'. The major example of this type of fallacy was the phlogiston theory of heat that proposed that this mysterious substance was transferred from hot objects to warm up colder objects. This is the implicit assumption in all theories of light, which view an unknown type of matter (æther or photons), which acts as the existential object that is transferred from the optical emitter to the receiver. This type of assumption hides behind statements of the type "the light bounced off the mirror".

Structures, not Mixtures

Ancient and medieval philosophers were fascinated with ontology (or the existence of 'things'). Also, since the concepts of existence and non-existence map to the bases of all numbers (1 and 0) this approach is always susceptible to the arithmetical error of assuming additive solutions to existential questions – this is just the mathematical version of the "chocolate cake" fallacy. Thus, if $A \neq C$ then the 'solution' is to assume that $C = A + B$. This means finding a new 'thing' like B. This led to the idea of the 'soul' (B) being proposed to explain the difference between a dead body (A) and a live person (C). Physics continues with this approach with electrical charge (B) being 'added' to the neutral particle (A) to distinguish this from a charged particle (C). However, when A and C are two different arrangements of the same components ('things') then there is no need to invent new 'stuff' (B) to explain the difference; this is the metaphysical approach taken in this programme.

Nominalization confuses Reality

Mathematicians have eagerly adopted the technique of 'nominalization'. This is the linguistic process whereby a verb is converted into a noun. This is particularly simple in English where the gerund form of many verbs is readily available, so that a real activity or process, such as the act of moving rapidly on a set of legs can be referred to as 'running'. Now any actual act of running involves the existence of a real animal but the concept of running is an abstraction – these are two very different philosophical categories, mixing them can easily generate paradoxes. Mathematics long ago abstracted from the results of the real activity of counting real objects an abstraction known as 'number'. Mathematical physics continues these acts of re-ification (or making real) many new abstractions derived from macroscopic measurements, such as 'force'.

Einstein had Two Views of Light

Einstein was already acting in a self-contradictory manner when he wrote his SRT paper [29], as the relativity theory was explicitly constructed on Maxwell's theory of light. By 1905, he was already convinced of the non-classical contradictions that were implicit in Planck's theory of black-body radiation that "violated both electromagnetism and mechanics". He had also acknowledged that: "Maxwell's theory could have no general validity since it could not account for the micro-structure of radiation." [132] Logically, Einstein's problems with asymmetries with Faraday induction should have directed him away from Maxwell's field approach, not to assume its validity and then deconstruct the very foundations of the concepts of space and time.

4.4 THE ROLE OF TIME

4.4.1 DIFFERENCES & DURATION

Time is different from Space

Since Newton (see 4.4.2), time has been represented by a line; even as a metaphor, this is not a helpful concept. A more accurate representation would be an explicit, *special point on a line*, which changes the *quality* of the line (e.g. its color), distinguishing continuously the difference between the past and the future as the special point (representing the 'now') progresses along the line. This type of representation reflects that time is intimately involved with process, not a static totality with distinctions anywhere on the line. The geometrization of time regularly made by physicists ignores the key differences between space and time; namely, the irrevocable distinction between past, present and future that is reflected in the basic structure of all real verbs. As Yourgrau has pointed out [133] : "space is ontologically neutral"; in other words, a real object's existence does not depend on its location in space but the death of a living creature is forever, after it has died.

Dingle, as a philosopher, was acutely aware of the need to use words carefully. He believed that confusions over the single word 'time' (or *Zeit* in German) were behind much of the professional mystery thought to lie behind Einstein's SRT. In his final book [134], he draws the distinction in meanings between totality, single example and difference when used for the two concepts of space and time. He specifically uses the term *eternity* to signify the totality of time as the word *universe* is used to denote the totality of space. He shows how these meanings are clearly distinguished when talking about space with three separate and distinct words but how common speech simply uses the single word 'time' for all three meanings, with obvious dangers of confusion. So, for example, in talking about a single trip or journey the following pairings can be made.

1. The trip occurred in *space* (and *time*). <totality = concept>
2. The *location* (*time*) of the start of the trip was in London (at noon). <single example>
3. The *length* (*time*) of the whole trip was 50 miles (two hours). <difference>

The Power of History

The concept of time has two key features: **duration** (how long?) and **phase** (when?); exemplified by the two proto-typical questions: How long did X live? When did X die? Semantically, these two characteristics correspond to the view that all processes extend across time between distinct events. Physics has more commonly focused on the simpler problems of duration. In particular, when 'constants of the motion' can be identified in a dynamic system then the timing (phase) of specific parts of the process can be totally ignored. For example, Coulomb's Law is considered true at <u>any</u> time, i.e. for the force at <u>any</u> time 't' : $F[t] = F[0] = F_0$ and, thus, at <u>all</u> times, hence the appellation '*static* electricity'. Similarly, Noether's Theorem is the inevitable result of continuum activity, where in the limit: $X[t + \delta t] \rightarrow X[t]$. The history of mathematical physics is the ongoing story of an assumption that has never been challenged, namely, the continuity of action over time; hence the near universal use of the calculus from Newton, through LaGrange, Hamilton, Maxwell, Einstein, Dirac to Feynman, etc. Quantum mechanics is a continuation of this tradition but now the idea of individual particle trajectories (when? where?) has been explicitly rejected; so mathematical physics is reduced to calculating durations, that is, energy changes. However, the Lienard-Wiechart retarded potentials and Feynman's "sum over histories" are both indications of the importance of history in the micro-world. In human affairs, it has long been recognized that **when** an event occurs is usually vital to its impact, as can be seen in the consequences of multiple interactions. The most famous example is found at the beginning of the US Declaration of Independence: "*When in the Course of Human Events …*". This was written in 1776 but it had a direct impact on the French Revolution in 1789. Similarly, history will always link the events of December 7, 1941 in Hawaii with those in Japan on August 6, 1945. It is now time to bring history to the forefront of theoretical physics.

4.4.2 SINGLE TIME

Mathematicians eliminate Time

Both the single-time (or God-like) view of the universe and the zero-time view (involving only statistical, time-averages) are very attractive schemes for mathematicians attempting to describe the natural world as either technique maps directly to the static, geometrical model that lies at the historical foundations of mathematics. This timelessness is viewed as fundamental by the Platonists, who developed their ideas of 'eternal forms' from the Pythagorean primacy of timeless mathematics.

Newton's Great Invention

It was Newton's greatest achievement to simplify the complexity of the real world when he developed his single-time model of the universe. It was appropriate that his admirers created the metaphor of the great clockwork controlling the evolution of the world. In reality, there is no universal time spanning all of space throughout the universe, except in our mental models and abstractions. Each electron occupies its own point in space at every moment.

Newton's Fluxions

Newton's fluxions or time derivatives (e.g. Å[t]) and the geometrical view of his dynamics demonstrated in his *Principia* [3] both reflect his <u>one-time analysis</u>, selecting any (arbitrary) single point in time on the object's orbit or the timelessness of his results (total duration of one complete, closed orbit).

Alternative Schemes

Einstein was wrong to base his method of clock synchronization using light waves propagating spherically when he knew that this would conflict with his second 'postulate'. It would have been better to rely on oscillating phenomena that exhibit observable, invariant motion (e.g. remote planetary orbits) viewed **transversely** to establish a network of real clocks defining a universal time. Measures of length can then be <u>defined</u> by point-to-point electron interactions.

No Universal Now

In the present theory, there is no universal, real 'now' as each electron has its own 'now'. The idea of a universal 'now' is operationally meaningless to finite human beings. The idea of one single time spanning the universe is also, at best, a pure abstraction without operational significance. This concept is only significant to an omnipresent god; in other words, universal time is a religious, not a scientific concept; it is an ancient inheritance from pre-scientific times.

4.5 THE PRINCIPLE OF RELATIVITY

Modern physicists, for example [26], often begin their retelling of SRT in terms of the '*Principle of Relativity*' (P.of.R). This is the key requirement that any theory of physics should **not** rely on any particular inertial reference frame. This is casually and innocently recast as the requirement that "the equations of physics should retain their 'form' in alternative inertial co-ordinate frames". This latter '*covariant*' requirement has become one of the central dogmas of modern physics. In fact, Einstein only required that (in the direction of motion, say x) that points on the wave-front propagated with the same speed parameter, *c* in the two co-ordinate reference frames, namely: $x = c\ t$ & $x' = c\ t'$. A set of formulas was introduced relating the original and transformed electric and magnetic fields to 'prove' that Maxwell's Equations were covariant.

Covariance is Pythagorean

The definition of *covariance* was proposed in 1908 [135] by Einstein's former professor, Hermann Minkowski (1864-1909), where his proof of the preservation of the form of Maxwell's Equations, was a classic example of Pythagorean thinking, quite appropriate from a mathematician of his standing. This cannot be viewed as having any fundamental significance as the Relativistic transform is only one dimensional and valid only for non-accelerated motion. Assis comments on Newton's simple equation of motion ($\underline{F} = m\ \underline{a}$) when rotation is introduced – the non-inertial form of this equation cannot be described as simple or elegant but the force calculated in either reference frame has the same numerical value and direction [136].

Jefimenko's Perspective

Jefimenko translates [137] Galileo's *Principle of Relativity*, that appeared in 1632, as: "The are no **experiments** whereby a state of uniform motion in a straight line can be distinguished from the state of rest." This emphasis on reality contrasts with Einstein and Minkowski, who interpreted this physical principle as a purely mathematical imposition, stating that theoretical **equations** (even involving intermediate variables, like force field intensities) should be unchangeable in their **form** when rewritten using variables defined in an alternative inertial reference frame. Jefimenko also emphasizes that while the <u>scalar</u> parts of Maxwell's Equations (e.g. $\underline{\nabla}' \bullet \underline{E}' = 4\ \pi\ \rho'$ and $\underline{\nabla}' \bullet \underline{B}' = 0$) and the <u>individual</u> Cartesian components are each Lorentz invariant (which was all that was demonstrated by Larmor, Lorentz, Poincaré and Einstein) <u>the complete vector form</u> of the Heaviside Duplex Equations (the modern, vector form of Maxwell's Equations) are themselves **not** Lorentz invariant due to the Lorentz factor ($\mathcal{L}$) appearing on both sides of these equations in the longitudinal, spatial components.

Physics is not a Set of Axioms

This research programme shares the view of the early 20th Century Cambridge physicists that a proper electrodynamics has to be <u>constructed</u> from an Electron Theory of Matter. This view rejects the idea that the *Relativity Principle* should be given axiomatic status, which is still the present position in modern physics. The key role that Poincaré played in developing the *Principle of Relativity*, beginning in 1895, has been well-described by Charles Scribner [138]. Although Poincaré's version of this principle is often quoted in a form that strongly resembles Einstein's version, it must be remembered that Poincaré always believed in the reality of Maxwell's stationary æther. Poincaré actually wrote [43]: "The principle of relativity is the recognition of the impossibility of detecting the absolute motion of the Earth, or rather, its motion with respect to the æther." As a consequence, in Poincaré's view it was only necessary that Maxwell's EM theory propose that the speed of light be 'c' when it is measured in co-ordinate systems at rest in the æther. Since Poincaré found no experimental evidence for this proposition, he was never tempted to raise its status to a fundamental principle of nature, as Einstein did. Einstein's version of the "*Principle of Relativity*" is misdirected – it is not the invariance of each and every <u>single</u> point event in space-time that is significant but the <u>difference</u> between the pair of interacting point events, as will be shown in this paper.

Born's invalid Extension of the Principle

The Cambridge Maxwellian and student of Larmor, J. W. Nicholson wrote one of the first British papers on the *Principle of Relativity* in 1912 applied to uniformly rotating electrical systems [139]. This paper demonstrated, in the ETM tradition, that the mathematical form of Maxwell's Equations was <u>not</u> preserved beyond the second order (in v/c) when these equations were transformed into a reference frame that rotated along with the rotating electrical system. This approach also provided a solution to Ehrenfest's Paradox (see later) while recognizing, like Newton, rotation as the only form of absolute motion. This paper directly challenged the axiomatic claim made in 1909 by Max Born (1882-1970) that the P.of.R could be applied kinematically to any infinitesimal element of a body whatever its state of motion, including rotation [140]. The Thomas precession calculation ignored this result in trying to provide a relativistic explanation for electron spin.

Invariant Intervals, not Forms

Minkowski was wrong when he reformulated Poincaré's Relativity Principle as "the laws of physics should be covariant". In insisting on the preservation of the **form** of the equations used in physics when recast in terms of variables defined in a different inertial reference frame, he was reinstating Plato's ancient plea for priority in reality to be given to the 'eternal forms'; his variation of the Pythagorean claim that the world was defined by changeless mathematics. Rather, the present theory's restatement of *Poincaré's Principle* (he deserves some respect) is that the relative space and time intervals (that is, **differences**) defining the relative motion of two interacting electrons should be invariant to the relative motion of all third-party observers.

Independent of ALL Observations

The revised *Principle of Relativity*, in the present theory, is that the mutual interaction between two electrons is independent of all motion of third-party observers, since they do not participate in the interaction. This must include linear and rotational accelerations of the 'observer' electrons as well as relative, linear motion. Third-party 'observers' may only interact with either of the two target electrons before and after their mutual interaction to measure their actual trajectories. If 'observer' electrons interact with either (or both) target electrons during the interaction then the final trajectories must inevitably be different than if such intervening interactions had not occurred: this is the source of the 'strangeness' in quantum mechanics.

4.6 REFERENCE FRAMES

The human attempt to provide a description of the physical universe must be such that when we imagine different observers in relative motion then the relationship between their measurements must be deducible from the theory itself and not treated as postulates. It is this requirement that has lead to the introduction of Cartesian reference frames in physics. Nonetheless, it must always be remembered that real experimentalists are rarely concerned with comparing moving observers' actual measurements. More generally, they are interested in one observer (themselves, in the laboratory) measuring differences in the interaction between bodies at rest in the lab and in relative motion. Physics, since Newton, has always been about observations and their transformation into comparable numbers.

Frames are Abstractions

Kant was right: reality existed before humans and will continue to exist long after the last human beings disappear from the universe. However, humans will remain part of reality as long as we continually interact with the rest of reality throughout our individual lives. Empty space or eventless time intervals have no significance for electrons or humans (massive electron systems), so neither do abstract frames of reference. Einstein had to assume the (positivistic) prior existence of clocks and rigid-rods so that he could 'construct' such artificial foundations for assigning 'real' numbers to his space and time points relative to the origins of such reference frames. Since Maxwell's theory of EM focused on a single (and arbitrary) 'field' point in space at an instant of time, there was an obvious link to Einstein's 'point on the wave front', as both required such metaphysical reference frames to give meaning to these singular points lacking any intrinsic physical content.

Frames are not Measuring Devices

Some scholars of relativity have gone so far as to compare Einstein's and Newton's 'theory of information' [141], writing: "Newton assumed implicitly that it is possible to transmit information from one place to another instantaneously. Einstein assumed explicitly that this is not possible and that there is a finite maximum speed with which information can be actually be transmitted from place to place." The present theory does not view Newton's metaphysical foundations of space and time as an 'implicit theory of measurement'. Newton was aware of the finite speed of light, after Römer's announcement in 1667, but was totally unaware of the modern concept of 'information' and neither was Einstein in 1905. Newton did view his mechanics as the instantaneous transfer of velocity-changing impulses across space between particles of finite mass, in contrast to DesCartes' contact theory of interaction. The present theory extends Newton's metaphysical foundations but does not view 'frames of reference' as frameworks for human measurements with 'real' objects like Einstein's 'rigid rods' and 'microscopic clocks'. Space and time are viewed, like Newton, as the passive, foundational levels of reality that form the background 'stage' for all electrons – it is how their relative movements and interactions are defined. Reference frames are theoretical constructs to map our views of space and time into a calculational framework: our rods and clocks are only approximations of this reality. It is up to the experimentalists to device mechanisms and techniques for generating numbers that correspond to our theories of reality: Einstein's *gedanken* approach of rigid rods and micro-clocks is **not** one of them.

SRT makes Time primary

The theory of Special Relativity failed to make its metaphysical assumptions explicit. As a result, its conclusions were implicit in its initial hypotheses. In particular, this theory was constructed from an *optical* propagation theory (Maxwell's EM theory) with a built-in *fixed* velocity (a medium theory) that defined *time* in terms of *two-way* reflected light between fixed and moving pairs of massive objects. It also defined *spatial* separations in terms of this new time so it was inevitable that the space and time parameters defined in each inertial frame of the two moving objects would need to undergo mutual transformations. When these new definitions of variable space and time are proposed as the very foundation of reality, they must logically appear as a bizarre theory of movement (kinematics), in contrast to the fixed view of the passive background of space and time that was the basis for Newton's dynamical physics.

Man at the Center

Einstein's theory of relativity was not a traditional Newtonian theory, which viewed God as everywhere and omni-present, so the whole universe was known at any single time. None-the-less, Einstein implicitly assumed that all of reality could be viewed from the Center-of-the-Universe (the 'origin') by issuing two-way pulses of light everywhere at all times: a post-Darwinian image of Man-as-God. Only what Man observed became real – everything else was left to the rival theologians.

SRT is only about special Points

Einstein's SRT is based directly on Maxwell's EM Equations, which in free space combine into the wave equation for the electric and magnetic fields. However, Einstein's analysis in this paper is based only on the optical interaction between two points: the origin (where the light is both emitted and eventually absorbed) and one other location in space where the light is reflected. From a modern perspective, both of the points must only involve single electrons, as emitter and re-emitter, with a (perhaps) third electron being involved at the final absorption point. However, Maxwell's Equations are not valid at points of electric source or sink. Mathematically, this is where the modern model of continuous electric charge density (ρ) breaks down, where the continuous ρ[x] function must be transformed into the non-continuous Dirac delta function: $\rho \rightarrow \delta[x]$. All other intermediate points (the 'field') are irrelevant as no observations are ever made at these locations.

Instantaneous Frames

Einstein interpreted the symbol 'v' in the 'Lorentz' EM force equation as the velocity of the charge moving relative to the observer. This contrasted with the interpretations of the originators of this equation, J. J. Thomson and Oliver Heaviside, who both defined this velocity relative to the physical dielectric through which the particle was traveling [142]. Einstein's interpretation even contrasted with Lorentz, who had specifically introduced 'his' magnetic force term to reflect the velocity of the charged particle relative to the æther [143]. In the final section of his SRT paper Einstein transformed a static electric Coulomb force to the dynamic, electro-magnetic 'Lorentz' force by switching from a reference frame, stationary relative to the particle, to a reference frame where the electron is moving with velocity 'v'. From all viewpoints, the position, velocity and acceleration are all changing so all of this analysis can only be valid for an instantaneous inertial reference frame. This is operationally meaningless, when velocities and accelerations have to be measured (not just calculated), which requires finite times and therefore accelerated (non-inertial) reference frames. That the transverse mass derived in this section could then be proposed as an explanation for measured behavior of the high speed electrons rotating around the magnetic field in Kaufmann's experiments was more than a little optimistic.

Time is not like Space

Although Minkowski was able to transform the temporal dimension to appear like a spatial dimension [53] the appearance of the imaginary factor (i c t) indicates that two different time values must always be considered – this is the situation in the Natural Vector representation of the interaction between two electrons at two locations in space at two different times.

5. DISCRETE CLASSICAL MECHANICS

This section presents a new classical theory of particle mechanics constructed around the central idea that electrons interact with each other on their mutual 'light-cones' both ***asynchronously*** (finite time differences) and ***discontinuously*** over time. The basic approach taken will be to extend Newtonian mechanics with as few explicit, extra hypotheses as possible. This section will follow Newton and focus just on **one** single particle. This singular focus has always simplified the mathematics, as only one point in time and space is significant – the location of the 'target' particle at any one time. Furthermore, all of the sources of the interaction with the target particle become aggregated into a single, net 'cause' – in the case of Newton, the continuous 'force' on the particle. As the previous paper in this series has demonstrated [4] there can be no continuous forces between inertial particles like electrons when the interactions occur 'on the light-cone'. This major result voids all continuous theories like classical EM but also all relativistic mechanics that describes real phenomena involving electrons, where the electron's velocity is treated as a continuous variable. Thus, the present theory replaces the idea of continuous interactions over time with a set of discontinuous impulses, which results in a **digital** model of classical mechanics. The next section will investigate the full symmetry of the real situation by returning the focus to the interaction itself, which will require examining the dynamics of **two** interacting electrons when the interaction between two particles acts both asynchronously and discontinuously. The next paper will add discreteness to the magnitude of the interaction.

5.1 CONTINUUM PHYSICS

This section will briefly summarize the major areas of classical physics that have exploited both the metaphysical view that the real world is either filled with continuous matter and/or can best be described by continuum mathematics. This brief summary will show that it has been the evolution of this form of mathematics, which has driven the evolution of theoretical physics. This has left theoretical physics exposed to its own contradictions and the deep anomalies exposed by generations of experimental physicists, not the least of which, were the fundamentally discrete nature of matter and the mysterious, discontinuous (or quantum) interactions of matter at this scale of reality.

5.1.1 CONTINUUM MATHEMATICS

Calculus make it easier

In spite of the difficulties many students find learning the calculus, continuum mathematics is actually easier than discrete mathematics (which is why Newton invented the calculus in the first place). The limit process in the differential calculus means that size of the difference (e.g. Δx defined in 5.3) can be eventually ignored; for example:

$$\Delta(x^2) / \Delta x = 2x + \Delta x \qquad \text{while} \qquad d(x^2)/dx = \lim_{\Delta x \to 0} \{\Delta(x^2) / \Delta x\} = 2x$$

This simplification explains the near universality of differential equations in modern science. Finite difference equations are only introduced when the differences are significant e.g. in atomic physics [144]. The present research programme **always** uses finite differences as it rejects the 'Continuum Hypothesis'; calculus is only used to recover standard results. This view is adopted on the principle that the idea of the infinite is only an intellectual concept and no examples are found in reality. This radical step eliminates the division by an infinitesimal that has always been problematic in calculus; these problems were only avoided by Lebesgue's very careful 'limit process'. The corresponding problems associated with using these techniques in the physics of continuous interactions (e.g. field theory) were the appearance of non-physical infinities.

Mathis rejects Calculus

Miles Mathis, in his e-book *The Greatest Standing Errors in Mathematics & Physics* [145] challenges the ancient view of the geometrical point as a representation of reality. From this, he draws the conclusion that finite differences should be used in physics, not Newton's infinitesimal calculus. This conclusion is the starting point of the present research programme that rejects the use of the 'Continuum Hypothesis' in physics. This programme now focuses on the mathematics of the **D**iscrete **N**atural **V**ector (DNV) interaction model, described in the first paper in this series [11], where the space and time variables represent the differences of these values between the two electrons (e.g. $t = t_1 - t_2$), not the single-value at the traditional 'target' electron (t_1). Mathis also challenges Newton's identification of the circumferential 'velocity' (a 2D curve) with the tangential velocity (a 1D vector), even in the limit when $\Delta t \to 0$. Incidentally, Mathis's difficulties in getting his radical ideas published in refereed physics journals illustrate the problem that new ideas find in surfacing through an orthodoxy.

Continuous Single-Time Functions

Since classical and modern physics are single-point theories that describe continuous motion (or spatial change) over time, their mathematical form must inevitably introduce differential calculus in terms of spatial gradients and comparable single-location operators (grad ∇, divergence $\nabla\bullet$ & curl $\nabla\wedge$) and the single-time differential operator ($\partial/\partial t$). The present theory is constructed around true, *instantaneous*, finite impulses, i.e. defined over time intervals of zero duration ($\Delta t = 0$), so that this theory does not need to use the continuum operators that inevitably lead to field concepts. Mathematically, the new theory uses the mathematics of (extended) finite differences defined across finite intervals of time.

5.1.2 CONTINUUM DYNAMICS

LaGrange's Spatial Potentials

Joseph Louis LaGrange (1736-1813), a mathematician of the first rank, played a major role in transforming Newton's theory of nature into a programme where the mathematical features came very much to the fore and the philosophical innovations sank into the background. Since his 1788 treatise *Analytical Mechanics*, LaGrange has established the model of continuum mechanics that has been in the forefront of physics ever since. Central to this approach of interactions between points **in** the continuous material (not discrete particles) was the revolutionary concept of energy of position or *potential energy* and its continuous transformation into the energy of motion or kinetic energy. This Leibnizian metaphysics failed to explain **where** this new form of energy was stored and **how** it was subsequently released. In particular, when this approach is inevitably extended to the mechanics of discrete particles interacting at a distance then statements like "stored in the field" do <u>not</u> specify where this potential energy is stored (is it localized? everywhere? at the boundary?) and how the <u>exact</u> amount of kinetic energy 're-appears' when discrete particles re-establish their original, relative positions. Space is not a mattress.

Even one of the major textbook writers on classical EM has had to acknowledge, when trying to justify the widespread use of continuum mathematical methods for systems of interacting charged particles [146]: "The (EM) Lagrangian is a function of the instantaneous velocities and co-ordinates of all the particles. When the finite velocity of propagation of EM fields is taken into account, this is no longer possible, since the values of the potentials at one particle due to the other particles depend on their state of motion at retarded times." Thus, these classical mathematical techniques can only be approximately valid for non-relativistic velocities when relativistic (delay) effects can be neglected. This is obviously only true for large collections of charges and never for micro-systems of actual electrons that react dramatically due to their small inertial mass.

Potentials, not Fields

The present theory follows Maxwell's original [23] conception of the primacy of the <u>electro-kinetic momentum</u> per unit charge (the magnetic or vector potential, $\underline{A}$); an approach still actively promoted by C. John Carpenter [147] over the last 40 years. This approach eliminates all references to field concepts (variables defined everywhere and always) since $\underline{A}$ and its temporal complement, the electric or scalar potential, ϕ are only evaluated **at** the locations of each of the pair of interacting electrons **when** they each interact discontinuously. This focuses attention on the trajectories of the real electrons and how these are modified by the asynchronous interactions. So-called electric and magnetic energy densities are reduced to time-varying potentials **between** the charges and kinetic energies **of** the charges. This theory's use of discrete mathematics [6] (DNVs) has shown that the continuum limit in Maxwell's EM theory has irretrievably lost all hope for an understandable physical model (involving micro-dynamics), leaving only a skeleton of differential equations behind.

Poincaré recognizes Threat to DEs

In 1911, Henri Poincaré anticipated the impact of the quantum on the foundations of mathematical physics when he wrote [148]: "It is hardly necessary to remark how these [quantum] ideas differ from traditional conceptions. Physical phenomena would cease to obey laws expressible by *differential equations* and this, undoubtedly, would be the greatest and most radical revolution in natural philosophy since the time of Newton." Although this 'clue' has been staring at physicists for nearly a century now, the mathematicians that dominate theoretical physics could not give up their favorite tool. The present theory will demonstrate that **all** quantum ideas derive from the hypothesis that the fundamental EM interaction is **discrete in time** and not continuous.

5.1.3 CLASSICAL FIELDS

In a later section (6.6), in the situation of two classical point charges moving directly towards a head-on collision (referred to here as *The Terrible Twins*), both particles lose their kinetic energy as they approach closer to each other, slowing down under their mutual repulsion (the particles have equal electrical charge). They both recover all of this kinetic energy as they 'rebound' from their points of closest encounter. When viewed from standard EM theory, each electron should continuously radiate EM energy away from itself in the form of *outbound spherical waves*, both during the inbound and outbound phases as the velocity of each charged particle is continuously changing. Furthermore, the outbound phase interactions need to correlate exactly the identical amount of energy that was lost during the inbound phase. "Arm-waving" about Coulomb potential energy etc does **not** explain this physical situation; worse, this very simple model is never discussed in any texts on EM – perhaps, its problems are too embarrassing, hence the name given here. An appropriate and consistent explanation of this model is viewed as paradigmatic for any acceptable EM theory, including this research programme.

Coulomb's Conservative Paths

A wide reading into the history of classical EM and SRT exposes the key role that Coulomb's electrostatic law plays in both theories. The second paper in this series [6] reminded physicists that Maxwell focused on the problem of magnetism when he constructed his theory of the EM field; he simply imported Coulomb's result to also include electric effects. Similarly, in 1905 Einstein again simply transformed Coulomb's static force in a stationary reference frame into the 'Lorentz' force law in a moving frame: most modern texts on SRT simply repeat this technique. It is important to notice how Coulomb's 'law' was converted into a key component in later field theories by switching from a 'force' viewpoint to one involving 'potential fields'. Indeed, in many introductory expositions of electrostatics, such as Pauli [149], the clever use of the 'invisible hand' is repeatedly invoked. Here, electric charges are moved around each other (by the *hand*?) while others stay in place (fixed by the *hand*?) while the forces generate their effects on the charges. In reality, there are only individual electrons, which move under their own mutual EM influence and never stay still. So in terms of the real carriers of electricity (and not large 'pith balls') Coulomb's force theory is simply a 200 year-old *gedanken* fiction. It is also rarely remarked that since this is an inverse square effect, it is instantaneous across all of space (the 'Coulomb gauge') so that every electron is always under the influence of every other electron in the universe: indicating that the concept of an *isolated charge* is just another very useful mathematical fiction. At best, Coulomb's 'law' can only be viewed as a macroscopic, long-term, local average and not the very foundation of any EM theory. This will be the viewpoint adopted in the present theory.

Fields as Simplification

One mathematical physicist conceived of *the field* as [150]: "a quantity, like a number, one of which *lives* at each point in space. As *you* move through space, the value of the field changes continuously." Apart from the bizarre anthropocentric implications, this quotation is typical of the modern metaphysical viewpoint of the physical reality of this mathematical concept. In practice, the physicist's concept of the field reflects the conscious assumption that an effect can be separated from the dynamical interaction of its contributing entities. It is a deliberate attempt to simplify the complex world into a single-time model that then becomes more amenable to mathematical manipulation. The physicists' fields involve one to six (complex) real numbers, each requiring an infinite number of decimal digits; all of them varying infinitely across space and continuously across time; Pythagoras would, indeed, be proud: "all is number". The mathematics of fields relies on the analytic properties of regular functions, in other words, 'smooth' or differentiable. Unfortunately for field theory, the world is constructed from point-like particles (especially electrons), which can only be represented within field theories by the so-called Dirac 'delta function', $\delta[x]$: and this is not a regular function but a highly discontinuous 'distribution'. These major problems are by-passed in any theory that uses finite mathematics, as is done here.

Bridgman, with his clear commitment to clarity and commonsense, pointed out [131] that: "there is no physical phenomenon whatever by which light may be detected apart from the phenomena of the source and the sink." This programme simply views these as locations of interacting electrons. For any field to make its presence felt it is necessary to first introduce a 'detector'. In the case of all forms of EM field theory, the detector is always a charged particle, in other words, an electron. In terms of classical EM, the source currents are defined by the product of charge density and local velocity, defined in the observer's inertial frame of the charge that is the source of the field. The problem here is that the field point is always fixed relative to the inertial observer centered in his own reference frame. However all real detectors of the EM fields situated at this 'field point' must involve real electrons: they are inertial and move away from the field point under the ever-present influence of the EM 'Lorentz' force; similarly the real source electrons react away from their initial 'free' motion as they participate in the interaction with the target electron. Unfortunately, Maxwell defined his theory before the discovery of the electron so that the real nature of electricity was unknown to him – hence his invention of the luminiferous æther to support his model of light.

Einstein builds in the Field

Einstein finally realized that his whole physics (and most of modern theoretical physics) was built on a single metaphysical assumption: that the world really exists as a continuum and, correspondingly, that the mathematical concept of the field was an appropriate representation of reality; if this mathematical/philosophical assumption was invalid then his physics totally collapsed. As quoted by one of the foremost historians of physics, Einstein wrote: "I consider it quite possible that physics might not, finally, be founded on the concept of the field – that is to say, on continuous elements. But then out of all my castles in the air – including my theory of gravitation, but also most of current physics, there would remain *nothing*." [151].

The Complexities of EM

The following table highlights some of the major distinctions between the phenomena of classical mechanics (CM) and the current views of classical electromagnetic (EM) theory; this list illustrates the greater complexity of the EM interaction.

Feature	CM	EM
Interaction Speed	Infinite	Finite (c)
Interaction Delay	Zero	Finite
Focus	Points	Densities
Direction	Linear	Rotational
Medium	None	Æther
Momentum Conservation	Yes	No
Force Law	Direct	Lorentz (velocity)

5.2 CLASSICAL ELECTRON METAPHYSICS

The necessity for metaphysics and the metaphysics underlying classical EM were both analyzed critically in an earlier paper [6]. They will not be repeated again here; suffice is to say that Maxwell's original metaphysical model of EM (the æther) is no longer given credence today due the discovery of the electron. The mathematical model of quasi-interacting 'electric fluid' also has no ontological meaning but, as it is simply visualizable and retains much of Maxwell's mathematics, it is still the model used to teach classical EM to undergraduates of physics and engineering. In summary, metaphysics is viewed here as those features of the world that are (at least, at present) non-verifiable but none-the-less are regarded as necessary in any theory that is to be considered 'real'. The central concepts in this research programme are always electrons and their interactions, which occur against a passive background of universal space and time. The metaphysics of the electron, as it is viewed in the present theory, will be briefly discussed here in this paper.

5.2.1 A THREE-LEVEL METAPHYSICAL MODEL

Reality, Imagination & Experiment

The model of physics proposed in this research programme consists of a hierarchy of three distinct levels. The foundational level of the world is referred to as *reality* – it is defined simply as all that *is* or the totality of existence. *Imagination* consists of all the verbal and visual models of reality that humans can generate in their heads and can communicate to other humans. *Experiments* are those manipulations of parts of reality by humans that are interpreted by our shared imagination.

Level 1 - Reality

At the human level, reality is everything that interacts (or is observable) to human beings using their standard senses. At the cosmic level, reality consists of the planets, stars, galaxies etc – some of these can be revealed to us by our technological inventions. The microscopic foundations of reality are not directly accessible to us as we are gigantic collections of atoms. The components at this level have been described in the above metaphysical model of the micro-world. They consist of point electrons that interact at discrete points in space at specific instances of time, in pair-wise combinations.

Level 2 - Imagination

As can be seen, it is our imagination that plays the central role in this schema and, in the case of the foundations of natural philosophy, it becomes the key area of theoretical physics. Since the EM interaction here is always viewed as point-to-point (ray-like) it does not even need the concepts of continuous spherical waves or plane waves extending to infinity. It is one of the explicit metaphysical assumptions of this programme that there are no infinities in nature, so they should never appear in any of our representations.

Level 3 - Experiments

Natural science has always progressed best when its areas of investigation are made subject to repeatable experiments. This ultimately prevents human fraud and minimizes errors, as many experimenters can confirm the initial new findings of the few pioneers. When any experimenters can change the components (or magnitudes of the components) of the parts of reality under investigation, it becomes clearer to everyone what is important and how variations engender correlations. All of these experimental aspects help to confirm or disprove the predictions of any theory developed to provide explanations for this part of reality. The absence of manipulation or repetition of the experimental conditions makes such explanations much harder to arrive at or to help distinguish one theory from another. This theory will therefore ignore purely observational sciences (such as astronomy) or "one-off" phenomena, like the origin of the universe.

5.2.2 THE METAPHYSICS OF SPACE & TIME

Geometry

Since this theory hypothesizes that reality only consists of point-like electrons and ray-like, direct interactions between these electrons in space then an imaginary model involving only points and straight-lines in a three dimensional (3D) continuous analog should prove a suitable model in our imagination. It is an observable fact that a three-dimensional arrangement of four charged bodies in an equilateral tetrahedron arrangement can result in scale-invariant motion, indicating the 3D nature of space. As an incomparable act of the human imagination (level 2) in generalizing from human experience, Euclidean geometry has proven the ideal model for mathematicians but since it is scale-less in its lengths and timeless in its static structures it is not directly suitable as a basis for representing the activity of change in 3D physics. However, the present theory is finite across time (rejecting the Continuum Hypothesis) and so does not need the concept of continuous curves that have also been used extensively in geometry, especially with the best-known curve: the circle. Since space is viewed here as passive, there is no need to introduce complex geometries into this theory; applying the *Principle of Least Change* [6] once again, as well as Ockham's *Principle of Simplicity*, it would seem hopeful that the adoption of Euclidean geometry will probably prove quite sufficient. The addition of a serial sequence of a fourth parameter can model the behavior of time that underlies reality. The finite nature of this 'time' parameter, referred to here as the *chronon*, not only scales time but through the introduction of a universal space-time conversion factor (or *Interaction Constant* more popularly known as 'light-speed') also scales space. The new element here is that interactions occur neither continuously nor periodically over time.

Passive Space, Active Time

This theory follows Newton in its metaphysical approach so that space is viewed purely as a passive backdrop to the drama of particle dynamics unfolding over time. In contrast to field theories that view space as the primary focus of activity in the world, either through the support of a medium (like Maxwell's æther, see [6]) or today, as the foremost ontological element of reality, the separation here between electrons carries no momentum, energy or any other dynamical property.

In this theory, it is the interactions between electrons, over time, that generate complex changes in their relative motions.

Only Parameters, not Reality

The four real numbers ($\underline{x}$) and (t) that characterize the 'target' point at any instant of time are simply parameters in an appropriate theory – they are not physical things in themselves and since they are offsets from arbitrary origins in space and time they are also equally arbitrary. The present theory agrees with Mendel Sachs who viewed SRT only as a mathematical theory [152] so that there are no physical changes in spatial separations or temporal durations involving real objects when viewed by observers in other inertial reference frames that are moving with a constant velocity. This view is based on the idea that a major metaphysical error is committed whenever the <u>measure</u> of a real thing is confused with the thing itself – a danger that the philosophies of Pythagoreanism and Operationism are always at risk of falling into.

5.2.3 MATERIAL METAPHYSICS

The present theory is a materialist model of reality: only matter forms real 'things'. The ultimate form of matter in this theory is the electron (and only the electron). This sub-section discusses some of the characteristics that define the nature of electrons in this theory and how they are assumed to interact amongst each other; this is contrasted with the idea of energy.

Helmholtz's Conservation of Energy

When Maxwell reviewed Helmholtz's famous 1847 essay (*On the Conservation of Energy*), he summarized how one of his German rivals had thought about energy [153]. "If the forces acting between material bodies were equivalent to attractions or repulsions between the particles of these bodies, the intensity of which depends only on the distance, then configuration and motion of any material system would be subject to a certain equation which, when expressed in words, is the principle of the conservation of energy." Maxwell failed to realize that these distant-dependent forces, like the Coulomb force, imply only instantaneous forces that are also independent of velocity, neither condition applying to the asynchronous, velocity-sensitive world of EM.

Energy is not an Entity

The fundamental motivation for all field theories is the unjustified assumption that the total energy **never** changes; in other words, energy can never disappear at **any** time. This characteristic of *always* ***existing*** is the defining feature of real entities. So the issue ultimately becomes one of whether energy is an entity (i.e. an independent existent) or not. Since this has never been resolved experimentally, this becomes a problem for philosophy - it requires a deep linguistic analysis of the physical situations that are hiding behind the mathematical symbols of modern physics. This issue was raised in an earlier paper [6] where attention was focused on the three primary verbs in the English language: to BE (exist), to DO (action), to HAVE. The latter is the most problematic as it is associated with several diverse meanings. Most importantly, it is used to convey the possession of an intrinsic quality (like color) but it can also indicate relationships between several real entities, such as the ownership of a car. For 200 years following Newton, physics viewed energy as a quality: particles possessed energy in the same way that they had an intrinsic location or a velocity. It was Maxwell, who first moved the idea that energy was an entity independent of any particles into the central arena of modern physics. If the idea of color were to be substituted for the term 'energy' in the interaction between two electrons, it would be perverse to suggest that an independent carrier (the invisible paint-can?) be invented to transfer this quality from one remote electron to another. Similarly, if a smile were passed through a group of people, no one would expect to find some object called a 'smile' being handed from person to person, as if it were a real object like a gold coin. This is exactly what has happened in field theory: its proponents have introduced *fictional carriers* (waves or particles) to 'transport' inherent electron qualities such as momentum and energy across space. This theory rejects all necessity for these fictions, invoking Ockham's *Principle of Parsimony* and demanding that introducers of such ideas justify their extra metaphysical innovations; remember Newton's "non fingo hypotheses".

Explicit Electron Metaphysics

In contrast with almost all modern theories, the present theory deliberately makes its metaphysical assumptions explicit:

1. Each electron is assumed to exist only at a **point** in space at any instant of time; that it, it has **no** structure, it is **not** a small rigid body and it does not contain any electrical fluid – it **is** electricity.
2. Each electron is **eternal**; that is, it exists at every instant of time, forever.
3. Each electron is **identical**; it has the same universal properties at all times, independent of motion.
4. Time is **universal**; it is the same for all electrons so that each electron cycles through a possible 'send' and 'receive' state at the same universal **rate** (the *chronon*) that is independent of **all** motion.
5. The electron interaction is **discrete**; it consists of one single impulse occurring at an instant of time.
6. The electron interaction is **saturated**; in other words, it always only involves **pairs** of electrons that are committed to each single EM interaction – one electron 'sending', the other always 'receiving'.

This research programme is founded on the ontological hypothesis that the world consists only of electrons. In other words, the concept of matter is an aggregate view only of electrons. These objects are now known to be the particulate exemplars of that area of human experience known as 'electricity'; as such, matter and electricity are viewed here as synonymous. The concept of space requires the separation of two electrons. The concept of time requires that at least two of these electrons interact. This programme will eventually demonstrate, in subsequent papers, that all known examples of the many so-called 'elementary particles', such as protons, neutrons etc, are stable configurations of small numbers of negative and positively charged electrons. It will be shown that only motion in space distinguishes positive and negative electrons.

Unique Electrons

The anti-symmetric nature of two-electron functions means that no two electrons can ever occupy the same location in space at the same time. Further the EM interaction proposed here is between two electrons, so there is no 'self-interaction'; this has been both the problem generated by finite models of the electron 'filled' with continuous electrical 'fluid' (e.g. Lorentz) or the source of modern EM field theory problems where the interaction always occurs at points of zero spatial separation. Furthermore, due to the anti-symmetric nature of the electron-pair functions, there is never an interaction here between two electrons at zero spatial separation: the infinite 'curse' of point-particle models of EM. Since pairs of electrons only interact in this theory when there is a finite spatial separation and when both electrons are "on each other's light-cone" then there is **no** globally significant **single** time that characterizes the interactions between any **two** electrons. Each electron (labeled #k) is characterized by both its local position in space ($\underline{x}_k$) at its own 'local' time (t_k), so the symbol T is reserved here to denote the differences between the times when the two electrons interact, i.e. $T \equiv t_1 - t_2$.

5.2.4 INTERACTIONS 'ON THE LIGHT-CONE'

The earlier historical review has shown that Maxwell's metaphysical conception of a continuous medium pervading all of space has become the *de facto* model of classical electromagnetism. Eventually, Maxwell's theory of electricity (stress in the medium) was reluctantly replaced with substance models of electricity, such as Helmholtz's electric-fluid model or the Lorentz Electron Theory (see 2.3.2). This only replaced the sources and focus of electrical variation – the medium was still retained to 'support' the electromagnetic (EM) effects, such as energy and momentum, between the two remote points of interaction. Although the concept of 'æther' has been formally dropped from the 'fashion runway' of modern physics, its role has been absorbed into the modern view of the very nature of space itself: the $\underline{E}$ and $\underline{B}$ fields now just 'are', without any need for any supporting medium. This dualistic model of EM continued to haunt Einstein until his death; it was always his unitary dream that particles eventually would be shown to be constructed from the fields themselves (like the Higgs boson). The present research programme might be seen as 'Einstein's Nightmare' as it explicitly rejects all field concepts, not only metaphysically but also mathematically, and returns to the Newtonian view that all of physics can be modeled from a purely discrete viewpoint involving only point particles. This programme follows Gauss's suggestion that Newton's instantaneous action-at-a-distance model should be extended to include asynchronous interactions between pairs of point particles that interact at two different times.

The hypothesis of *Standard Separation* is assumed for all interactions between pairs of particles. This is sometimes referred to, as the "*Light-Cone*" condition (see I-7.4.5). An interaction between any two point particles **may** only occur when their absolute spatial separation ΔX, divided by their absolute time separation ΔT, is exactly equal to the universal constant 'c' (called here the *Interaction Constant*). This constant has the dimension of speed and it is now universally called the "speed of light" (with a value of about 3 x 10^{10} cm/second) as it appears in the wave equations of Maxwell's EM theory of light, even though it was introduced first by Weber, his action-at-a-distance rival. It is thus only for historical (and ironic) reasons that this principal requirement is still referred to here as the 'light-cone' condition.

The **Light-Cone** Condition: $\Delta X_{12} \,/\, \Delta T_{12} = c$ or $(\underline{x}_1 - \underline{x}_2) \bullet (\underline{x}_1 - \underline{x}_2) = c^2 (t_1 - t_2)^2$

This condition is independent of the velocities of either electron or the motion (including non-inertial) of any 'third-party' observers as nothing 'flows' between the electrons and the interaction occurs without benefit of human observation.

Interactions define Reality

Physics, since Newton, has distinguished the interaction between two particles; by dropping the source particle(s) it became much simpler mathematically to transform the real interaction into a disembodied force, that took on an existential life of its own, before finally mutating into that ontological conundrum known as 'energy'. Once released by applied mathematicians from its sources, this powerful concept finally transmogrified into the field concept, which has taken over all of theoretical physics. It is the finite time differences, inherent in the inter-electron interaction, which led to the major difference between electromagnetism and Newton's instantaneous gravitation. The previous paper in this series [4] has shown that a ray-like (or point-to-point) view rather than spherical or plane waves is a more suitable viewpoint in avoiding the contradictions arising from the continuous force model of inter-particle interactions between point objects with inertial mass.

5.2.5 CONTINUOUS LOCATIONS

Only Location must be Continuous

Physics has correctly mapped the intuitive idea of existence as 'somewhere in space'. However, since the idea of time is ambiguous, depending on the viewpoint of the observer, it is only a god-like viewpoint that has universal domain spanning all of space at the same time. The only logical alternative is the one adopted here: all real existents (electrons) exist for all time. This means that at any instant, each point-like electron must exist somewhere in space and as it changes its location it must execute a continuous trajectory. Traditional physics has made the unwarranted jump from this viewpoint to one where the velocity of each particle must also be continuous over time and that the interactions between particles must also occur continuously. Neither of these latter two assumptions is made in the present theory. In fact, the quantum effects in the real world are here viewed as a direct corollary of this discrete view of time.

Discontinuous Velocity

The universal assumption in all of physics is that the 'Continuum Hypothesis' applies to all of physics, even down to the smallest levels of reality. In particular for any two consecutive interactions involving the same electron occurring at, say t_1 and $t_2 = t_1 + \Delta t$, it has always been assumed (following Newton) that it is always possible to distinguish these two events (or measurements) for all values of t_1 and t_2, even in the infinitesimal limit of Δt going to zero. Newton himself based his use of the infinitesimal calculus on this assumption to define the concept of *instantaneous velocity*. This has remained completely unchallenged throughout classical and quantum physics until the present research programme, which introduces differing and finite time differences between consecutive interactions as one of its fundamental hypotheses for the activity of real electrons; this idea immediately results in the concept of *discontinuous velocitie*s at the time of each interaction.

The 'weirdness' of both 20th Century innovations, special relativity and quantum mechanics, both derive from the classical use of the basic kinetic concept of **velocity** in domains where the traditional concepts of continuity and pure observation no longer apply (i.e. high-speed interactions and within atoms). It is only the relative spatial and temporal differences that are observational primitives – velocity is a calculational (theoretical) concept. Appropriately, in both 'special' domains, all the original 'weird' experiments were conducted on electrons around 1900. In the present theory, electrons are viewed as eternal so that their real existence in space is forever; i.e. their spatial positions are continuous at all times. This can be restated in a mathematical form for every electron (labeled arbitrarily with a unique integer index, j) in terms of an *existence* condition (or 'operator', $\mathcal{E}$) that has only two eigenvalues: 1 corresponding to the existence of an object and 0 to represent the non-existence of an object. If the state of the universe at any time 't' (relative to an arbitrary reference frame) is represented by a (big) function $\Omega(t)$, then for the jth electron: $\mathcal{E}_j\, \Omega(t) = \Omega(t)$. Its continuity is represented by: $\underline{X}_j[t + \delta t] \rightarrow \underline{X}_j[t]$ for two very close times. The discrete nature of the interactions between electrons implies that interactions only occur at a finite number of times T_{jk} for each electron j, when each electron's velocity changes discontinuously: $\underline{V}_j[T_{jk} + \delta t] \neq \underline{V}_j[T_{jk} - \delta t]$. Each of these interactions is attributed to an impulse received from the other electron, originating at a <u>different</u> time. In this view, impulse can be thought of as "impact at a distance"; in the case of electrons, it is manifest as an instantaneous and finite change in an electron's velocity at the 'moment of impact'.

Variable Time Differences

The discrete nature of the electron interaction means that all kinetic and dynamic quantities of each electron (e.g. V_n, P_n, K_n) can be calculated **at** either the <u>interaction times</u> T_n or at the <u>mid-points between these times</u> $\mathcal{T}_n = \frac{1}{2}(T_{n+1} + T_n)$. In the present theory by design, electrons may only interact at one of their interaction times when they are at the spatial location X_n (i.e. when they are on the 'light-cone' of their interacting companion, which may be the intervening 'measurement' electron) then the kinematical values are always calculated from the appropriate interaction times and locations. It must be noted that such kinematical (difference) quantities are **never** measured directly (a false assumption in standard quantum mechanics that will be explored later in another paper).

$$\Delta T_n \equiv T_{n+1} - T_n \qquad \Delta X_n \equiv X_{n+1} - X_n \qquad \Delta\mathcal{T}_n \equiv \tfrac{1}{2}(\Delta T_{n+1} + \Delta T_n)$$

The result of the previous paper [4] for interactions between inertial particles has shown that: $\Delta T_n \neq \Delta T_{n+1} \;\therefore\; \Delta T_n \neq \Delta\mathcal{T}_n$

The definition of the nth value of the electron's velocity: $V_n \equiv \Delta X_n / \Delta T_n = (X_{n+1}[T_{n+1})] - X_n[T_n)]\,) / (T_{n+1} - T_n) = V[\mathcal{T}_n]$

This can be compared with the <u>average velocity</u> of the electron calculated at (i.e. around) the n^{th} interaction time T_n.

$$V[T_n] = \langle V_n \rangle = \langle V[T_n] \rangle \equiv \tfrac{1}{2}(V_n + V_{n-1}) \quad \therefore \langle V_n \rangle \neq V_n \quad \text{or} \quad V[T_n] \neq V[\mathscr{T}_n]$$

These distinctions are only possible in a discontinuous theory, whereas these differences are lost in all continuous theories. These distinctions will be analyzed in greater detail in section 6.4, where they are used to provide a physical explanation of Planck's Proposal for revising Newton's invariant definition of inertial mass.

5.3 THE MATHEMATICS OF FINITE DIFFERENCES

In avoiding the infinitesimal calculus it is only required that all differences remain finite. The present research has come to realize that the standard calculus of simple finite differences needs to be extended to represent the dynamics of inter-electron interactions. Some of the basic results of standard finite differences are first reviewed. The extensions are introduced in the next sub-section, where irregular differences are explored.

5.3.1 STANDARD FINITE DIFFERENCES

Analytic Functions

Much of modern mathematical physics relies on the concepts of analytical functions – a branch of mathematics that is not used in the present theory. Since the alternative algebra of finite differences used here is sometimes finally evaluated in the continuum limit (the approach taken by Newton) it is useful to summarize the key ideas associated with analytic functions.

Whenever there is a unique relationship between two sets of numbers, say x and t, such that when a specific value for t is given then a **unique** value of x is determined, then x is said to be a function of t and this is written as x[t]. In the present theory, the valid range of the independent variable t is limited to finite, positive and negative numbers, as is the resulting dependent variable, x. Since this theory is attempting to create a purely algebraic representation of nature then only finite algebraic functions and finite series will be admitted – this will exclude transcendental functions like exponentials.

There is no evidence to assume that time itself is discontinuous, although the present theory is based on the hypothesis that <u>consecutive</u> electron interactions only occur after <u>finite</u> intervals of time. Similarly, all electrons are assumed here to exist 'for ever', that is, across an actual span of time that is vastly beyond all human measures or experience compared to the smallest interval between interactions. These metaphysical ideas lead to the idea of mathematical continuity. A function F[t] is <u>continuous</u> if it can be defined at <u>every</u> value of its argument [t] throughout its range of definition. Analytic functions introduced the idea of infinitesimal limits, where a small variation in t, usually represented by δt, is eventually allowed to go to the limit of zero, this 'limiting process' can be reached from 'above' or 'below' at any specific target value T in the range:

$$\text{Definitions} \quad \textbf{Above.Limit}: \quad F^+(T) \equiv \lim_{\delta t \to 0} F[T + \delta t] \quad \& \quad \textbf{Below.Limit}: \quad F^-[T] \equiv \lim_{\delta t \to 0} F[T - \delta t]$$

A function is **analytic** if it satisfies the double conditions: $F^+[T] = F^-[T] = F[T]$ for all values T in the range. A function is **discontinuous** if there are a finite number of values (here called '*interaction times*' – anticipating the physical theory) and denoted as T_j, where the above and below limits differ in value; i.e. discontinuous at T_j when: $F^+[T_j] \neq F^-[T_j]$.

The foundational function in the calculus of finite differences is the Heaviside 'unit' (or step) function θ[t], which is defined as zero when t is negative and one otherwise. This can be used to define the more useful '*block*' function $\Theta[t; T_1, T_2]$ as the offset difference between two 'step' functions, which has the value one inside the '**interval**' $(T_1 ; T_2)$ and zero otherwise:

$$\text{Definitions: The } \textbf{Block} \text{ Function} \quad \Theta[t; T_1, T_2] \equiv \theta[t - T_1] - \theta[t - T_2] \quad \text{and} \quad \Theta_n[t] \equiv \Theta[t; T_n, T_{n+1}]$$

A function will be considered '*regular*' if it can be defined at a <u>finite</u> number of points t_n in the complete range. Following Dirichlet, a function will be a *piecewise*, regular function if it can be viewed as a finite sum of regular functions that are each continuous within their separate interaction-intervals. Such a function may be continuous everywhere or just discontinuous at only the 'interaction values'.

$$\text{Definition: } \textbf{Piecewise-Regular} \text{ Function} \quad F[t] \equiv \Sigma_n F_n[t]\, \Theta_n[t]$$

The physical time variable 't' is itself an analytic function as it continuous, defined everywhere in the range and its above and below limits are finite and equal. The '**free particle**' location function (moving along any one dimension, say Z, at a constant speed u_0 and found at Z_0 at time T_0) is: $z_0[\,t\,] = Z_0 + u_0\,(t - T_0)$. This is also continuous and analytic. If this particle receives an instantaneous impulse at a finite number of times T_n then its subsequent (constant) speed will be u_n in the next 'interaction interval'; this can be represented by the following piecewise-regular function:

$$X[\,t\,] \equiv \Sigma_n X_n[\,t\,]\,\Theta_n[\,t\,] \quad \text{where} \quad X_n[\,t\,] = X_n + u_n\,(t - T_n)$$

Finite Difference Definitions

A *discrete function* is defined as a *set* of (N + 1) values $\{\zeta_n\}$ *ordered* by a unique *identifier* n, spanning the positive integers from 0 to N. A discrete function is either *point-like* or *piecewise continuous*. A point-like discrete function f_n is defined only **at** its set of identification points $\{f_n\}$. A piece-wise continuous discrete function F[t] is defined as a set of (N + 1) functions $\{F_n[t]\}$, whose values vary according to a continuous parameter t. Each individual function $F_n[t]$ is a **single** value F_n defined in the range T_n to $(T_{n+1} - \delta t)$, where $\delta t <<$ any $(T_{n+1} - T_n)$, and zero outside this range. Each of the critical values T_n are referred to as 'interaction points', which are not usually equally distributed. Each range is characterized by its mid-point value $\mathcal{T}_n$, defined as:

$$\mathcal{T}_n \equiv \tfrac{1}{2}\,(T_{n+1} + T_n) \quad ; \quad F_n \equiv F[\mathcal{T}_n].$$

These concepts are illustrated in the following two diagrams

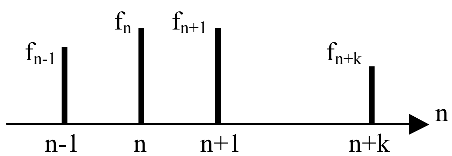

Fig. 1 f_n

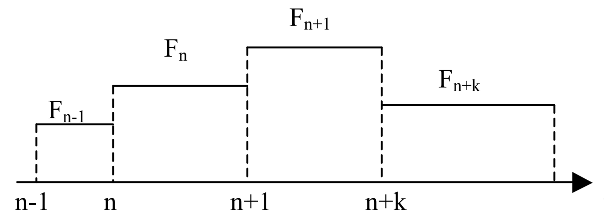

Fig. 2 $F_n(t)$

In the case of single electron kinematical variables, examples of point-like discrete functions are time and location (t_n & $\underline{x}_n$); while the single electron dynamical variables: velocity, momentum and kinetic energy ($\underline{V}_n$, $\underline{P}_n$ & K_n) are examples of piece-wise continuous functions. Two new classes of discrete functions can be derived from any discrete function, namely the sum and differences of adjacent values, which could be given their own unique symbol but are usually designated by a (prefix) modifier of the original function. The most commonly used derived discrete functions are the average of adjacent values designated by surrounding angular brackets and the difference designated by a small delta prefix.

Definitions: Average $< \zeta_n > \equiv \tfrac{1}{2}\,(\zeta_{n+1} + \zeta_n)$ Difference $\Delta\zeta_n \equiv \zeta_{n+1} - \zeta_n$

The difference function is used most often, so it is very useful to define a comparable linear operator ('diff') designated by a larger, **bold** delta symbol.

Definition: **DIFF.OPERATOR**: $\boldsymbol{\Delta}[\zeta_n] \equiv \zeta_{n+1} - \zeta_n$

The functional (square) brackets can often be omitted when there is no ambiguity: $\boldsymbol{\Delta}\zeta_n = \boldsymbol{\Delta}[\zeta_n] = \Delta\zeta_n$. The symbol $\boldsymbol{\Delta}$ acts like a linear operator as it can be applied repeatedly e.g. $\boldsymbol{\Delta}^3[\zeta_n] = \boldsymbol{\Delta}[\boldsymbol{\Delta}[\boldsymbol{\Delta}[\zeta_n]]]$ and may be applied to sums and differences of series; thus:

$$\boldsymbol{\Delta}[\alpha_n \pm \beta_n] \equiv \boldsymbol{\Delta}\alpha_n \pm \boldsymbol{\Delta}\beta_n \qquad\qquad \boldsymbol{\Delta}[\alpha_n * \beta_n] \equiv \alpha_{n+1}\,\beta_{n+1} - \alpha_n\,\beta_n$$

It is sometimes useful to define a 'super-difference' series where non-adjacent values are used to compute the new series.

Super-Differences: $\boldsymbol{\Delta}_k[\zeta_n] \equiv \zeta_{n+k} - \zeta_n = \Delta_k\zeta_n$ Note: $\boldsymbol{\Delta}_k[\zeta_n] \neq (\boldsymbol{\Delta}\zeta_n)^k$

Repeated use of these operators leads to results that sometimes (but not always) resemble the results of differential calculus.

$$\boldsymbol{\Delta}^2[\zeta_n] = \zeta_{n+2} - 2\,\zeta_{n+1} + \zeta_n = \boldsymbol{\Delta}_2[\zeta_n] - 2\,\boldsymbol{\Delta}[\zeta_n] \qquad \therefore \quad \text{'double-diff'} \quad \boldsymbol{\Delta}_2 = \boldsymbol{\Delta}^2 + 2\,\boldsymbol{\Delta}$$

Also: $\boldsymbol{\Delta}_2[\zeta_n] = \boldsymbol{\Delta}[\zeta_{n+1}] + \boldsymbol{\Delta}[\zeta_n] = 2 < \boldsymbol{\Delta}\zeta_n >$ and $\boldsymbol{\Delta}_2[\zeta_{n-1}] = \boldsymbol{\Delta}[\zeta_n] + \boldsymbol{\Delta}[\zeta_{n-1}] = < \zeta_n > - < \zeta_{n-1} >$

These latter two identities illustrate that the double-diff of the prior value equals the sum of the last two differences or the difference of the last two averages. The product rule also displays some useful results.

$$\Delta[\alpha_n * \beta_n] = <\alpha_n> \Delta[\beta_n] + \Delta[\alpha_n] <\beta_n> \qquad \text{So} \qquad \Delta[\alpha_n * \alpha_n] = 2<\alpha_n> \Delta[\alpha_n]$$

There is another useful approximation that will be used in analyzing Planck's model of relativistic momentum.

$$\Delta[\ln(\zeta_n)] = \ln(\zeta_{n+1}) - \ln(\zeta_n) = \ln(\zeta_{n+1} / \zeta_n) = \ln((\zeta_n + \Delta\zeta_n) / \zeta_n) = \ln((1 + \Delta\zeta_n) / \zeta_n) = \sum_{k=1}^{k=\infty} (-\Delta\zeta_k / \zeta_k)^k / k$$

$$\text{So, if } \Delta\zeta_n << \zeta_n \text{ then: } \Delta\zeta_n / \zeta_n \cong \Delta[\ln(\zeta_n)] \quad \text{and} \quad \ln(\zeta_n / \zeta_0) \cong \sum_{k=0}^{k=n-1} \Delta\zeta_k / \zeta_k \quad \text{(“Log-Diff Approx.”)}$$

Equal Difference Sets

An *equal-difference* set is a discrete function $\{\beta_n\}$ where every pair of adjacent values, when ordered by n, has an equal difference; in other words, all differences are equal: $\Delta[\beta_n] = \Delta\beta_0$ for all n. Using the previous identities then gives:

$$\Delta^k[\beta_n] = 0 \text{ for } k > 1 \text{ and } <\Delta\beta_n> = \Delta\beta_0 \text{ and } \Delta[\beta_n * \beta_n] = 2<\beta_n>\Delta\beta_0 \text{ and } \beta_n = \tfrac{1}{2}(\beta_{n+1} + \beta_{n-1})$$

This last result shows that for an equal-difference set, each value is the average of both its neighbors in the sequence. When the first term in an equal-difference set is zero (called a 'zero-based, equal-difference set') then $\beta_0 = 0$. This has some attractive properties:

$$\beta_n = n\,\Delta\beta_0 = n\,\beta_1 \quad \text{and} \quad \Delta_2[\beta_{n-1}] = 4\,n\,(\beta_1)^2 \quad \text{and} \quad <\beta_n> = (n + \tfrac{1}{2})\,\beta_1$$

A zero-based, equal-difference set $\{\beta_n\}$ combined with a standard, discrete set $\{\alpha_n\}$ generates the following identities:

$$\Delta_2[\alpha_{n-1}\beta_{n-1}] = ((\alpha_{n+1} + \alpha_{n-1}) + n\,\Delta_2[\alpha_{n-1}])\,\beta_1 \quad \text{and} \quad \Delta[\alpha_n\beta_n] = ((n+1)\,\alpha_{n+1} - n\,\alpha_n)\,\beta_1$$

The zero-based, equal-difference set $\{\beta_n\}$ will be shown later to be a suitable representation for the electron's speed $\{V_n\}$. The inverse of the difference operator Δ is the discrete summation 'operator', designated by the conventional sigma Σ ; this leads to the useful identity:

$$\text{“\textbf{Sum-Diff}”} \qquad f_{n+1} = f_0 + \Sigma^n \Delta f_k \qquad \text{where the sum extends from } k = 0 \text{ up to n.}$$

Advanced & Retarded Differences

It is usual to progress through a set of discrete values in the ascending order of its identification index; i.e. $n \to n + 1$. Since the present EM theory is based on the central importance of time that is proposed to only produce interactions between pairs of electrons at certain finite times it appears logical to introduce the point-like discrete 'interaction' set $\{T_n\}$ that maps one-to-one with these critical time values. Accordingly, the index 'n' is defined in terms of this physical set of ascending time values that will be shown not to be equally spaced over time whenever this time set is used to characterize the sequence of interactions between any pair of electrons. The standard 'causal' viewpoint will be adopted here to define the normal flow of time from past to future and, anticipating the mapping of electron interactions, this normal flow will also be referred to as 'retarded', reflecting $F_{n-k} \to F_n$ where $k > 0$. The alternate viewpoint of progressing through an ordered list in descending order (i.e. $n \to n - 1$) is obviously mathematically equivalent and any physical result should only depend on the actual list of data values and not depend on the direction of processing the list. In mapping these ideas to physical reality, this alternative is described as 'the future impacting the past', or symbolically: $F_{n+k} \to F_n$; this 'direction of influence' is conventionally referred to as 'advanced' as the effect is advanced ahead of the cause (occurs first in time). The standard (or historical) convention is followed here with 'retarded' activity denoted by a minus and 'advanced' by a plus sign. This allows a global time symmetry to be introduced using the sign convention $\lambda = \pm$ or sometimes, $\lambda = \pm 1$.

Definitions: **Retarded.Diff** $\Delta^-[\zeta_n] \equiv \zeta_{n+1} - \zeta_n$ and **Advanced.Diff** $\Delta^+[\zeta_n] \equiv \zeta_{n-1} - \zeta_n$

Generically: $\Delta_k^\lambda[\zeta_n] \equiv \zeta_{n-\lambda k} - \zeta_n$ with $k > 0$ and $\lambda = \pm$. Obviously: $\Delta^- = \Delta = \Delta_1^-$

Finite Generator Definitions

There is another linear difference operator that can be defined, which is sometimes useful when working with finite difference sets, this is the 'generator' Γ that is related to the difference operator Δ ; it has both retarded and advanced versions.

Definitions: **Retarded.Gen** $\Gamma_k^-[\zeta_n] \equiv \zeta_{n+k}$ and **Advanced.Gen** $\Gamma_k^+[\zeta_n] \equiv \zeta_{n-k}$

Since the adjacent values are the default (k=1), the following convention will often be used: $\Gamma^{\lambda} = \Gamma_1^{\lambda}$. These definitions show that the relationship between the generator and the difference operators is independent of all n:

$$\Gamma_k^{\lambda} = 1 + \Delta_k^{\lambda} \quad \text{and} \quad \Gamma^{\lambda} = 1 + \Delta^{\lambda} \quad \text{while} \quad \Gamma_k^{\lambda} = (\Gamma^{\lambda})^k = (1 + \Delta^{\lambda})^k$$

The basic definitions also give the universal identity: $\zeta_m = \Gamma^{\lambda}_{\lambda(n-m)}\, \zeta_n$ for all n & m subject to $\lambda(n-m) \geq 1$.

The 'signed' generators are their mutual reciprocals: $\Gamma_k^{\lambda}\, \Gamma_k^{-\lambda} = 1$ or $(1+\Delta^{\lambda})^k (1+\Delta^{-\lambda})^k = 1$ for all $k > 0$.

Discrete Vector Functions

When several sets of discrete values (each with the same cardinality) can be ordered by the same unique identifier (i.e. n) they can be aggregated into an ordered superset, known as a discrete vector function, usually denoted here by an underlined symbol. This is only meaningful when the values across all these sets are homogenous, that is, mathematically of the same number type (e.g. integers, real-numbers, complex numbers, etc). Triple supersets may then represent 3D directed physical quantities, such as velocity or momentum. Each set is referred to as a component of the vector (superset). These component sets are usually labeled with superscripted identifiers, numbered 1 through 3, so that the superset can be manipulated as a single algebraic object. For example, let $\{A_n\}$, $\{B_n\}$ and $\{C_n\}$ be the components of the vector (superset) $\{\underline{F}_n\}$; so in terms of superscripted subsets, then:

$\{\underline{F}_n\} = \{ \{A_n\}, \{B_n\}, \{C_n\} \} = \{ \{F^1{}_n\}, \{F^2{}_n\}, \{F^3{}_n\} \}$ these can also be ordered in row and column (matrix) format.

The three components of a 3D spatial vector function can be mapped to a three component orthogonal abstract vector space defined by its three unit vectors $\{ \underline{\hat{e}}_1, \underline{\hat{e}}_2, \underline{\hat{e}}_3 \}$ where their (scalar) product is defined by: $\underline{\hat{e}}_j \bullet \underline{\hat{e}}_k = \delta_{jk}$ with j, k = 1, 2, 3.

So, isomorphically: $\underline{F}_n \Leftrightarrow F^1{}_n\, \underline{\hat{e}}_1 + F^2{}_n\, \underline{\hat{e}}_2 + F^3{}_n\, \underline{\hat{e}}_3 = \Sigma_n F^j{}_n\, \underline{\hat{e}}_j$

Periodic Discrete Functions

A discrete function set $\{F_n\}$ is *periodic*, with cycle κ, if every value has the same value as another member in the set when offset by the same difference identifier κ.

Definition: **Periodic Discrete Set** $\{F_n\}$ when $F_{n+\kappa} = F_n$ for all n where κ is a positive integer less than the cardinality.

Alternatively, this may be defined in terms of the discrete generator: $\Gamma_\kappa [F_n] = F_n$.

For example, the 'send' and 'receive' states of each electron form a periodic discrete function set of cycle 2 with values ± 1. Spatial periodic, discrete vector functions may have up to 3 distinct periods κ_j (with j = 1, 2, 3), so: $F^1{}_{n+\kappa 1} = F^1{}_n$ etc. The three cyclic values $\{\kappa_1, \kappa_2, \kappa_3\}$ can themselves form their own abstract 3 component 'frequency' vector $\underline{\kappa}$.

$$\underline{\kappa} \Leftrightarrow \kappa_1\, \underline{\hat{e}}_1 + \kappa_2\, \underline{\hat{e}}_2 + \kappa_3\, \underline{\hat{e}}_3 = \Sigma\ \kappa_j\, \underline{\hat{e}}_j$$

Creation and Destruction Operators

The 'signed' difference operators Δ^{λ} can be given a graphical representation that foreshadows their roles in the theory of electron interactions. Let $\{F_n\}$ denote a monotonically <u>increasing</u> piece-wise continuous discrete set. This set's positive difference will be used throughout so it will be given its own symbol here: $\varepsilon_{n+1} \equiv \Delta F_n \geq 0$ for all n. Another set $\{D^-{}_n\}$ may be defined here based on the normal (retarded) differences of the first set:

$$D^{-}_{n+1} \equiv \Delta^{-}[F_n] \qquad \text{this immediately leads to the isomorphism: } D^{-}_{n} \Leftrightarrow \varepsilon_n$$

The simple result: $F_n + \varepsilon_{n+1} = F_{n+1}$ can be represented diagrammatically:

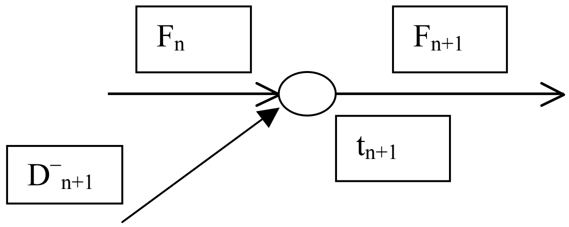

Fig. 3 Retarded Absorption.

So, letting ε_{n+1} represent a positive energy 'virtual particle' coming in from the past ($t_n < t_{n+1}$) then D^{-}_{n+1} can represent its absorption (or 'destruction') at time t_{n+1} in a standard (retarded) interaction by a real particle whose property F_n (or attribute) is increased by ΔF_n as a result of the interaction, which is here represented by the retarded difference operator Δ^{-} acting at the (n+1) interaction node.

A complementary view can be derived by defining another set $\{C^{+}_{n}\}$ here based on the advanced differences of the first set:

$$C^{+}_{n} \equiv -\Delta^{+}[F_n] \qquad \text{this immediately leads to the isomorphism: } C^{+}_{n} \Leftrightarrow \varepsilon_n$$

The simple result: $F_{n-1} + \varepsilon_n = F_n$ can be represented diagrammatically:

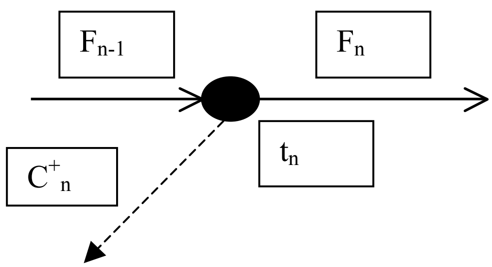

Fig. 4 Advanced Emission.

So here, if ε_n represents a positive energy 'virtual particle' going back into the past, then C^{+}_{n} represents its creation at time t_n in a 'reversed' or 'advanced' interaction represented now by Δ^{+}. Since all ε_n are positive then F_n can only increase its value (like energy) as time progresses if it either absorbs a positive-energy 'virtual particle' <u>from</u> the past (Δ^{-}) or emits such a 'particle' back <u>to</u> the past (Δ^{+}).

Additional 'advanced' insights may be gained from considering the 'complement' of the previous analysis. Let $\{G_n\}$ denote a monotonically <u>decreasing</u> piece-wise continuous discrete set. This set's positive difference will be used throughout so it will be given its own symbol here: $\varepsilon_{n+1} \equiv -\Delta F_n \geq 0$ for all n. Another set $\{C^{-}_{n}\}$ may be defined here based on the normal (retarded) differences of the first set:

$$C^{-}_{n} \equiv -\Delta^{-}[G_{n-1}] \qquad \text{this immediately leads to the isomorphism: } C^{-}_{n} \Leftrightarrow \varepsilon_n$$

The simple result: $G_{n-1} = G_n + C^{-}_{n}$ can be represented diagrammatically:

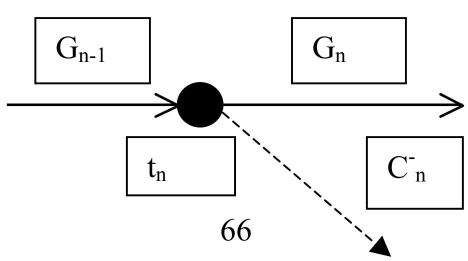

Fig. 5 Retarded Emission.

This diagram can be interpreted as representing a positive energy 'virtual particle' ε_n being created at time t_n in a standard (retarded) interaction represented by the retarded difference operator $\boldsymbol{\Delta}^-$ acting at the n^{th} interaction node.

The complementary view can be derived by defining another set $\{D^+_n\}$ based on the advanced differences of the first set:

$$D^+_{n+1} \equiv \boldsymbol{\Delta}^+[G_{n+1}] \qquad \text{this immediately leads to the isomorphism:} \quad D^+_n \Leftrightarrow \varepsilon_n$$

The simple result: $G_{n+1} + \varepsilon_{n+1} = G_n$ can be represented diagrammatically:

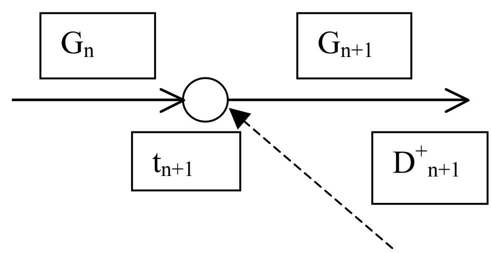

Fig. 6 Advanced Absorption.

Here, if ε_{n+1} represents a positive energy 'virtual particle' going backwards <u>into</u> the past then D^+_{n+1} represents its own 'destruction' (or absorption) in an advanced interaction, represented by $\boldsymbol{\Delta}^+$. Since all $\varepsilon_n > 0$ then G_n can only <u>decrease</u> its energy as time progresses normally if it either emits a positive energy 'virtual particle' into the future ($\boldsymbol{\Delta}^-$) or absorbs such a 'particle' coming from the future ($\boldsymbol{\Delta}^+$). In summary, the retarded and advanced 'diff' operator can represent four types of changes. The lesson here is that simple point-like changes in an electron's attributes (such as momentum or energy) may be represented by simple arithmetic differences or the exchange of 'virtual particles', which should therefore only be seen as visual or calculational aides and **not** as representing ontological primitives.

$\boldsymbol{\Delta}^-[F_{n-1}] = \lambda\, \varepsilon_n$ represents both <u>retarded</u> destruction ($\lambda = +1$) or retarded creation ($\lambda = -1$).

$\boldsymbol{\Delta}^+[F_{n+1}] = \lambda\, \varepsilon_{n+1}$ represents both <u>advanced</u> destruction ($\lambda = +1$) or advanced creation ($\lambda = -1$).

5.3.2 ENHANCED FINITE DIFFERENCES

Point Finite Differences

The value of a piecewise, **discontinuous** function $\{F_n[t]\}$ changes discontinuously at each of its 'interaction' or 'transition' points. In the limit of small variations δt around any 'interaction' point (say T_n) the value of the function goes suddenly from $F[T_n - \delta t]$ to $F[T_n + \delta t]$ at T_n. In order to describe this 'instantaneous' change, the following symmetric notation will be introduced.

Definitions **Above.Value**: $F[T_n + \delta t] \equiv F_n^+ = F[T_n] = F_n$ & **Below.Value**: $F[T_n - \delta t] \equiv F_n^-$

These definitions may be combined into the definition of a '**point-difference**' that is represented by a new, linear finite difference operator, colloquially referred to as the **diff-dot** operator, written long-hand as a delta surrounding a dot or as ◊.

Definition **Point-Difference** (diff-dot) $◊F_{n-1} \equiv F_n^+ - F_n^- = F[T_n + \delta t] - F[T_n - \delta t]$ N.B. **not** $◊F_n$

If, and only if, the piecewise functions are constant throughout their intervals then: $F[T_{n-1} + \delta t] = F[T_n - \delta t] = F_{n-1}$ then:

$$◊F_{n-1} = F_n - F_{n-1} = \Delta^-[F_{n-1}] \quad \text{or} \quad ◊ = \Delta$$

The purpose of introducing this operator is to isolate the possible discontinuities around the interaction points from the rest of the smooth (or analytic) region between such points. The changes occurring in the remaining interval will be handled by another discrete difference operator that will be defined next.

If, and only if, the piecewise functions are continuous over their whole range then: $F_n^+ = F_n^-$ so: $◊F_n = 0$.

Thus, for the 'time' function itself: $t[\,t\,] = t$ then: $◊t = (t + \delta t) - (t - \delta t) = 2\,\delta t$. In the 'infinitesimal limit' $\delta t \to 0$.

The one-dimensional 'free particle' location function (see section 5.3.1) $z_0[\,t\,] = Z_0 + u_0\,(t - T_0)$ is continuous throughout its range, so:

$$◊z_0 = ◊z_0[\,t = T_n] = z_0[T_n + \delta t] - z_0[T_n - \delta t] = 2\,u_0\,\delta t \quad \therefore\ ◊z_0 = u_0\,◊t \quad \text{or} \quad ◊z_0[\,t\,] = u_0\,◊t$$

If this new point-difference operator is applied to the continuous, piecewise, regular function $X[t]$ introduced in section 5.3.1 that was used to describe the dynamics of a classical particle, no longer subject to continuous forces but now only subject to a series of irregular impulses applied at the interactions times T_n then within each segment the value of the function is no longer constant but increases linearly with time, so:

$$X_n[t] = X_n + u_n\,(t - T_n) \quad \text{then:} \quad ◊t = 2\,\delta t \ \text{ and } ◊T_n = 2\,\delta t$$

$$◊X_{n-1}[t = T_n] = X[T_n + \delta t] - X[T_n - \delta t] = (X_n + u_n\,\delta t) - (X_n + u_{n-1}\,\delta t) = (u_n + u_{n-1})\,\delta t = ½\,(u_n + u_{n-1})\,2\delta t = \langle u_{n-1} \rangle\,◊T_n$$

This demonstrates that the classical 'point' definition: $dX[t]/dt = u[t]$ corresponds now to: $◊X_n / ◊T_n = \langle u_n \rangle$.

Extended Finite Differences

In any continuous interval $(T_n\,;\,T_{n+1})$ for any value of the time parameter t it is possible to define the '**extended-difference**' $\underline{\Delta}F[t]$ in terms of the corresponding **diff-dash** operator, written as an underlined delta $\underline{\Delta}$ (the underline symbolizing extent).

Definition **Extended-Difference**: $\underline{\Delta}F_{n-1} \equiv F[T_n - \delta t] - F[T_{n-1} + \delta t] \equiv \underline{\Delta}[\,F[T_{n-1}]\,]$ N.B. **not** $\underline{\Delta}F_n$.

The purpose of this definition is to move disjointly through a set of discrete function values from *just beyond* the last interaction point, where there may have been a discontinuous change in the value of the function, to *just before* the next interaction point, where again there may have been another discontinuous change. The definition of 'interaction points' means that there can be no discontinuous change during this interval. This definition deliberately excludes the critical regions around each interaction point. The result of the application of this extended-difference operator to a piece-wise discontinuous discrete function F[t] is analytic as long as the temporal parameter t is outside the '**proximity**' of each interaction point T_n, where the proximity is defined as the temporal interval: $(T_n - \delta t/2) < t < (T_n + \delta t/2)$.

Thus, for the 'time' function itself: t[t] = t then: $\underline{\Delta}T_{n-1} = (T_n - \delta t) - (T_{n-1} + \delta t) = \Delta T_{n-1} - 2\,\delta t \;\; \therefore \;\; \Delta T_n = \underline{\Delta}T_n + \lozenge T_n$

The one-dimensional 'free particle' location function (see section 5.3.1) is continuous throughout its range, where:

$$z_0[\,t\,] = Z_0 + u_0\,(t - T_0)$$

$$\lozenge z_0 = \lozenge z_0[\,t = T_n] = z_0[T_n + \delta t] - z_0[T_n - \delta t] = 2\,u_0\,\delta t \quad \therefore \; \lozenge z_0 = u_0 \lozenge t \quad \text{or} \quad \lozenge z_0[\,t\,] = u_0 \lozenge t$$

If this new extended-difference operator is applied to the continuous, piecewise, regular function X[t] introduced in section 5.3.1 that was used to describe the dynamics of a **classical particle**, not subject to continuous forces, but *only subject to a series of irregular impulses* applied at the interactions times T_n then within each segment the value of the function is no longer constant but increases linearly with time, so: $X_n[t] = X_n + u_n\,(t - T_n)$ then:

$$\underline{\Delta}X_{n-1}[t = T_{n-1}] = X[T_n - \delta t] - X[T_{n-1} + \delta t] = (X_n - u_n\,\delta t) - (X_{n-1} + u_{n-1}\,\delta t) = (X_n - X_{n-1}) - (u_n + u_{n-1})\,\delta t = \Delta X_{n-1} - < u_{n-1} > \lozenge t$$

$$\therefore \; \Delta X_n = \underline{\Delta}X_n + < u_n > \lozenge T_n = \underline{\Delta}X_n + \lozenge X_n \qquad \therefore \; \mathbf{\Delta}[X_n] = \underline{\mathbf{\Delta}}[X_n] + \lozenge[X_n]$$

These three results suggest that, in general, the difference operator can be separated into two components: $\therefore \; \mathbf{\Delta} = \underline{\mathbf{\Delta}} + \lozenge$

Electron Interaction Times

The present model of the electron includes the *Chronon Proposition*, whereby any one electron **may** only interact with one other electron when each electron's time is an integral multiple of the universal interval of time: the *chronon* τ. This allows an integer label 'μ' (for *micro*-time) to be associated with every **possible** interaction time, in other words: $t_\mu = \mu\,\tau$. This hypothesis imposes a regular microstructure on the continuous concept of time that is assumed to underlie all of reality. It is this discrete **micro-time** t_μ in the present theory that corresponds the closest to the traditional concept of **continuous** time.

Combined Finite Differences

Let the ordered set $\{F_n[t]\}$ represent a piecewise, discontinuous discrete function F[t] whose value changes discretely at N 'interaction points' T_n. A finite time duration τ is introduced that is smaller than any of the adjacent temporal differences such that each difference is an integer multiple η_n of this smallest difference; in other words, $\Delta T_n = T_{n+1} - T_n = \eta_n\,\tau$ where η_n is a positive integer. If the *equally* spaced time values t_μ are defined to be commensurate with integer multiples of the fundamental time duration τ (that is: $t_\mu = \mu\,\tau$) then F[t] is also a **regular**, piecewise, discontinuous, discrete function.

$$F[T_{n+1} + \delta t)] = (F[T_{n+1} + \delta t] - F[T_{n+1} - \delta t]) + (F[T_{n+1} - \delta t] - F[T_n + \delta t]) + F[T_n + \delta t] = \lozenge F_n + \underline{\Delta}F_n + F[T_n + \delta t]$$

$$\mathbf{\Delta}[F_n] = \Delta F_n = F_{n+1} - F_n = F_{n+1}^{+} - F_n^{+} = F[T_{n+1} + \delta t] - F[T_n + \delta t] = \lozenge F_n + \underline{\Delta}F_n \qquad \therefore \; \mathbf{\Delta} = \underline{\mathbf{\Delta}} + \lozenge$$

The first result is consistent with the standard definition of the finite difference operator; here it is used to calculate the real difference between any time δt after an 'interaction event' at time T_n to a similar time interval after the next interaction event at T_{n+1} , where a discontinuous change in the operand's value may have occurred.

This last result, that the application of the difference operator is equivalent to the application of the point-difference operator and the extended-difference operator (colloquially: diff = diff.dot plus diff.dash) means that the finite difference calculus, as developed here, can be applied to regular, piece-wise discontinuous discrete functions. This is the necessary mathematical step to extend Newtonian mechanics to asynchronous, discrete interactions, where the time intervals between interactions are <u>both finite and no longer identical</u>. It is this last feature that prevents the use of the infinitesimal limit and the reduction to continuous classical mechanics. In the next section, this discontinuous irregularity will be seen to provide an explanation of the results of relativistic mechanics and avoid the bizarre results of special relativity, which requires that space and time must both change their historical invariant characteristics.

Each of the extended-difference operators can be applied consecutively; in either case, the result is simply: $\underline{\boldsymbol{\Delta}}\Diamond = \Diamond\underline{\boldsymbol{\Delta}} = -1$

Proof: (A similar proof holds for $\underline{\boldsymbol{\Delta}}\Diamond F_{n-1}$)

$$\Diamond\underline{\boldsymbol{\Delta}}\,[F[T_{n-1} + \delta t] = \Diamond\underline{\boldsymbol{\Delta}}\,F_{n-1} = \Diamond[\,F[T_n - \delta t] - F[T_{n-1} + \delta t]\,] = \Diamond F_{n-1} - \Diamond[\,F[T_{n-1} + \delta t]\,]$$

$$= \Diamond F_{n-1} - (\boldsymbol{\Delta} - \underline{\boldsymbol{\Delta}})[\,F[T_{n-1} + \delta t]\,] = \Diamond F_{n-1} - \boldsymbol{\Delta}[\,F[T_{n-1} + \delta t]\,] + \underline{\boldsymbol{\Delta}}F_{n-1} = \Diamond F_{n-1} + \underline{\boldsymbol{\Delta}}F_{n-1} - F[T_n + \delta t]$$

$$= (F[T_n + \delta t] - F[T_n - \delta t]) + (F[T_n - \delta t] - F[T_{n-1} + \delta t]) - F[T_n + \delta t] = -F[T_{n-1} + \delta t] \qquad \therefore\ \Diamond\underline{\boldsymbol{\Delta}} = -1$$

Enhanced Advanced & Retarded Differences

Just as it was possible to introduce so-called 'advanced' and 'retarded' distinctions for the standard definition of the finite difference operator, with the default always defining the retarded operator (i.e. $\boldsymbol{\Delta} = \boldsymbol{\Delta}^{-}$), a similar set of extensions can be defined for the component difference operators $\underline{\boldsymbol{\Delta}}$ and $\Diamond$; the lambda convention will continue to be used: $\lambda = \pm$ or $\lambda = \pm 1$.

Definitions: **Advanced.Point.Diff** $\Diamond^{+}[F_n] \equiv F[T_n - \delta t] - F[T_n + \delta t] = F_n^{-} - F_n^{+}$ N.B. Advanced is $\Diamond F_n$

Definitions: **Advanced.Extended.Diff** $\underline{\boldsymbol{\Delta}}^{+}[F_n] \equiv F[T_{n-1} + \delta t] - F[T_n - \delta t] = \underline{\boldsymbol{\Delta}}[\,F[T_n]\,]$

These advanced component versions are related to the previous retarded definitions by:

$$\Diamond^{+}[F_n] = -\Diamond^{-}[F_{n-1}] \qquad \text{and} \qquad \underline{\boldsymbol{\Delta}}^{+}[F_n] = -\underline{\boldsymbol{\Delta}}^{-}[F_{n-1}]$$

These new definitions only reverse the sign and decrement the index n by one; this preserves the identity:

$$\boldsymbol{\Delta}^{\lambda} = \underline{\boldsymbol{\Delta}}^{\lambda} + \Diamond^{\lambda}\ .$$

5.4 DISCRETE CLASSICAL PHYSICS

Below Classical Limits

In this theory it is recognized that quantum effects become dominant at atomic distances, where one standard atomic length is formally defined here as 10^{-8} cm or 1/10 of a nanometer. Classical physics will be defined here as situations that involve inter-electron separations exceeding 100 nm between pairs of electrons, while the intermediate length scale will be referred to as *mesoscopic*, about the lowest scale (middle-scale) that classical EM can be expected to apply. The mesoscopic domain will always be expected to also apply when interactions involving over 100 electrons are involved even if they are below this spatial separation. It is important to remember that optical wavelengths are in the range 400 to 700 nm, so mesoscopic phenomena will never be directly observable to human beings without the use of additional technology. Even extreme ultra-violet light involves wavelengths above 50 nm. Interestingly, today's advanced technology enables scientists to experiment with very small structures, like quantum dots (30 nm or 300 atoms wide) or carbon nanotubes with diameters of about one nanometer (10 atoms) that allow single electrons to flow readily through these tubes. Operationally, the classical arena may be defined as the range of interactions that are not significantly affected by human measurements (no qualitative changes).

Electron Trajectories

The new theory views electrons as real entities – that is, individual objects with ongoing existence throughout time. Further, each electron is viewed as a point particle with a unique location in space at all times – an electron must be at one and only one place in 3D space at every single instant in time. These metaphysical assumptions imply that as universal time evolves each electron may move to a 'nearby' location. The set of locations for each electron over any finite time interval defines its trajectory, which is continuous over space. Thus, at any time t, an electron, arbitrarily labeled α, exists at a unique point in space, which is therefore labeled here as $\underline{x}[\alpha: t]$ and then moves to a nearby location $\underline{x}[\alpha: t + \delta t]$ in a small positive time δt. This subsequent location, in the limit as δt becomes a very small positive value, will be labeled $\underline{x}^+[\alpha: t]$. Similarly, the prior location in space $\underline{x}^-[\alpha: t]$, where the electron was located just before at time (t – δt); these are defined mathematically as:

$$\underline{x}^+[\alpha: t] = \underset{\delta t \to 0}{\text{Limit}} \{ \underline{x}[\alpha: t + \delta t] \} \qquad \underline{x}^-[\alpha: t] = \underset{\delta t \to 0}{\text{Limit}} \{ \underline{x}[\alpha: t - \delta t] \}$$

The mathematical statement that corresponds to the metaphysical idea that each electron exists at all times, known here as the *Existence Principle*, is:

$$\underline{x}^+[\alpha: t] = \underline{x}^-[\alpha: t] = \underline{x}[\alpha: t] \qquad \text{for all } \alpha \text{ and all } t.$$

5.4.1 SINGLE ELECTRON KINEMATICS

Electron Velocity

Two adjacent locations, that are each **potential** interaction points, on a given electron's trajectory are separated by the shortest finite difference, labeled as $\Delta_0\underline{x}[\alpha: t]$ that are separated by only one chronon in time; this spatial difference is defined as:

$$\Delta_0\underline{x}[\alpha: t_\mu] \equiv \underline{x}[\alpha: t_{\mu+1}] - \underline{x}[\alpha: t_\mu] \quad \text{where:} \quad t_{\mu+1} - t_\mu = \tau$$

This can be also defined in terms of the smallest linear difference operator $\mathbf{\Delta}_0$ (the electron's label α will also be dropped):

$$\underline{x}[t_{\mu+1}] = (1 + \mathbf{\Delta}_0) \, \underline{x}[t_\mu]$$

$$\text{Since} \quad t_\mu = t_0 + \mu\,\tau \quad \text{then:} \qquad \Delta_0 t_\mu = \mathbf{\Delta}_0 t_\mu = (t_0 + (\mu + 1)\tau) - (t_0 + \mu\,\tau) = \tau$$

The present model follows Newton's First Law of Motion, in that it is assumed that an electron moves in a straight line through space between consecutive interaction times; this allows an electron's *local-velocity* to be defined:

$$\text{Definition: Electron } \alpha\text{'s } \textbf{Local.Velocity} \;\; \underline{v}[\alpha: t_\mu] \equiv \Delta_0\underline{x}[\alpha: t_\mu] / \Delta_0 t_\mu \qquad \Delta_0\underline{x}_\mu = \tau\,\underline{v}_\mu$$

The temporal origin, in any reference frame, corresponds to a particular selection of t_0. The most convenient notation is the choice for the origin of μ = 0, allowing the universal set of possible interaction points to be defined by $t_\mu = \mu\,\tau$ with the index 'μ' taking on all integer values: positive, negative and zero.

It is therefore plausible to assume that the trajectory of the electron, labeled α, can be represented by the regular piecewise continuous discrete function $\underline{x}[\alpha: t]$ whose value changes discretely at N 'interaction points' T_n. ; in other words, by the discrete set $\{\underline{x}_n[\alpha: t]\}$. At any single interaction time T_n each electron α is only involved in one interaction with one other electron β (α ≠ β) whose corresponding interaction time is $T_{n'}$ when it is located at the spatial position $\underline{x}[\beta: T_{n'}]$. The two sets of values are constrained by the 'light-cone' condition (5.2.4):

$$(\underline{x}[\alpha: T_n] - \underline{x}[\beta: T_{n'}]) \bullet (\underline{x}[\alpha: T_n] - \underline{x}[\beta: T_{n'}]) = c^2 (T_n - T_{n'})^2$$

In terms of the *point-difference* operator introduced in section 5.4.2 and the continuity conditions imposed on both time and at each point on every electron's trajectory, while imposing the '**smallness condition**' δt << τ, then for both:

$$\Diamond t_\mu = 0 \text{ and } \Diamond T_n = 0 \quad \text{plus} \quad \Diamond\underline{x}[\alpha: t_\mu] = 0 \text{ and } \Diamond\underline{x}[\alpha: T_n] = 0 \quad \text{with} \quad \Delta_0\underline{x}[\alpha: t_\mu] = \tau\,\underline{v}[\alpha: t_\mu]$$

The finite time duration τ was introduced so that it would never be larger than any of the adjacent **interaction** differences where each difference is an integer multiple η_n of this smallest difference; in other words, $\Delta T_n = T_{n+1} - T_n = \eta_n\,\tau$ where η_n is a positive integer. It is the interaction time difference ΔT_n, which when combined with the above 'smallness condition' , that defines the range of the *extended-difference* operator $\underline{\mathbf{\Delta}}$.

$$\underline{\Delta}T_n = T_{n+1} - T_n = \mathbf{\Delta}[T_n] = \eta_n \tau \quad \text{and} \quad \underline{\Delta x}_n = \underline{x}_{n+1} - \underline{x}_n = \mathbf{\Delta}[\underline{x}_n] = \mathbf{\Delta}[\, \underline{x}[\alpha : T_n]\,]$$

These ‘extended’ (or interaction) differences allow the electron’s *extended-velocity* $\underline{V}_n$ to be defined:

Definition: Electron α’s **Extended.Velocity** $\underline{V}[\alpha: T_n] \equiv \mathbf{\Delta}[\underline{x}[\alpha : T_n]\,] \,/\, \Delta T_n$ $\qquad \Delta\underline{x}_n = \Delta T_n \, \underline{V}_n$

The application of Newton’s First Law of Motion, here applied from T_n to just before T_{n+1} , means that the electron retains its local-velocity across the whole time interval, as (by design) there can be no further interaction in this range; in other words:

$$\underline{V}[\alpha: T_n] = \underline{v}[\alpha: t_\mu] \quad \text{where, for all } \mu \text{ such that:} \quad T_n \le t_\mu < T_{n+1}$$

Since there is no difference in the numeric value of these two definitions of an electron’s velocity then it is reasonable to omit the two qualifying prefixes and just refer to the electron’s **velocity** $\underline{V}_n$ defined from T_n to just before T_{n+1}.

If the ‘clock-time’ T_n corresponds to an actual number μ_n of ‘ticks’ (or chronons) then: $T_n = \mu_n \tau$ and $\eta_n = \mu_{n+1} - \mu_n$. In these equations, the index ‘n’ refers to the number of **actual** consecutive interactions, while μ_n refers to the number of **possible** interactions at the same time, T_n. This shows that Aristotle’s distinction between actual and potential in the real world was significant.

5.4.2 DISCRETE VELOCITY CHANGES

Electron Acceleration

Only in the theoretical world of a single particle is it possible for the electron to maintain its constant velocity. In the real world of physics, electrons interact with one another and the evidence for this is that their velocities change as a result of their mutual interactions. The focus here is on when an electron participates in an interaction. The previous paper [4] concluded that there could be **no** continuous interactions involving inertial particles. This implies that only instantaneous changes in the velocity of an inertial particle are possible, as changes over even small but finite durations would conflict with this result. In this section, the focus remains on the motion of a single particle, subject to a series of successive distinct interactions from other electrons; in particular, attention is focused on a specific interaction event at time T_n and its prior and successor events T_{n-1} and T_{n+1}. As above, the electron’s velocity in each of these time intervals is defined by:

$$\underline{V}_n = \underline{V}^+_n = \underline{V}[T_n + \tau / 2] = \underline{V}[T_n] = \Delta_0\underline{x}[\, t_\mu \,] / \Delta_0 t_\mu \quad \text{where, for all k such that:} \quad T_n \le t_\mu < T_{n+1}$$

The definition of T_n means that the electron’s velocity changes *discontinuously* from $\underline{V}_{n-1}$ to $\underline{V}_n$ (from $\underline{V}^-_n$ to $\underline{V}^+_n$) **exactly** at time T_n. This may be visualized graphically:

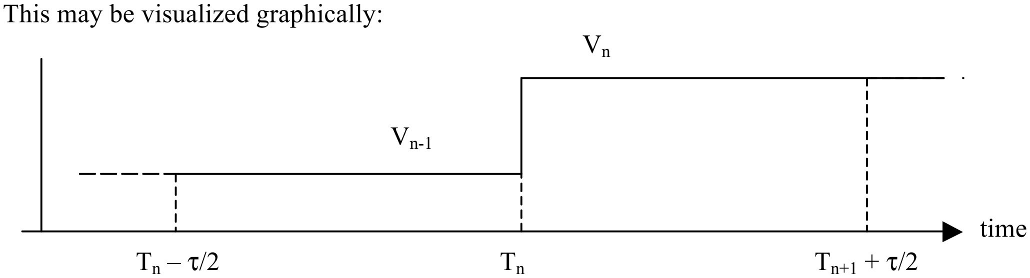

Fig. 7 Discontinuous Velocity Change.

The *instantaneous* change in velocity at T_n is represented mathematically by the point-difference operator $\Diamond$ (defined in section 5.4.2) and which is applied to the discontinuous, piecewise vector representation of the electron’s velocity $\{\underline{V}_n\}$.

$$\Diamond\underline{V}_n = \underline{V}_{n+1} - \underline{V}_n = \mathbf{\Delta}^-[\underline{V}_n] \quad \text{with} \quad \mathbf{\Delta}\underline{V}_n = \Diamond\underline{V}_n \quad \text{as} \quad \underline{\mathbf{\Delta}}\, \underline{V}_n = 0$$

This is now the replacement for the concept of acceleration; here there are only discontinuous changes in velocity.

This formulation is consistent with the continuous, piecewise discrete location function X[t] (introduced in section 5.4.1); that is to say, the electron's 3D spatial location over time is described by the mathematical representation:

$$\underline{X}[\,t\,] \equiv \Sigma_n \underline{X}_n[\,t\,]\,\Theta_n[\,t\,] \quad \text{where} \quad \underline{X}_n[\,t\,] = \underline{X}_n + \underline{V}_n\,(t - T_n)$$

So, although an electron's location is continuous over time, its velocity is discontinuous at its interaction points.

5.4.3 NEWTONIAN PHYSICS

History of Newton's Dynamics

The key ideas in the *Principia* were first described four years earlier in his own seminal work *De Motu Corporum in Gyrum* ('On the Motion of Bodies in Orbits'). Newton's first attempt at the parallelogram of forces began incorrectly with trying to compound simultaneously the 'force' of inertia and an externally impressed force. It was not until the second edition of the *Principia* (1713) that Newton correctly compounded the resulting velocities (reflecting the real unitary nature of a particle) rather than the causative forces. *De Motu*'s Theorem I (which became *Principia*'s Proposition I) treated force as a series of discrete impulses occurring at *equal* time intervals [154].

All of Newton's published work on dynamics was based on the private research he conducted during 1664 and 1665 when he invented fluxions (time derivatives) and continuous quadratures (integration). This work was never published in his own lifetime as he regarded these techniques as being too controversial; they were also his 'secret weapons' [155]. Conceptually, Newton's ideas on dynamics drew on DesCartes' concept of mechanical impulse, loosely referred to as "the force of any particle's motion" and observed as the change in a body's momentum during instantaneous, elastic collisions. Newton's key insight (which resulted in Law II) was "so much force is required to destroy any quantity of motion in a body (momentum), so much is required to generate it." Similarly, his Third Law of Motion (III) was also derived from his own study of elastic collisions between two particles. Newton's dynamics was centered on his key concept of interaction or 'force', in contrast with Leibniz's focus on the idea of kinetic energy. His dynamical studies led him to conclude that only two forms of a force-law were compatible with the existence of elliptical orbits, which Kepler had shown to characterize planetary motion, rather than the perfect circular motion of all earlier Greek thought. Algebraically, these corresponded to forces proportional to the linear separation (kR) or to its inverse distance (K/R^2) between the Sun and the planet. Since Newton treated gravity as instantaneous, rather than delayed, he only calculated half of the observed rate of the moon's elliptical precession [156].

Newton's Views on Momentum

The heart of Newton's dynamics was centered on his concept of '*mass*' (that he viewed as a bounded, continuous property of matter), which was subject to both the inertial resistance of externally impressed forces (i.e. external impulses) and was the cause of impulsive impacts when colliding with other particles. This concept was introduced right at the beginning of his *Principia* as "the quantity of matter" so that he could define his central concept of '*momentum*' as the "quantity of motion". This key definition was associated with a material body through the equivalent algebraic definition of "the product of the body's velocity and the quantity of matter." Implicit in his use of the term 'velocity' is a standard, inertial reference frame associated with (to Newton) the distant stars as Newton discussed in the following *Scholium* [157], where Newton defined absolute motion (momentum) as the translation of a body from one absolute place to a different absolute place in finite time. Here Newton is indicating that the essence of real motion is independent of the motion of any observer or person conducting any possible measurements. As a Deist, Newton viewed reality as defined by his unitary god, who was the only observer that mattered in his universe.

Newton's Views on Force

Newton made four explicit assumptions (stated verbally, not mathematically) when he introduced one of his primary concepts in the *Principia* [3], which in Latin he called *vis* and is usually translated in English as 'force'.

1. Forces generate continuous changes in motion (Definition VII); i.e. acceleration is continuous, $\underline{a} = \mathrm{Lim}\{\Delta\underline{v}/\Delta t\}$.
2. Forces can be represented by vectors that are additive (Corollary I); $\underline{F}$ equals $\underline{f}_1$ **and** $\underline{f}_2$ $\therefore$ $\underline{F}[t] = \underline{f}_1[t] + \underline{f}_2[t]$.
3. Action and reaction are equal but opposite forces (Law III); $\underline{F}_{12}[t_1] = -\underline{F}_{21}[t_2]$ and $t_2 = t_1$.

4. Forces between pairs of interacting bodies act along their line of centers-of-gravity (Corollary IV).

Each of these assumptions is 'valid' or accurate enough for macroscopic objects, like planets moving under the gravitational influence of a very large body (like the Sun), so that astronomy remains 'classical'. The new theory challenges each of these assumptions at the microscopic level of electrons that only involve the electromagnetic interaction; in particular:

1. The continuum limit in the time dimension has a finite, minimum value, the *chronon* τ; $\Delta t \to \tau \neq 0$.
2. Electromagnetic interactions (or impulses $\underline{I}$) are saturated; $\underline{I}$ equals $\underline{I}_1$ **or** $\underline{I}_2$ $\therefore$ $\underline{I}(t) = \underline{I}_1[t]$ OR $\underline{I}_2[t]$.
3. Electromagnetic impulses do not propagate instantly across time; $\underline{\mathbf{I}}_{12}[t_1] = -\underline{\mathbf{I}}_{21}[t_2]$ & $t_2 = t_1 + n\,\tau$ with $n \neq 0$.
4. Electromagnetic impulses (the 'Heaviside force') do not act simply along the line of centers.

Interpreting Newton's Laws of Motion

There are valuable insights to be gained from contrasting the interpretations of Newton's Laws of Motion by a great 19th century natural philosopher, like Maxwell and a famous, modern mathematical physicist like S. Chandrasekhar (1910-1995). Maxwell summarized his life-long obsession with Newton when he wrote *Matter and Motion* [158]. Chandrasekhar also wrote his ironically misnamed study [159] near the end of his own life. Both commentators used the first version in English that was translated by Andrew Motte [3] in 1729, only three years after the publication of the heavily revised 3rd edition, where Newton still used minimal algebra and absolutely no calculus. In reviewing the three laws (that were presented by Newton only in words), Maxwell gives a greater emphasis on the concept of 'force', illustrating it with our intuitions of gravity and elastic strings. Both authors recognize that Law II is a self-referencing definition of mass and force. Newton had only provided a circular definition of mass (Definition I) in terms of its density and volume, while his definition of force (Definition IV) implied that is an interaction with another body. Only Maxwell pointed out that Newton never defined the concept of 'body' although it could apply to a 'mass-point'.

Unlike Newton, Maxwell also defined the 'center-of-mass' (CM) for a collection of mass-points forming an extended material structure but he implicitly assumed that this definition occurs at one instant of time across the whole structure. He also invoked Law III to claim that the motion of the CM is not affected by the mutual interactions of the component parts while still implicitly using the single-time idea for the total body. Chandrasekhar just followed Motte's translation, retaining the word 'force' in Law II while subtly replacing the word 'alteration' in Motte's phrase "alteration of motion" with the word 'change' so that he can smuggle in the critical phrase "differential change" to produce the popular form of Law II as 'force equals mass times acceleration'. Neither author ever remarks that Newton is always talking about **one single instant of time** – an idea that is only valid for instantaneous forces. Although Newton very carefully introduced his key concept of 'momentum' Motte just used the ambiguous word 'motion'. Again, Motte's translation of Law III was careless in its use of the word 'action' now defined as "equal and opposite in direction to reaction'. Newton (who was very careful with words, as befits a philosopher) did not define either 'reaction' or 'action' in this context. Again, each of these famous scientists failed to make explicit that all of this activity is occurring only at a single instant of time, even when the two interacting bodies are separated remotely in space. In other words, all assume instantaneous interactions: $\Delta\underline{P}_1[t] = -\Delta\underline{P}_2[t]$. Since Newton was only interested in point-collisions between two particles or instantaneous forces across neighboring bodies (i.e. gravity), this view was quite adequate for his purposes. Maxwell had defined mechanical 'work' as "the act of producing a change of configuration in a system in opposition to a force that resists that change." He goes on to define 'energy' simply as "the capacity to do work": a possibility and not an actual attribute. In a critical footnote, Maxwell smuggled in the idea that energy is an ontological primitive when he wrote that: "The idea of work implies a fund of energy [like gold coins!], from which the work is supplied." In contrast, Newton implicitly defined 'power' (or the instantaneous rate of change of mechanical work) in the *Scholium* as "force and velocity conjunctly" without any suggestion that work or energy were independent entities – the position taken by his rival, Leibniz and, ironically, by Maxwell (a great admirer of Newton).

Maxwell's Recognition of Newton's Impulse

Maxwell's views on physics were strongly influenced by his education at Edinburgh and Cambridge universities, where the Newtonian approach was vigorously promoted as the 'British' way of natural philosophy, in contrast with Lagrange's more mathematical approach, that was viewed as more in the 'Continental' tradition of DesCartes and Leibniz. Maxwell always viewed the concept of momentum as central to Newton's Laws of Motion, so most importantly to the current EM theory, Maxwell presents Newton's Second Law (II) as: "The change of momentum of a body is numerically equal to the **impulse** which produces it, and is in the same direction" or mathematically: $\Delta\underline{\mathbf{I}} \to \Delta\underline{P}$; it is only in the limit of continuous change (that is, $\Delta t \to 0$) that this becomes the standard force law as $\Delta\underline{\mathbf{I}}[t] = \underline{F}[t]\,\Delta t$. Since this interpretation can also be used for finite differences and, more importantly, as this research programme universally rejects the Continuum Hypothesis, then this will be the approach adopted here, instead of the continuum-based approaches of Lagrange or Hamilton that now dominate modern physics. In his development of particle dynamics [3], Newton first focused on the *discontinuous* change in momentum $\underline{P}$, which he had previously defined as the product of the particle's mass m and the particle's velocity $\underline{V}$ at any time. This perspective indicates that Newton ultimately viewed a particle's velocity to be discontinuous – the position taken by this research programme. So, Newton's original concept of discrete 'impulse' $\Delta\underline{I}$ as the **cause** of change in momentum $\Delta\underline{P}$, both at the same time, say T_n, now becomes $\Delta\underline{I}[T_n] \rightarrow \Delta\underline{P}[T_n]$. The corresponding discrete view is now:

$$\Delta\underline{I}_n = m\, \Diamond\underline{V}_{n-1} \quad \text{where} \quad \underline{V}_n = \Delta\underline{X}_n / \Delta T_n \qquad \text{with continuous solutions:} \quad \underline{X}_n[t] = \underline{X}_n + (t - T_n)\,\underline{V}_n$$

5.4.4 RECOVERING NEWTONIAN DYNAMICS

Only the Temporal Derivative

In the present discrete theory, all physical changes are attributed to time alone. Unlike all types of continuum theories, such as Maxwell's æther theory or its modern equivalent using Helmholtz's continuous 'charge-density', there is no significance to purely spatial variations, where the medium (or density flux) flows over the 'field point' or the target point moves to an infinitesimally nearby spatial point where the field variables are slightly different. In other words, there is no longer any need in this theory for Maxwell's 'nabla' (or 3D vector differential operator ∇) or even the partial time derivative ($\partial/\partial t$) since all change is now due completely to finite changes in time. As a result, it will be impossible to recover the so-called Maxwell Equations in the present theory of electromagnetism. This was **never** the objective of this new EM theory.

If the idea of the finite nature of durations of time (i.e. the *chronon*, τ) is found to be a fundamental characteristic of nature then both Zeno (and most mathematicians) will have to give up on the contrasting idea that time can be continually divided without limit. However, for every continuous function of time A[t], it is always possible to define, at *any* time, a finite difference between any two values that are separated by a standard, temporal duration of one chronon τ. The long-standing infinitesimal definition of the time derivative (d/dt) can be recovered from this discrete, temporal difference operator in the limit that the chronon becomes infinitesimally small. This suggests an 'open-dot' notation for such finite differences, to distinguish this approach from the infinitesimal time differences introduced by Newton in his 'theory of fluxions'.

$$\mathring{A}[t] \equiv \{ A[t + \tau/2] - A[t - \tau/2] \} / \tau \qquad \text{Compared with} \qquad dA[t]/dt = \lim_{\tau \to 0} \{ \mathring{A}[t] \} = \lim_{\tau \to 0} \{ \underline{\Delta}A[t] / \tau \}$$

So, for instantaneous actions, where the Heaviside 'unit' (step) function $\theta(t)$ is defined as zero when t is negative and one otherwise, the 'point-difference' is well defined as '$1/\tau$' while the continuous derivative becomes Dirac's delta 'function' $\delta[t]$, which is actually a mathematical distribution, not a well-defined function.

In order to retain the distinction of the new definitions (or components) of finite, difference operators (introduced above) a symmetric difference operator $\mathfrak{D}$ will be temporarily introduced to show the links to the Newtonian differential operator.

Definition: **Chronon Difference** $\mathfrak{D}\, A[t - \tau/2] \equiv \mathring{A}[t] \equiv (A[t + \tau/2] - A[t - \tau/2]) / \tau$

In contrast to the standard (asymmetric) definition [144] for the difference operator, this new definition is symmetrical around any interaction time T_n and satisfies Dirichlet's Condition for piecewise functions with only a finite number of finite valued discontinuities so that it can always be represented in the interval $T_n - \tau/2$ through $T_n + \tau/2$ by a finite Fourier series.

This operator also satisfies Gregory's theorem:

$$A[t + (n - \tfrac{1}{2})\,\tau/2] = (1 + \mathfrak{D})^n A[t - \tau/2] = \textstyle\sum_m C^n_m\, \mathfrak{D}^m A[t - \tau/2] \quad \text{with} \quad (1 + \mathfrak{D})^n (1 + \mathfrak{D})^m = (1 + \mathfrak{D})^{n+m}$$

In general, Taylor's theorem gives: $A[x + w] = \exp(w\, d/dt)\, A[x] = (1 + \Delta)\, A[x]$ so that: $\exp(w\, d/dt) = (1 + \Delta)$

a) $A_1[t] = t$ then: $\mathfrak{D}\, A_1[t - \tau/2] = \mathfrak{D}\,[t - \tau/2] = \tau \qquad \therefore\ d/dt\ A_1[t] = 1 = \mathfrak{D}\, A_1[t] / \tau$

b) $A_2[t] = t^2$ then: $\mathfrak{D}\, A_2[t - \tau/2] = \mathfrak{D}\,[(t - \tau/2)^2] = 2\,t\,\tau \qquad \therefore\ d/dt\ A_2[t] = 2\,t = \mathfrak{D}\, A_2[t] / \tau$

c) $A_3[t] = t^3$ then: $\mathfrak{D}\, A_3[t - \tau/2] = \mathfrak{D}\, [(t - \tau/2)^3] = 3\, t^2\tau + \tau^3/4 \;\therefore\;$ d/dt $A_3[t] = 3t^2 \neq \mathfrak{D}\, A_3[t] / \tau = 3t^2 + \tau^2/4$

In general, for $n \leq 2$ then: $\mathfrak{D}[(t - \tau/2)^n] /\tau =$ d/dt (t^n) but for $n > 2$ this is true only in the limit of τ going to zero.

Fortunately, for classical mechanics (and Newton!), this equivalence ($n = 1$) is still valid for velocity, so that:

$$\Delta\underline{\mathbf{I}}[T_n] = \Delta\underline{P}[T_n] = m\, \mathfrak{D}\, \underline{V}[T_n - \tau/2] \quad \text{since} \quad \underline{P}[T_n + \tau/2] = (1 + \mathfrak{D})\, \underline{P}[T_n - \tau/2] = \underline{P}[T_n - \tau/2] + \Delta\underline{\mathbf{I}}[T_n]$$

While for the definition of kinetic energy: $K[\, t\,] = ½\, m\, V[\, t\,]^2$ so that: d/dt $K[\, T_n\,] = K[T_n - \tau/2] / \tau = V_n\, P_n$

Discrete Momentum and Kinetic Energy

In keeping with the minimal change view, the momentum and kinetic energy of each electron (labeled 'α') are defined in the Newtonian tradition in terms of the electron's velocity $\underline{V}_n$, defined in section 5.4.1 above. This measure is unchanged from the previous interaction time at T_n until just before the next interaction time at T_{n+1}; in particular, it is also the value at its mid-time point $\mathcal{T}_n$, where $\mathcal{T}_n = < T_n > = ½\, (T_{n+1} + T_n)$.

Definition: Electron α's **Momentum** $\underline{P}[\alpha\!: T_n] \equiv m\, \underline{V}[\alpha : T_n] = \underline{p}_n$

Definition: Electron α's **Kinetic Energy** $K[\alpha\!: T_n] \equiv ½\, m\, \underline{V}[\alpha : T_n] \bullet \underline{V}[\alpha : T_n] = K_n$

Assuming Uniform Differences

The shared primary error in both SRT and quantum mechanics is the unstated *assumption* that Newton's mathematical definition of a particle's **velocity** as the **differential** rate of change of position can still be used in extreme situations. In particular, this **definition** was still thought to be valid in those situations involving high-speed interactions (where it was *assumed* that the changing situations are distinguished by uniform, consecutive Δt's) or in situations involving atomic scale measurements (where the spatial differences Δx were *assumed* to be measurable at the same time). Physics has continued to *assume* that what we think we are 'seeing' (SRT) or what we think we are 'measuring' (QM) is identical to what is really happening; in other words, our senses (made from electrons) perceive reality accurately in all situations. In the present theory, this is confusing the mapping between Levels II and III and the actual reality, which is described by Level I.

6. TWO-ELECTRON RELATIVISTIC DYNAMICS

The last section developed a digital model of classical mechanics. Like Newton, and many who have followed him, the focus was on the effects on a single particle – the 'target' particle. This **singular** focus simplified the mathematics as only one point in time and space was significant – the location of the particle at any one time. Furthermore, all of the sources of the interaction were absorbed into a net 'cause' – in the case of Newton, the continuous force on the particle, here the set of discontinuous impulses. This ancient separation of the cause from its effect has led to some peculiar results in physics, in particular, when the particle is moving at high-speed, the introduction of mysterious increases in the particle's inertial mass. This section now restores the full symmetry of the situation by returning the focus to the full interaction itself. Unlike the previous paper, this section investigates the situation when the interaction between two particles acts both asynchronously and discontinuously over time. Since this theory is based on a symmetric view of the interaction between two electrons, neither of which can make a privileged claim on 'universal' time, then this new theory adopts a completely symmetric view of the interaction, with neither electron able to claim that it is 'sending' its impulse exclusively forward in time to the other. This fully symmetric viewpoint will more extensively investigated in the next paper; this paper focuses on the variable rate of interaction as experienced (differently) by the two electrons. This will be seen to be the physical explanation for the bizarre predictions of relativity theory.

6.1 INTERACTIONS: DIRECTED & DISCRETE

This section begins with a discussion on the nature of two-particle interactions, starting with a comparison with the much more familiar concept of 'force' – an idea that relates directly to our daily experiences as macroscopic creatures. The new approach taken here is to make the smallest number of modifications of Newton's Laws of Motion, which were introduced in his masterpiece, the *Principia* [3]. Although the present theory is a new approach to explaining the phenomenon of EM, it needs only point-to-point interactions and therefore rejects the standard assumption of spherical symmetry, reserving this approach for a later paper describing a model of 'light' as the statistical interactions among very many electrons.

6.1.1 INTERACTIONS, NOT FORCES

Fields are much too Busy

All field theories are too 'busy'. Field theories reduce all interactions to action at every local point (in space and time) and inevitably introduce an infinity of spatial activity over an infinite number of infinitesimal time intervals. When the proposed interaction forces can also become infinite with infinitely small spatial separations (e.g. inverse square static forces), it is not surprising that all calculated quantities in such field theories become infinite, especially when these interactions can occur continuously. Pseudo-mathematical 'solutions' to this intrinsic problem, like QED 'renormalization', will never resolve this flawed approach: over 75 years of enormous intellectual effort centered on resolving these intrinsic problems with field theory have failed to provide a satisfactory resolution.

Revising Newton's Laws of Motion

Newton's three laws of motion can be re-interpreted in terms of the present theory. Newton's first law can be restated as an electron moves in a straight line relative to all other electrons with a constant velocity until it interacts with another electron. The second, dynamical law can be re-stated (following Maxwell) as the change in momentum of an electron at the time of an interaction is equal to the impulse exchanged. Newton's third law is re-stated as each electronic interaction is pair-wise, symmetrical and discrete.

Extending Newton's Law I

In the present theory, time is the fundamental measure, with units defined as integral multiples of the universal, smallest duration: the *chronon*, designated here by the symbol τ. Space, as the separation between electrons, is a calculated measure introduced through the universal, constant space-time conversion factor, popularly known as the 'speed of light' and always designated by the symbol *c*. Accordingly, the present mechanics always makes its propositions known in a temporal context. Thus, the revised version of Newton's first law of motion becomes: "Two electrons remain in constant relative motion over a finite time duration unless they interact with one another or any other electron during this same time period."

Extending Newton's Law II

Conventional formulations [159] of Newton's Laws of Motions separate the interaction between two particles into a scheme focusing on a single material body (the 'target' particle) and a 'force' between the two bodies. Almost casually, and without any justification, it is then assumed that when there are three or more bodies interacting together, then all the separate forces acting on the target particle may simply be added arithmetically together at any instant in time in each of the three spatial directions (vector addition); this assumption will be referred to as the *Superposition Hypothesis.* In the present theory, this basic assumption is challenged *ex hypothetico* by the view that in the smallest interaction time duration (one *chronon*) only one interaction is ever selected (at most) between any two electrons. This views the EM interaction between electrons as 'saturated', a characteristic that has only be proposed historically for the 'strong' force between nucleons. This *Saturation Hypothesis* will be investigated later in more detail when the collective dynamics of three or more electrons is examined.

Extending Newton's Law III

In the new EM theory, like Newton's Third Law of Motion, the action of one electron and the reaction of the other electron are equal in magnitude and opposite in direction since they are the two irreducible components of the same interaction. In contrast to Newton's contact or instantaneous action-at-a-distance assumption, the present theory explicitly acknowledges the asynchronous nature of the fundamental EM interaction, so that action and reaction **never** occur at the **same** time.

Maxwell's Magnetic Impulse

Since Maxwell was creating an EM theory centered on the continuum concept of the æther, he only focused on a **single** point (any point) in space and time, which is traditionally referred to as the 'field point'. His physical innovation was the realization that magnetic effects at this point, defined in terms of a single function – the magnetic or vector potential could reflect **all** the history of the dynamical sources of magnetism as they generated magnetic effects at this point. Essentially, *Maxwell ignored all the sources of EM and simply focused on their effects at the field point*. His equations correlate these effects but do not provide a causal perspective (see Jefimenko [123]). Since he ignored the interaction and did not know that electricity manifested itself through material point particles (electrons) his theory failed to satisfy Newton's (third) law of conservation of momentum i.e. the Law of Action and Reaction. The present theory addresses all of these problems by identifying the (finite) change in Maxwell's (actually Lorenz's) vector potential ($\Delta \underline{A}$) with the fundamental impulse from the other electron ($\Delta \underline{I}$) that is manifest as an exchange in momentum ($\Delta \underline{P}$) between the electrons: $\Delta \underline{P} = \Delta \underline{I} = (e/c)\, \Delta \underline{A}$.

No Self-Interactions

The foundational metaphysical hypothesis of the new theory is that all interactions may only occur when both electrons are 'on each others light-cone', algebraically: $(\Delta X)^2 = c^2 (\Delta T)^2$, where c is a universal parameter of nature (known here as the *EM Interaction Constant* – see 5.2.4) and ΔX is the absolute spatial separation between the electrons at their mutual times of the interaction, which has an absolute temporal separation of ΔT. This temporal separation is always an integral number of universal units of time (the '*chronon*'). As this is always a finite, positive number there is never any self-interaction for a single electron – thus *ab initio* avoiding a result that continues to embarrass all quantum field theories.

6.1.2 DIRECTED INTERACTIONS

Mechanics is more than One Particle

Classical and relativistic mechanics both focus on a single particle with real number attributes, such as mass, position, etc. This approach can result in a semantically meaningless universe of a single particle with 'measurable' properties; but these properties all require at least two particles to have operational meaning. It is only self-consistent to begin with the concept of entities that are defined in terms of relationships between each other i.e. recursively. Mass can only be defined in terms of response to interaction with (or a force due to) another particle. Location is only significant relative to other particles while the concept of velocity implies both changes in relative location defined over relative, finite time differences. Newton's imaginative introduction of plausible interactions (such as gravitation) transformed this kinematical picture of particles moving around space over time into a dynamical theory of physics; this is the approach followed here in this theory.

No High-Energy Symmetry

There is no symmetry in Maxwell's EM theory between source and field point: this was a theory focused exclusively on the field point, where at great distances, high frequency variations in the electric sources are detected by other electric charges and were interpreted by Hertz as a tiny part of a very large, expanding spherical wave of varying EM intensity.

'Fire & Forget'

The electric and magnetic fields in classical EM theory are mathematical fictions (point derivatives of other mathematical functions – the electric and magnetic potentials) designed to create a one-time formulation at the 'field' point of the target electron (that 'measures' these fields) while 'forgetting' all the history of the EM sources that generated the interaction. Like all field theories, this technique ignores the response (reaction) of the source electrons. Like a 'fire and forget' (non-smart) anti-aircraft shell, the 'hit' can only be assured if the 'gunner' knows where the target is going, by knowing all about its intermediate motion. In this model, the shell could hit, miss or even hit another object that is either flying closer or flying further away if it misses the primary target. Actually, Maxwell's field theory is more like an explosion with the fragments flying in every direction and maybe, hitting multiple targets. This analogy illustrates the importance of first clarifying the underlying metaphysical foundations (or models) before constructing theories of nature.

Light-Speed defines the Possibilities

Since 'light' is **not** assumed to be an entity in the present theory, there is **no** movement of a **real** object between the two interacting electrons. Accordingly, the speed *c* is not the speed **of** light but the measure that defines the relative velocity **between** the two electrons when they are interacting: they do not interact if their relative velocity is higher or lower than this fundamental constant. This key value also defines the ratio of the space-time metric when two electrons might interact with each other; i.e. when they are 'on each others light-cone', that is they satisfy the equation: $(\Delta X_{12})^2 = c^2 (\Delta T_{12})^2$. This view should be contrasted with Einstein's view of light implied by his second postulate (see section 2.4.1), where he defined the speed of light through the deceptively simple equation: Light-speed = Light-path / Time-interval. The whole of Einstein's SRT is hidden in this definition along with his approach to defining time-intervals. This then results, mathematically, in the L-transform that changes the classical ideas of space and time. This approach is rejected in this research programme.

Interactions are only Statistically Spherical

All EM theories have assumed that point charges interact equally in all spatial directions at all times. These continuum models must inevitably introduce spherically symmetric solutions as the existence of all remote interacting 'partners' are assumed to have no impact on the 'waves' or 'photons' that were emitted earlier in time. This is a critical assumption in all continuum theories, since both Gauss's theorem and Green's theorem implicitly rely on this assumption that the EM forces fall off faster than 1/R at spherical spatial infinity; in other words, all such fields vanish at infinity. In the present theory, the interaction of every electron is in theory only potentially spherically symmetric but in **actuality** each one is only statistically spherically symmetric, since each individual interaction here is always point-to-point. Thus, over significant time-periods (many *chronon*s) the interactions will be spherically symmetric relative to many distant electrons but not when the nearest interacting electrons can configure themselves into cyclic trajectories.

Fokker's Spherical Action Integral

Adrien Fokker's action integral ($\mathcal{S}$) is a 4D symmetric (retarded plus advanced) version of Coulomb's Law [160]. It only becomes an equivalent starting point for deriving Maxwell's Equations when continuous changes in the electron's velocity and acceleration are assumed so that infinitesimal variations become meaningful; that is to say, $\delta\mathcal{S} = 0$ is well-defined. Although this approach does exclude self-action, it is deliberately spherically symmetric (that is, it averages over all three space directions around each particle), reflecting its implicit use of the *Superposition Hypothesis*. Fokker's approach also assumes that the electric charge is neither created nor destroyed, that is: his model also assumes that electrons are **eternal** or each electron's world-line extends from minus infinity to positive infinity in time. Even then, Maxwell's Equations are only defined **on** each particle's world-line and **not** throughout all of space; in other words, these equations describe functions, not fields. Fred Hoyle (1915-2001) cautiously calls these 'direct-particle fields' as they have **no** extra degrees of freedom [161]. As a mathematician, Hoyle must have known that this was a misuse of the mathematical definition of the concept of 'field'.

Messages, not Broadcasting

Both classical and quantum theories of the EM interaction are 'broadcast' models. That is to say, activity occurs at a point and everywhere else in the universe eventually becomes aware of this local change: equally in all directions and equally at all points that are equally distant from the source of the change – the distance of separation only effects the awareness delay and the strength of the 'signal'. This is not the model used in this theory, where the message is only received by one other electron and the 'signal strength' is independent of distance: the 'message' is always maximally 'received and understood'.

6.1.3 DISCRETE INTERACTIONS

Impulse equivalent to Force

In all continuum calculations of changes in velocity it is sometimes said that the continuous force $\underline{F}_0$ need only be replaced by the comparable impulse $\Delta\underline{I}$ divided by the time that force is applied ΔT; the reality is somewhat more complicated. The clue is found in a footnote in Westfall's biography of Newton [162] that Newton needed an extra factor of '2' in his results. This is re-derived here for the first time. Consider a particle of mass *m* moving at velocity $\underline{u}$ at time t_1 that is subjected to a constant force $\underline{F}_0$ only for a finite time ΔT until time t_2 which leaves the particle moving with final velocity $\underline{v}$. Let this particle be at location $\underline{A}$ at t_1 and be at location $\underline{B}$ at t_2, reaching the location $\underline{X}$ at some intermediate time t with intermediate velocity $\underline{w}[t]$. Integrating Newton's Second Law of Motion for a constant force: $\underline{F}_0 = m\, d\underline{w} / dt$ gives the standard result: $m\, \underline{w}[t] = m\, \underline{u} + (t - t_1)\underline{F}_0$. One can let $t \to t_2$ and define impulse as the change in momentum then:

$$\Delta\underline{I} = \Delta\underline{P} = m\, \Delta\underline{v} = m\,(\underline{v} - \underline{u}) \quad \therefore \quad \Delta\underline{I} = (t_2 - t_1)\, \underline{F}_0 = \Delta T\, \underline{F}_0 \quad \therefore \quad \underline{F}_0 = \Delta\underline{I} \,/\, \Delta T$$

Although this is the usually quoted result, it is *only true in the infinitesimal limit* of $\Delta T \to 0$. This must be altered when the particle actually moves through a <u>continuous</u> curve $\underline{S}[t]$ for any <u>finite</u> time difference. First, recognize that: $\underline{w}[t] = d\underline{S}[t]/dt$.

After integrating from t_1 to t, the general result is: $m\,(\underline{S}[t] - \underline{A}) = (m\, \underline{u} - t_1\, \underline{F}_0)\,(t - t_1) + ½\, \underline{F}_0\,(t^2 - t_1^2)$ with $\underline{X} = \underline{S}[t]$.

Going to the limit of $t \to t_2$ and substituting: $\underline{S}[90] = \underline{B} = \underline{A} + \underline{S}_0$ and $\underline{w}[90] = \underline{v}$ gives: $m\, \underline{S}_0 = m\, \underline{u}\, \Delta T + ½\, \underline{F}_0\, (\Delta T)^2$

A third fixed point C can be defined as the location the particle would have reached after ΔT, had the force <u>not</u> been present.

Vectorially: $\underline{B} = \underline{A} + \underline{AC} + \underline{CB}$ Now $\underline{AC} = \underline{u}\, \Delta T$ and $\underline{CB} = \Delta\underline{v}\, \Delta T$ $\quad \underline{S}_0 = (\underline{u} + \Delta\underline{v})\, \Delta T = \underline{v}\, \Delta T$

$$m\, \underline{S}_0 = m\, (\underline{u} + \Delta\underline{v})\, \Delta T = m\, \underline{u}\, \Delta T + \Delta\underline{I}\, \Delta T = m\, \underline{u}\, \Delta T + ½\, \underline{F}_0\, (\Delta T)^2 \qquad \therefore \Delta\underline{I} = \underline{F}_0\, (\, ½\, \Delta T\,)$$

So, for a constant force, a single-point impulse is equivalent to the (constant force * **half** the time that the force is applied).

Rest Mass needs instantaneous Change

There can be no measure of an electron's 'proper' (or rest) mass without instantaneous EM impulses as there is no common inertial frame of reference, which can be used to define or measure the asynchronous finite acceleration and reaction of any two interacting point electrons. This constraint is hidden in the continuum limit of vanishingly small time-differences.

6.2 DISCRETE TIME INTERACTIONS

The present theory is grounded on the experimental observation that interactions between remote electrically charged bodies do not occur simultaneously. When interactions 'flow forward in time' (with us) and only produce effects later than their initial changes they are known as 'retarded'; should the opposite situation ever occur when the response precedes in time the initial change then these situations are called 'advanced' interactions: overwhelmingly, the focus has been only on retarded interactions. A brief history of so-called 'retarded action-at-a-distance' was given in section 2.4.2 of the second paper in this series [6]. As was shown there, even retarded interactions have been rejected by most philosophers and scientists, who have preferred only local (or contact) interactions, at the same point in space at one instance of time. This programme joins the minority and rejects all local theories, as these are seen as inevitably resulting in continuum models of matter - these are not found experimentally and cause infinite mathematical difficulties. One further advantage of action-at-a-distance (AAD) is that it draws attention to the complete interaction - both interacting particles receive equal treatment, integrating cause and effect. The omission of the emitter and the exclusive focus on the receiver (or 'target' field point) is a direct consequence of the 'force' concept, which is not only undetectable but is the origin of all the problems with field theories. The concept of 'force' is a calculational device to simplify the mathematics of many-body interactions and has no independent existence apart from the particles that are interacting; metaphysically, it is not an entity. The present theory follows the Boscovitch hypothesis that all of material nature can be explained in terms of action-at-a-distance between point particles.

6.2.1 UNIVERSAL TIME

Dirac reconsiders Absolute Time

In 1953, frustrated with the contradictions of QED and, perhaps, allowing his full admiration for Isaac Newton to re-emerge, Dirac was prepared to consider the re-introduction of the concept of 'absolute time' [84] : "one can try to build up a more elaborate theory with absolute time involving spins, which one may hope will lead to improvements in the existing QED."

Possible Periodic Interactions

There are four possibilities for determining the nature of any fundamental interactions between the basic units of reality:
1) No interactions – there would then be no macroscopic structures, so there would be no humans; so this is ruled out;
2) Continuous interactions – this has been the choice of physics to date, it has resulted in paradoxes and calculated infinities;
3) Aperiodic interactions – there would be no consistency or macroscopic stability, so this possibility is also ruled out;
4) Periodic interactions – this is the choice made by the present theory, it appears plausible enough to merit further research.

Fundamentals always Finite

All the fundamental quantities involved in the dynamical behavior of matter (e.g. mass, charge, etc) have been found in experiments to be quantized i.e. occurring with finite, discrete values and are not continuous with some occurrences being found to be smaller and smaller without limit. It is therefore not surprising that time, which is the common factor in all dynamical behavior, should also be quantized. In fact, the quantization of all the electron parameters (e, m, h) will be found to be the direct result of this quantization of timing in the inter-electron interaction.

Need for a fundamental Time Unit

There is a fundamental need for a universal, temporal scaling constant to define the duration of the universe. This research programme rejects the *Continuum Hypothesis* so it views all 'real' numbers as a mystical intrusion into reality. The world is seen as finite and the counting numbers reflect the universal discreteness that is found throughout nature. This programme introduces its temporal hypothesis that all change in the world is defined as a multiple of this basic unit of time, here called the *chronon* and symbolized hereafter by τ; it is viewed as one of the foundational constants of nature. The universal, basic electron-electron interaction introduces two other universal parameters (e^2 and m) and the 'light-cone' condition that defines the acceptable ratio of spatial separations to temporal separations whenever a pair of electrons interact which introduces the fundamental space-time 'scaling' parameter, denoted by c (usually referred to as the 'speed of light'). This latter parameter is used to define the basic unit of spatial separation, here denoted by the symbol Λ and called the *luxon*, defined as $\Lambda = c\ \tau$. These fundamental parameters are inter-related and connected to the unit of change of activity in the world generated by the EM interaction and symbolized by Planck's constant, h. One of the primary objectives of this theory is to discover the basic relationship between these parameters so that a physical explanation can be provided for Arnold Sommerfeld's famous 'fine structure' constant, $\alpha = 2\pi\, e^2/ (h\ c) \approx 1/137$.

Chronon as the Quantum of Time

The present theory began with the thought that quantum theory could be the consequence of the discreteness of time itself. Since it was also thought that electrons might be eternal then their continuous existence through time implied that space was a continuous concept. The distinct interactions between the electrons across the universe were first conceived of as a 'ticking of the *Cosmic Clock'*, which like a high-speed movie would change the appearance of the world 'frame by frame'. This new concept was given the name of *chronon* in April, 1980 and its value was guessed at then to be about 10^{-30} seconds based on the SWAG formula of: $\tau = h / m\ c^2$.

Local Time, Universal Rate

In the present theory, all times (temporal markers) are <u>local</u> to each electron, while the <u>rate</u> that time passes is viewed as universal (all electrons 'click' every *chronon*). Furthermore, as this paper will show, the rate that consecutive interactions occur between pairs of electrons varies with their mutual, relative speeds.

Universal Time

When viewed from any inertial reference frame, each interaction with a single electron characterizes a real event, so that the totality of all these events which are simultaneous as viewed from the origin of this reference frame define a universal time-stamp, indicated by a common integer number of *chronons* relative to the frame's temporal origin. Since very many pairs of electrons interact per *chronon* there must be a universal measure of time, in each inertial reference frame, as these electrons may be spread across the whole spatial universe and the existence of every single one is never contingent.

Space & Time Ratios

When the hypothesis of an absolute unit of time duration (τ) is accepted then all real measurements of interaction durations reduce to an integral number of *chronons*: a result that is isomorphic with the operation of counting. Similarly, comparable measurements of spatial separations involving interactions must always result in an integral number of *luxons* ($\Lambda = c\ \tau$). Although these will usually be gigantic numbers, they are still finite and will usually be approximated by finite decimal numbers, reflecting the accuracy of the experimental situations. This should be contrasted with standard physics where, following DesCartes, all geometric spatial separations are defined in terms of ratios against arbitrary unit lengths that are represented (in theory) by infinite decimal ('real') numbers. It is the fact that the *chronon* is so small (10^{-24} seconds) that makes the use of 'real' numbers so effective in most theories of physics, so that the mathematics of real spatial vectors and real or complex field functions has proven so useful.

Each Electron's 'Life'

Time is the fundamental dimension in this theory because only the intrinsic time of each electron's 'life' has any universal significance. Space is only defined when two other electrons are present to provide relative interactions over time, with a computed measure of relative distance (using 'light-speed' c).

No Observable Else-When

There is no operational definition of simultaneity in the present theory. Each point in space may only be occupied by, at most, one electron at any instant of time. By hypothesis, a single electron can only interact with one other electron, that is somewhere else in space, within one *chronon* of time. Therefore, there can be no two or more 'elsewhen' events, which can be detected at the same single instant of time by any single electron (the 'ultimate observer'). The idea of simultaneity is here treated purely as a human abstraction with no corresponding physical reality: real time is always local to real electrons.

6.2.2 UNIVERSAL TIME CYCLE

The Universal Electron 'Clock'

In the present theory, each electron is the fundamental locus of activity in the universe. Each electron is a true point in that it has no spatial extent whatsoever, as spatial dimensions are viewed as the separation between electron interaction events. Every electron has its own rate of interacting with other electrons; in effect, each electron is its own 'clock' defining its own local time-line that 'ticks' at the same rate as all the other electrons in the universe. This is a universal, periodic **rate** (not a universal time), which is invariant and independent of all other factors such as the proximity or movement of any other electron. Obviously, a point 'object' like an electron cannot contain an actual mechanism (or 'clock'). This is hypothesized here as a universal rate of possible interactions with other electrons, just as electric charge is a fundamental property of an electron and would never be viewed as 'electric paint'. Particles have never needed a compass or a 'navigator' to keep them moving in straight-lines when not interacting with other objects in the universe: inertia, like all fundamental attributes, has always been viewed as 'intrinsic'.

Universal Time Rate

Time is the measure of all change in the world and the new theory views the 'send/receive' cycle as a universal property of all electrons. It therefore becomes appropriate to refine the fundamental temporal hypothesis (the *Chronon Hypothesis*) here by proposing that the *local time* of every electron evolves at the same rate, independent of their motion relative to any other electron. This implies that all physical matter (consisting only of electrons in this theory) is a 'self-referencing' quantized system with a universal synchronized zero phase point in the cycle. Metaphorically, it could be said that in the new theory 'the ticking of the universal clock is constant' – a view shared by Newton but not one sympathetic to either of Einstein's theories of relativity (of time).

Universal Time Cycles

Although inspired by Newton's dynamics, the present theory does not follow Newton in viewing space as absolute [163] but as relational, involving the differences in the locations of the two interacting electrons. Nor is the present theory one that involves the concept of 'absolute time' since this theory assumes that all electrons cycle through their *Send/Receive* states at the same universal and absolute rate (the '*chronon*' τ). Further, it is explicitly assumed that all electrons are synchronized at the same time, in other words, all electrons may '*send*' whenever their local time equals an even number of *chronon*s ($2\ N\tau$): 'phase' (or timing) is central throughout this theory.

The End of Chaos

The finite, discrete nature of the time interval characterizing the inter-electron interaction (i.e. the concept of the *chronon*) eliminates the Poincaré instabilities (or 'chaos') introduced by the use of infinite 'real' numbers describing the continuous interactions between three or more particles. This helps reduce the infinite number of interactions in any finite time to a very large but finite number proportional to the number of interacting bodies (an N-body problem, not an N^2 problem).

6.2.3 EM INTERACTION AS EXCHANGES

EM Interaction implies 3D Space & Time

In the present theory, the focus on the fundamental nature of the interaction between two electrons implies both passive spatial separations and the active nature of time. All electrons exist in space and their relative positions in space change in time. The delayed response of one electron in every interaction to the earlier action involving the other electron implies space/time recursion, i.e. the future depends on the past, repeatedly. The symmetry implied by allowing either electron to initiate the interaction (the 'send') with the receiving electron event being either ahead or behind the sending event in time also implies that the past also depends on the future – "temporal integrity above all".

Conservation of Relative Velocity & Momentum

The homogeneity of space can only be determined operationally by observing that the interactions are invariant between pairs of electrons everywhere and every-when. Proposals that the geometry of space has anything to do with the real world are metaphysical and the deductions from such theories can only be confirmed as being, at best, consistent with reality. The *Principle of Least Change* [6], which is one of the methodological foundations of the present research programme, would imply that the assumption of passive, Euclidean geometry, assumed by all humans and forming the basis for physics prior to the 20th Century, is sufficient to construct dynamical theories of nature. The homogeneity of space implies the conservation of **velocity** of all non-interacting objects everywhere. It is only when a theory further assumes (as is done here) that every real object in the world consists of the same fundamental entity (in this case, electrons) with the same *invariant inertial m*ass can this guideline be extended to a universal principle of conservation of **momentum**. This universal principle is equivalent to the requirement that the universal, unit impulse defining the smallest interaction between pairs of electrons, is invariant. It is these dynamical assumptions that underlie the dynamical conservation laws, not the geometric, metaphysical hypotheses concerning space and time that are usually proposed [120]. This principle can be readily stated using the simple algebra of finite (Δ) changes (or differences) in position ($\underline{x}$), mass (M), impulse ($\Delta\underline{I}$), velocity ($\underline{V}$) and momentum ($\underline{P}$) that occur over a finite time $\Delta t(t)$.

$$\text{Momentum:} \quad \Delta\underline{I}\,(\underline{x},t) = \Delta\underline{P}(\underline{x},t) = \Delta\{M(\underline{x},t)\ \underline{V}(x,t)\} = m\ \Delta\underline{V}(\underline{x},t) = m\ \Delta\underline{V}_n = m\ \Delta\underline{V}_0 = \Delta\underline{I}_0 = \text{constant}$$

The conservation of momentum in the present theory is based on the concept that a fixed 'quantum' of momentum is always exchanged during the course of each interaction between any two electrons which is independent of the spatial separation or relative motion of the participating electrons and is certainly independent of the velocity of any third-party observer.

Momentum Exchange

Due to the finite time of the EM interaction (the time duration between the absorption and emission) there can be no total conservation of energy or momentum during this time period in any form of finite action-at-a-distance theory – this was the primary motivation for the invention of field theory or the idea of virtual particles. Rather than assume that the mechanical conservation principles are valid at **all** times (the current hypothesis in physics), the present theory accepts fluctuations in these quantities during the interaction when neither one of these quantities is available for external measurement. In other words, the assumption of conservation of energy and momentum at all times is a purely metaphysical position, not one derived from experiments: it lies at the heart of the (usually unstated) *Continuum Hypothesis*.

Discontinuous Momentum Transfers

Since the interaction between two electrons is itself a relationship and not an entity (real object) then energy and momentum are not conserved at a point (the required role of the 'photon') but only between the two interacting electrons before and after their interaction is complete.

Discontinuous Energy Transfers

The remote exchange of momentum between two electrons in this theory resembles a named 'bankers draft' that is mailed from one customer to another at the other side of the country. The first customer's account is debited immediately the draft is issued and those funds are no longer available to this customer. When the draft is received by the second customer it can then be deposited into his account when these funds become available for use by the second customer. Unlike the transfer of cash between the two parties which can be intercepted (stolen) by a third-party, who would immediately benefit from this action, the bank draft must be deposited into the target account and has no value to anyone else. Similarly, the interaction between the two electrons cannot be intercepted by any third electron, as this is not part of the 'agreement'. It is important to note that while the draft is in transit the total amount of funds available to both customers is not conserved just as the total momentum is not conserved until the interaction is complete.

Potential Baseline not at Infinity

In standard EM, the baseline of the scalar (electric) potential between two interacting electrons is always taken to be zero, claiming this reflects an infinite separation between the two electrons. In the present theory, the zero potential base-line occurs when two electrons no longer interact with each other and this occurs when their relative (asynchronous) velocity exceeds light speed, c. This velocity-dependent condition occurs well before their spatial separation is infinite. In terms of the conventional, single-time perspective this occurs when the relative, instantaneous difference in speed is 2c.

6.2.4 SUMMARY OF THE NEW EM INTERACTION

Standard Assumptions concerning EM Forces

The history of EM theory from the 19th century onwards shows that almost all scientists have assumed that the EM 'force' always acts continuously across time (the *Continuum Hypothesis*) and acts equally, at all times, in all directions (isotropic). In addition, most have assumed that even when it is not instantaneous it still only acts forward in time (retarded). Since Coulomb's time, everyone has assumed that this force spreads across the entire universe with only its intensity diminishing with distance (universal). The present theory challenges **all** of these assumptions.

The EM Interaction as Transaction

The present theory assumes that pairs of electrons, which are finitely separated in space, 'agree' on an interaction (just like two business people would agree on an economic transaction). In the case of electrons, the 'deal' is the exchange of one unit of momentum from one electron to the other (this appears more like a 'charitable donation': one party gives while the other party receives). The exchange occurs not only across space but also over finite time as this interaction is viewed as an example of asynchronous action-at-a-distance. This transaction is viewed here as independent of the spatial and temporal differences between the two individual electron events as long as these differences are 'on the light-cone' (see 5.2.4). This constraint is independent of the motion of either electron or any 'third-party' observers, i.e. **all** reference frames, including those that are non-inertial. The 'deal' is the same whether it was agreed to in an office, on a ship, on a plane, or whatever.

Contrast with Classical EM Interaction

The present theory has a very simple image of the interaction between two electrons, involving only the two locations in space where the electrons exist at the two times that they interact with each other; as this is an asynchronous action-at-a-distance theory there are no third-party entities like 'photons' or 'EM waves' traveling between the electrons. The modern view of classical EM involves small cells of continuous (but non-repulsive) 'electric fluid' generating EM 'waves' that then cross the intervening empty space before effecting more 'electric fluid' in the target cell; an old model that still hides a lot of metaphysical baggage. It is one of the major embarrassments of Maxwell's EM theory that it still predicts an exponential increase of velocity over time, when a stationary charged particle is caused to move by a finite pulse-like electric force [66]. In contrast, the present theory only uses impulse-like interactions between electrons and these only cause each electron to change speed by a finite amount.

6.3 DIGITAL TWO-ELECTRON MECHANICS

6.3.1 TWO-ELECTRON KINEMATICS

When a system consists of only two electrons (this is only a pedagogical model) then **all** of the interactions will only occur between these two electrons, which will be labeled here as 'A' and 'B'. This prototypical system will be investigated in the *Symmetric Interaction Reference Frame* (or SIRF) that was introduced in the previous paper ([4] – see 6.2). In this frame, each electron's spatial location is anti-symmetric in time (relative to the space and time origins) and in their mutual locations at the same time. Thus, at any time:

$$1)\quad \underline{x}[\alpha: -t] = -\underline{x}[\alpha: +t] \qquad 2)\quad \underline{x}[B: t] = -\underline{x}[A: t] \qquad \text{where } \alpha = \text{'A' or 'B'}.$$

The second condition implies that there is at least one direction, where the spatial separation between the two electrons first decreases (called here the 'inbound' phase) until they reach their closest spatial separation before reversing direction with their separation continually increasing (the 'outbound' phase). The first space-time condition indicates that each electron moves towards the spatial origin (while $t < 0$) and then moves away from the origin in the outbound phase ($t > 0$). The direction of electron 'A' in its outbound phase will be used to define the positive spatial directions of the three space axes: $\underline{x}$, $\underline{y}$ and $\underline{z}$. The previous paper ([4] – see 6.4) has already demonstrated that when two electrons interact over finite space and time intervals (i.e. on their mutual 'light-cone') they may do so only consecutively if they interact discontinuously across time. In other words, each electron's velocity changes discontinuously whenever an electron interacts, even though their individual trajectories are continuous. These interaction times are labeled symmetrically, both incrementing serially using the integers from 1 to N; a similar scheme will be used to label the spatial locations of electron 'A' for each of these interaction times. This defines the complete set of interaction times for both electrons as $\{t_n\}$ and the spatial interaction locations of electron 'A' forming the set $\{\underline{x}_n\}$, for $\{n = \pm 1, \pm 2, \dots, \pm N\}$. The symmetries of the SIRF imply that:

$$3)\quad t_{-n} = -t_n \qquad\qquad 4)\quad \underline{x}_{-n} = -\underline{x}_n$$

The primary focus will be on the inbound phase of electron B when it interacts with points on the outbound phase of electron A. The explicit electron labels will sometimes be omitted for legibility and the parameters for electron B will be notated with dashed values with the index 'n' usually reserved for electron A and index 'k' used for electron B; thus:

$$\underline{x}_n = \underline{x}[A: t_n] \quad \underline{v}_n = \underline{v}^+[A: t_n] \text{ with } \{n = 1, 2,\dots, N\} \text{ and } \underline{x}'_k = \underline{x}[B: t_k] \quad \underline{v}'_k = \underline{v}^+[B: t_k] \text{ with } \{k = -1, -2,\dots, -N\}$$

The earliest interactions occur for both electrons at time t_{-N} and proceed successively down to $t = 0$ and finish at time t_N. Unless an explicit exception is made, most time intervals will be 'on the positive side'; i.e. $A^+_n = A[t_n + \delta t]$. Using the standard finite difference mathematics summarized in section 5.3, positive sequencing implies:

$$\Delta t_n = t_{n+1} - t_n > 0 \text{ (for 'A') and } \Delta t'_k = t'_{k+1} - t'_k > 0 \text{ (for 'B') ; with } \Delta\underline{x}_n = \underline{x}_{n+1} - \underline{x}_n \;\&\; \Delta\underline{x}'_k = \underline{x}'_{k+1} - \underline{x}'_k$$

The definition of the electron velocities remain as in 5.4.1: $\underline{v}_n = \Delta\underline{x}_n / \Delta t_n$ and $\underline{v}'_k = \Delta\underline{x}'_k / \Delta t'_k$

The set of consecutive interactions between these two electrons can be summarized as the complete set of interaction time-pairs (t'_k & t_n) and their corresponding location-pairs ($\underline{x}'_k$ & $\underline{x}_n$) or treated together (by their indices alone) [k & n]. The interactions thus involve the set:

$$\{ [-N \;\&\; 1] , [-N + 1 \;\&\; 2] , [-N + 2 \;\&\; 3] , \dots , [k \;\&\; n] , \dots , [-2 \;\&\; N -1] , [-1 \;\&\; N] \}.$$

The general formula for any interaction-pair [k & n] is : $k = -N + n - 1$ where $\{n = 1, 2,\dots, N\}$.

The previous paper derived the *Space-Time Integrity Condition* (see 6.4); this defined the constraints on the interaction time intervals for consecutive interactions in terms of the post-interaction velocities in terms of the *Interaction Constant c*:

$$(\underline{c} - \underline{v}[A: t_n]) \Delta t_n = (\underline{c} - \underline{v}[B: t_k]) \Delta t'_k$$

This constraint can be rewritten using only the variables associated with one of the electrons (say 'A'), remembering that if these two electrons interacted at [k & n] then their next interaction will occur at [k + 1 & n + 1]; also all these interactions must occur on the 'light-cone', so:

$$\underline{x}_n - \underline{x}'_k = \underline{c}_n (t_n - t'_k) \qquad \therefore \qquad \underline{x}_{n+1} - \underline{x}'_{k+1} = \underline{c}_{n+1} (t_{n+1} - t'_{k+1})$$

The previous paper also established that all the consecutive interaction impulses must be parallel and in the same direction, denoted by the 'light-vector' $\underline{c}$, which is the same direction as the vector $(\underline{x}_N - \underline{x}'_{-1})$; so:

$$\underline{x}_n - \underline{x}'_k = \underline{c} (t_n - t'_k) \qquad \therefore \qquad \underline{x}_{n+1} - \underline{x}'_{k+1} = \underline{c} (t_{n+1} - t'_{k+1})$$

Now: $$\underline{x}_{n+1} = \underline{x}_{n+1} \pm \underline{x}'_{k+1} \pm \underline{x}'_k \pm \underline{x}_n = (\underline{x}_{n+1} - \underline{x}'_{k+1}) + (\underline{x}'_{k+1} - \underline{x}'_k) + (\underline{x}'_k - \underline{x}_n) + \underline{x}_n$$

$$\therefore \ \underline{x}_{n+1} - \underline{x}_n = \underline{c}\,(t_{n+1} - t'_{k+1}) + \underline{v}'_k\,(t'_{k+1} - t'_k) - \underline{c}\,(t_n - t'_k) = \underline{c}\,(t_{n+1} - t_n) - (\underline{c} - \underline{v}'_k)\,(t'_{k+1} - t'_k) = \underline{c}\,\Delta t_n - (\underline{c} - \underline{v}'_k)\,\Delta t'_k$$

But $\underline{x}_{n+1} - \underline{x}_n = \Delta\underline{x}_n = \underline{v}_n\,\Delta t_n \qquad \therefore \ (\underline{c} - \underline{v}_n)\,\Delta t_n = (\underline{c} - \underline{v}'_k)\,\Delta t'_k$ (the two-electron *STI Condition*).

This result demonstrates both the consistency of the discrete interaction notation and the correct choice for the pairings. Using first the Interaction-Pair result above and then the symmetry conditions in the SIRF (equations 3 & 4 above):

$\Delta t'_k = \Delta t_{N-n}$ and $\Delta\underline{x}'_k = \Delta\underline{x}_{N-n}$ so $\underline{v}'_k = \underline{v}_{N-n} \quad \therefore \ (\underline{c} - \underline{v}_n)\,\Delta t_n = (\underline{c} - \underline{v}_{N-n})\,\Delta t_{N-n}$ (the one-electron *STI Condition*).

This STI equation limits the maximum speed to 'light-speed' (or *c*), otherwise one side of the equation becomes negative that can only be achieved by setting the time difference Δt_n negative, which is a logical contradiction. Physically, this speed corresponds to the maximum electron separation speed where the interaction is still defined (i.e. still on the 'light-cone').

A minimum speed 'b' can be defined as the speed each electron achieves <u>after</u> its change in direction at t = 0 when n = 1.

$$\therefore \quad c = v_N \qquad \text{and} \qquad b = v_1$$

Since the number of interactions, N is finite and each change in speed is also finite then 'b' (or 'N') is another universal constant of nature. One of the major objectives of this research programme is to derive an algebraic expression for this.

Extremal Separations

For two negatively charged electrons, which repulse each other, there will always be a minimum spatial separation $\mathcal{d}$ that occurs during the interaction-period and depends on the initial conditions when the interactions began. Since all these interaction events must be 'on their mutual light-cones' this will occur at a minimum time separation of $\mathcal{T}_0$, both defined by:

Minima: $$\underline{\mathcal{d}} \equiv \underline{x}[1: t_{10}] - \underline{x}[2: t_{20}] = \underline{x}_{10} - \underline{x}_{20} \quad \text{and} \quad \mathcal{T}_0 \equiv t_{10} - t_{20}$$

Similarly, there will occur a maximum spatial separation $\mathcal{D}$ and maximum temporal separation $\mathcal{T}$ between these two electrons <u>during</u> their interaction-period, when the electrons first (or finally) interact with each other:

Maxima: $$\mathcal{D} \equiv \underline{x}[1: t_{1N}] - \underline{x}[2: t_{2N}] = \underline{x}_{1N} - \underline{x}_{2N} \quad \text{and} \quad \mathcal{T} \equiv t_{1N} - t_{2N}$$

6.3.2 TWO-ELECTRON DYNAMICS

This sub-section will only introduce some of the dynamical principles characterizing the interaction of two electrons. The next paper will focus on the full three-dimensional motion of the electrons (using the Natural Vector notation) and will view the interaction from a completely time-symmetric perspective. This will provide a physical model for the 'Dirac electron'.

Time Symmetric Labeling

In section 6.2 of the previous paper [4], it was shown that the mathematical analysis of electron interactions is simplified when viewed from an inertial reference-frame that incorporates the maximum degree of symmetry in both space and time; this was called the "*Symmetric Inertial Reference Frame*" (or SIRF). Within this frame, the total (combined) velocity of the two electrons, $\underline{V}$ at any <u>one</u> single time t, is always zero. Since every electron has the same universal inertial mass parameter m then this immediately implies that the SIRF is equal to the conventional Center-of-Momentum reference frame; where an electron's momentum is defined as Newton's "quantity of motion", or algebraically: $\underline{p}_k = m\,\underline{v}_k$.
So, in the SIRF, where the origin of the SIRF is located at the center of the interaction (hence the nomenclature):

$$\underline{V}[t] = \underline{v}_1[t] + \underline{v}_2[t] = 0 \quad \text{and} \quad \underline{P}[t] = \underline{p}_1[t] + \underline{p}_2[t] = 0$$

The *inter-action* velocities $\underline{v}_k$ are defined in terms of the speed of electron #1 going from the interaction node at T_k to T_{k+1} :

$$\underline{v}_k \equiv (\underline{x}[1: T_{k+1} - \delta t] - \underline{x}[1: T_k + \delta t]) / (T_{k+1} - T_k)$$

It was shown in the previous paper that only "double-parallel" interactions are compatible with the electron's finite mass and the 'light-cone' condition, where only 'parallel-interactions' provide a valid mechanism for accelerating each electron during the divergence phase and decelerating during the convergence phase. The corresponding space-time diagrams were referred to as "Canonical Interaction Diagrams" and are 'constructed' according to the following rules.

1) All 'links' (impulses) correspond to light-speed (i.e. at 45º).
2) The innermost node of one electron 'links' to the outermost node of the other electron.
3) All 'links' (or 'rays') are parallel with incremental (but not equal) separation.

These rules can be applied for all N pairs of interactions, in a total interaction that reflects the rule "the closest negative interacts with the furthest positive". The extrema in this total interaction can be described in terms of interaction pairs when the impulse $<Z'_2 : A_1>$ needs to communicate between node $Z'_2 \Leftrightarrow (-\underline{x}_N , -t_N)$ & $A_1 \Leftrightarrow (\underline{x}_1 , t_1)$. The complementary impulse $<Z'_1 : A_2>$ communicates between $Z'_1 \Leftrightarrow (\underline{x}_N , -t_N)$ & $A_2 \Leftrightarrow (-\underline{x}_1 , t_1)$. The impulse $<A'_2 : Z_1>$ needs to communicate only between node $A'_2 \Leftrightarrow (-\underline{x}_1 , -t_1)$ & $Z_1 \Leftrightarrow (\underline{x}_N , t_N)$; its corresponding or complementary impulse $<A'_1 : Z_2>$ communicates between $A'_1 \Leftrightarrow (\underline{x}_1 , -t_1)$ & $Z_2 \Leftrightarrow (-\underline{x}_N , t_N)$. This is illustrated in the following diagram.

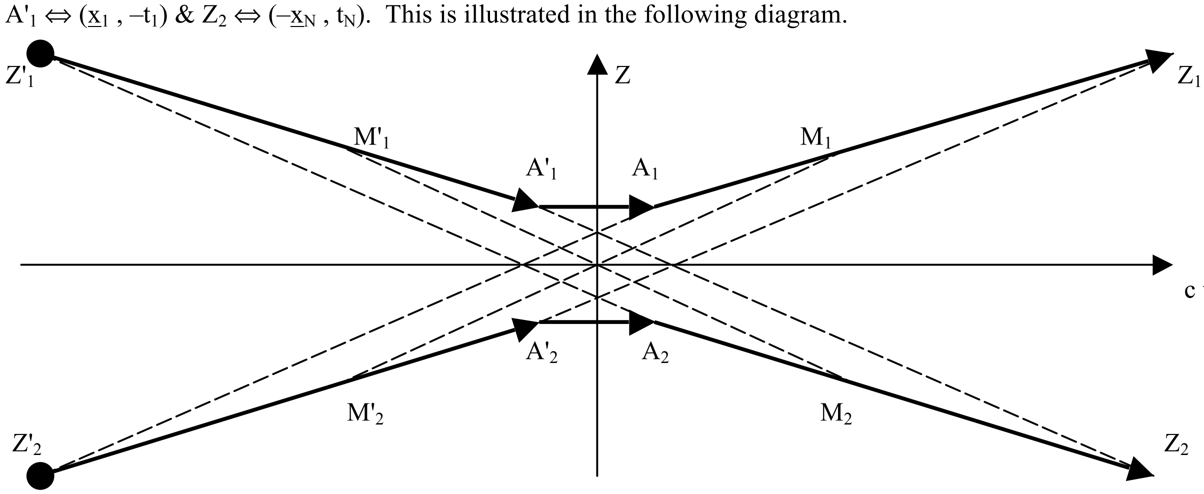

Fig. 8 Complete (Maximum) Symmetric Interaction Schematic.

6.3.3 THE INTERACTION VIEW

The complete set of interactions between two electrons across time may be viewed from two complementary perspectives, referred to hereafter as the *Interaction View* and the *Historical View*. The *Interaction View*, which is adopted more often in this research programme, focuses on each pair-wise interaction that extends between each electron and inevitably introduces a symmetric view of the two times involved, one for each electron; these time-pairs are then examined consecutively, as the complete interaction proceeds. On the other hand, the *Historical View* looks at the interaction from the perspective of one of the electrons at one single time that evolves throughout the whole interaction. This has been the traditional approach since Newton and it is strongly encouraged by the unique perspective that every single human-being personally uses to experience reality (hence the name). It is not a coincidence that the *Historical View* leads to simpler mathematics. However, it is the contention here that the resulting problems and confusions have been too high a price to pay for this asymmetry.

In the *Interaction View*, each smallest component of the complete interaction is always presented in symmetric pairs [k&n], where the interaction sequence number 'n' is used as an identification index; its immediate successor is then [k+1 & n+1]. Each matched pair of interaction events is sometimes referred to here as a '*photino*' but it is critical to always remember that this singular noun does not reflect any real entity (like the conventional 'photon') but is simply a mathematical abstraction. This set of 'photinos' was analyzed in section 6.3.1, where the set of N possible interactions was given by:

$$\{\, [-N \,\&\, 1]\,, [-N+1 \,\&\, 2]\,,\ [-N+2 \,\&\, 3\,]\,, \ldots\,,\ [\,k \,\&\, n\,]\,, \ldots\,,\ [-2 \,\&\, N-1]\,, [-1 \,\&\, N]\,\}.$$

The general formula for any interaction-pair [k & n] is : $k = -N + n - 1$ where $\{n = 1, 2, \ldots, N\}$.

The previous paper [4] derived the *Space-Time Integrity Condition* (see 6.4); this defined the constraints on the interaction time intervals for consecutive interactions in terms of the post-interaction velocities in terms of the *Interaction Constant* *c*:

$$(\,\underline{c} - \underline{v}_n\,)\,\Delta T_n = (\,\underline{c} - \underline{v}'_k\,)\,\Delta T'_k$$

Here, each electron's velocity $\underline{v}_n$ is defined as 'just after' the n^{th} interaction, which is also its value at the mid-time $\mathcal{T}_n$. In this view, both electrons slow down equally whenever they approach each other during their interaction and speed up while they are separating to complete the full interaction. Each electron is therefore losing kinetic energy, at the same rate, during the 'inbound' phase and regaining it on the 'outbound' phase. The kinetic energy of each electron (and together) is only conserved after the complete set of interactions is over but **not** during the interaction itself.

The metaphor here is that each electron instructs its 'speed-bank' on a daily basis to issue a post-dated cheque to the other electron while removing the 'funds' (defined speed-change) immediately from the 'account' when each cheque is written. When each cheque's due-date comes around each electron 'deposits' that particular cheque and recovers the original funds (speed) committed.

6.3.4 INTERACTION INVARIANCE

The interaction nodes may be labeled asymmetrically, using only positive indices running consecutively from 1 to N on the outbound phase and primed positive integers from 1′ to N′ on the inbound phase, so that N is furthest from the 'origin' (time of closest approach) while N′ is the closest node to the origin. The index 'n' identifies the n^{th} interaction between the two electrons in ascending time order. It seems a reasonable extrapolation of Newton's Second Law of Motion, in its impulse formulation, to propose that each and every interaction leaves them globally unchanged from before the interaction occurred ($t_1 = t_n - \delta t$ & $t_2 = t'_n - \delta t$) until after it has completed ($t_1 = t_n + \delta t$ & $t_2 = t'_n + \delta t$). In other words, it is proposed here that the combined motion through space of these two interacting electrons is kinematically invariant across each of the instants of the interaction in any inertial reference frame. If this were the only interaction between them then the world would be unchanged.

This is illustrated in the following diagram.

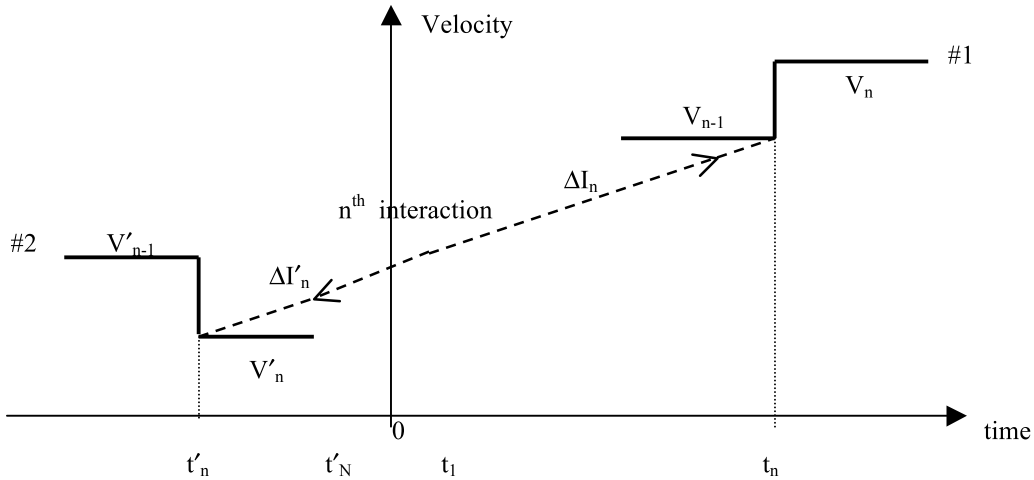

Fig. 9 Semi-Interaction ('photino').

The *Invariance* Hypothesis is: Total.Velocity.Before = Total.Velocity.After

Thus: $\underline{V}_1[t_n - \delta t] + \underline{V}_2[t'_n - \delta t] = \underline{V}_1[t_n + \delta t] + \underline{V}_2[t'_n + \delta t]$ or $\underline{V}_1[t_{n-1}] + \underline{V}_2[t'_{n-1}] = \underline{V}_1[t_n] + \underline{V}_2[t'_n] = \text{constant}$

Now $\underline{V}_2[t'_1 - \delta t] = \underline{C}$ and $\underline{V}_1[t_1 - \delta t] = 0$ while $\underline{V}_2[t'_N + \delta t] = 0$ and $\underline{V}_1[t_N + \delta t] = \underline{C}$ So, the constant is $\underline{C}$.

The Velocity Invariance Hypothesis therefore implies: $\underline{V}_1[t_n] + \underline{V}_2[t'_n] = \underline{C}$ where $\underline{C} = c\,(\underline{x}_N - \underline{x}'_1) \,/\, |\ (\underline{x}_N - \underline{x}'_1)\ |$

$$\therefore\ \underline{V}_1[t_n + \delta t] - \underline{V}_1[t_n - \delta t] = -\{\underline{V}_2[t'_n + \delta t] - \underline{V}_2[t'_n - \delta t]\}\ \therefore\ \Diamond[\ \underline{V}_1[t_n]\ ] = -\Diamond[\ \underline{V}_2[t'_n]\ ]\quad \therefore\ \Diamond[\ \underline{V}_1[t_n] + \underline{V}_2[t'_n]\ ] = 0$$

In contrast to Planck or Einstein, the present theory follows Newton and attributes a universal, scalar *m* to represent the measure of the inertial mass of every electron that does **not** change in magnitude or direction under any circumstances. This permits Newton's classic definition of an electron's momentum to be adopted : $\underline{P} = m\ \underline{V}$. Multiplying the Invariance Equation by this constant defines the total (two-time) momentum of the pair of interacting electrons.

Definition: **Total Two-Electron Momentum** $\underline{P}_{12}[t_n , t'_n] \equiv m\,\underline{V}_1[t_n] + m\,\underline{V}_2[t'_n] = \underline{P}_1[t_n] + \underline{P}_2[t'_n]$

So, an alternative formulation of the Invariance Hypothesis is that each interaction leaves the total momentum unchanged.

Total.Momentum.Before = Total.Momentum.After or $\Diamond\underline{P}_{12}[t_n , t'_n] = 0$

The single two-time interaction $\Delta\underline{I}_{12}[t_n , t'_n]$ is decomposed into an impulse $\Delta\underline{I}_1$ occurring at time t_n and a complementary impulse $\Delta\underline{I}_2$ at time t'_n . This may be viewed as the 'originating' electron (#2) 'sending' the impulse $\Delta\underline{I}_1$ to electron #1 that instantly changes its velocity (and momentum), while the act of 'emission' causes a reaction $\Delta\underline{I}_2$ on electron #2 (as if had been returned from electron #1) that changes its velocity and momentum by an equal amount. Thus, using the impulse form of Newton's Second Law of Motion for each electron:

$$\Delta\underline{I}_1[t_n] = \Diamond\underline{P}_1[t_n] \text{ and } \Delta\underline{I}_2\,[t'_n] = \Diamond\underline{P}_2[t'_n]\ \therefore\ \Delta\underline{I}_{12}[t_n , t'_n] = \Delta\underline{I}_1[t_n] + \Delta\underline{I}_2\,[t'_n] = 0\ \therefore\ \Delta\underline{I}_2\,[t'_n] = -\Delta\underline{I}_1[t_n]$$

This latter equation is the two-time extension of Newton's Third Law of Motion for the asynchronous interaction between two electrons: the reaction is equal and opposite to the original action (or impulse).

Global Energy Invariance

A similar analysis can be performed for the other invariant: the squares of the velocity across each interaction.

The local *Velocity-Square Invariance* Hypothesis might be: Total.(Velocity)^2.Before = Total.(Velocity)^2.After

Thus: $V_1^2[t_n - \delta t] + V_2^2[t'_n - \delta t] = V_1^2[t_n + \delta t] + V_2^2[t'_n + \delta t]$ or $V_1^2[t_{n-1}] + V_2^2[t'_{n-1}] = V_1^2[t_n] + V_2^2[t'_n] =$ constant

Now $\underline{V}_2[t'_1 - \delta t] = \underline{c}$ and $\underline{V}_1[t_1 - \delta t] = 0$ while $\underline{V}_2[t'_N + \delta t] = 0$ and $\underline{V}_1[t_N + \delta t] = \underline{C}$ So, the constant is c^2 .

The Velocity.Squared Invariance Hypothesis therefore would imply: $V_1^2[t_n] + V_2^2[t'_n] = c^2$

$$\therefore\ V_1^2[t_n + \delta t] - V_1^2[t_n - \delta t] = -\{V_2^2[t'_n + \delta t] - V_2^2[t'_n - \delta t]\}\ \therefore\ \Diamond[\,V_1^2[t_n]\,] = -\Diamond[\,V_2^2[t'_n]\,]\ \therefore\ \Diamond[V_1^2[t_n] + V_2^2[t'_n]\,] = 0$$

This allows the definition of the 'interaction' (two-time) kinetic energy of the pair of interacting electrons.

Definition: *Interaction Two-Electron Kinetic Energy* $\mathbf{K}_{12}[t_n , t'_n] \equiv \frac{1}{2} m\, V_1^2[t_n] + \frac{1}{2} m\, V_2^2[t'_n] = \mathbf{K}_1[t_n] + \mathbf{K}_2[t'_n]$

An alternative formulation of the Energy Invariance Hypothesis is that each interaction leaves the total energy unchanged.

Total.Kinetic-Energy.Before = Total.Kinetic-Energy.After or $\Diamond\ \mathbf{K}_{12}[t_n , t'_n] = 0$

The 'originating' electron (#2) 'sends' the impulse $\Delta\underline{\mathbf{I}}_1$ to electron #1 that instantly changes its velocity (and kinetic energy), while the act of 'emission' causes a reaction $\Delta\underline{\mathbf{I}}_2$ on electron #2 (as if had been returned from electron #1) that changes its velocity and kinetic energy by an equal amount. Thus, using the impulse form of Newton's Second Law of Motion for each electron gives the discrete form of Thompson & Tait's "impulse rule" [165]:

$$\Diamond\mathbf{K}_1[t_n] = \langle \underline{V}_1[t_n] \rangle \bullet \Diamond\underline{P}_1[t_n] \text{ and } \Diamond\mathbf{K}_2[t'_n] = \langle \underline{V}_2[t'_n] \rangle \bullet \Diamond\underline{P}_2[t'_n]\ \therefore\ \Delta\,\mathbf{K}_{12}[t_n , t'_n] = \Delta\mathbf{K}_1[t_n] + \Delta\mathbf{K}_2\,[t'_n] = 0$$

$$\therefore\ \Delta\underline{\mathbf{I}}_1[t_n] \bullet (\,\langle \underline{V}_1[t_n] \rangle + \langle \underline{V}_2[t'_n] \rangle\,) = 0 \qquad \therefore\ \Delta\underline{\mathbf{I}}_1[t_n] \bullet \underline{C} = 0$$

This final equation would indicate that if the interaction kinetic energy is to be conserved across <u>each</u> discrete, asynchronous interaction between two electrons then the impulse must be **transverse** to the line-of-centers of the two electrons at the two times of the interaction. Although this is reminiscent of Maxwell's transverse view of EM radiation, this result is in fact a contradiction, as the impulse $\Delta\underline{\mathbf{I}}_1(t_n)$ must be parallel to the electron's velocity $\underline{V}_1(t_n)$ to change its magnitude and hence its kinetic energy. Thus, the 'Energy Invariance' hypothesis must be rejected here. In summary, the total two-time velocity and momentum (of both electrons) are conserved locally at the individual interaction level [T_n & T_k] but the kinetic energy is only conserved globally across <u>all</u> of the consecutive interactions when all the *sent* impulses have been finally *received*.

6.3.5 THE HISTORICAL VIEW

The individual momentum and kinetic energy of each electron (here labeled '1' and '2') were defined in section 5.4.1 while the combined total momentum and total kinetic energy at the **one** time $\mathcal{T}_n$, designated as $\underline{P}_n$ and K_n , have been defined as:

Total.Momentum $\underline{P}[T_n] \equiv \underline{P}[1\!: T_n] + \underline{P}[2\!: T_n] = \underline{P}_n$ **Total.Kinetic.Energy** $\mathbf{K}[T_n] \equiv \mathbf{K}[1\!: T_n] + \mathbf{K}[2\!: T_n] = \mathbf{K}_n$

The symmetry defined into the SIRF means that: $\underline{P}_n = 0$ and $\mathbf{K}[1\!: T_n] = \mathbf{K}[2\!: T_n] = \frac{1}{2}\ \mathbf{K}_n$

Since the *Historical* View looks at the interaction only from the perspective of <u>one</u> of the electrons at <u>one</u> single time, the convention here will be to focus only on electron #1. In order to re-establish the link to the one particle model of classical physics, where the '*total energy*' $\mathbf{E}$ is conserved at all times, it is necessary to introduce the concept of '*potential energy*' $\mathbf{U}$. This concept is introduced here only as a 'book-keeping' device and has even less ontological significance than the kinetic energy of a single electron; in this case, <u>potential energy is a mathematical technique for viewing the complete interaction between two electrons from a single-time (& usually single-particle) perspective</u>.

Definition: **Total.Energy** $\mathbf{E}[T_n] \equiv \mathbf{K}[T_n] + \mathbf{U}[T_n]$ or $\mathbf{E}_n = \mathbf{K}_n + \mathbf{U}_n$

In the banking metaphor (introduced above) the potential energy U_n may be viewed here as the 'coins' locked up (in-transit) at time $\mathcal{T}_n$ by the banking system and are not accessible to anyone (not even the bankers!). Now, this potential energy is a function of the interaction between the two electrons but it is very convenient if it is divided equally between them. This is identical to the 'separability' requirement that was identified as necessary in section 5.3.3 of the previous paper [4], which analyzed the continuous interaction between two electrons; so: $U[1{:}\,T_n] = U[2{:}\,T_n] = \frac{1}{2}\, U_n$

Thus, *energy conservation* means: $E_n = E_{n+1} = E_0 \;\therefore\; \Delta E_n = 0 \;\therefore\; \Delta K_n = -\Delta U_n$ or $K[1{:}\,T_n] + U[1{:}\,T_n] = \frac{1}{2}\, E_0$

The minimum value of the potential energy is zero when each electron is traveling at light-speed *c*, as these two electrons can no longer interact (see section 5.2.4). In this situation, each electron's kinetic energy is $\frac{1}{2}\,mc^2$ so that $E_0 = mc^2$.

Coulomb's Model

Maxwell's theory of EM was really a model of magnetism (see [6] section 3.2). He simply adopted Coulomb's model of instantaneous electrical interaction as his own component of the electric field. In the *Historical View*, at any time T_n the instantaneous separation of the electrons is defined as R_n, then the electrostatic potential U_n was defined as: $U_n = e^2 / R_n$. The combined kinetic energy of the two electrons is K_n for a total energy E_n, which is now defined as constant E_0.

$$E_0 = K_n + U_n \quad \therefore \quad mc^2 = 2\,(\tfrac{1}{2}\,m\,v_n^2) + e^2 / R_n \quad \therefore \quad (c^2 - v_n^2)\,R_n = e^2 / m \quad \therefore \quad R_0 = e^2 / mc^2 = \Lambda_0$$

In this model, the maximum velocity, *c* only occurs when the two electrons are infinitely far apart. Taking differences gives:

$$c^2\,\Delta[R_n] = \Delta[\,v_n^2\,R_n\,] \quad \text{or} \quad (c^2 - \langle v_n^2 \rangle)\,\Delta R_n = \langle R_n \rangle\,\Delta[\,v_n^2\,]$$

6.3.6 ELECTROMAGNETIC POTENTIALS

Since this is a model of electro-magnetism, it seems appropriate to relate the particle's potential energy U, in the *Historical View*, to the electro-magnetic scalar potential ϕ that was discussed in the continuous model of electricity ([6] section 6.5) as both are single-point models of nature. However, rather than follow convention and continue to view electricity in terms of continuous electric charge density ρ, electricity is viewed only as point electrons, each carrying a constant electric charge *-e*. Therefore, for a single electron (say #1), it contributes an electric current $\underline{J}$ (not density) and experiences a potential ϕ :

$$\underline{J}[1{:}T_n] \equiv -e\;\underline{V}[1{:}T_n] \quad \text{and} \quad U[1{:}T_n] \equiv e\;\phi[1{:}T_n]$$

Rather than follow Maxwell's final Lagrangian approach to variations in a luminiferous æther as described in his famous *Treatise* [60], this research programme returns to Maxwell's *Dynamical* paper [23] published in 1865, where he introduced his central concept of the electro-kinetic momentum, $\underline{A}$. Here, Maxwell's electromagnetic hypothesis is directly related to the change in the momentum of the 'target' electron.

$$\Diamond\underline{P}[1{:}T_n] \equiv -e\;\Diamond\underline{A}[1{:}T_n] / c \quad \text{or} \quad m\,c\,\Delta\underline{V}_n = -e\;\Delta\underline{A}_n$$

Now $\Diamond K[1{:}T_n] = \frac{1}{2}\,m\,(V_{n+1}^2 - V_n^2) = m \langle V_n \rangle \Delta V_n = m\,(V_n + \frac{1}{2}\,\Delta V_n)\,\Delta V_n \approx m\,V_n\,\Delta V_n = -\Diamond U[1{:}T_n] = -e\;\Diamond\phi[1{:}T_n]$

$$m\,\underline{V}_n \bullet \Delta\underline{V}_n = -e\,\Delta\phi_n \quad \text{whenever} \quad \Delta V_n \ll V_n \qquad \text{or} \quad c\,\Delta\phi_n = \langle \underline{V}_n \rangle \bullet \Delta\underline{A}_n$$

The earlier results (section 6.2 in [6]) expect that a Classical EM require a full Lorenz relationship: $c\;\underline{A}_n = \underline{V}_n\,\phi_n$

If **both** of these relationships are assumed to be valid, then: $c\;\Delta\underline{A}_n = \Diamond[\,\underline{V}_n\,\phi_n\,] = \langle \underline{V}_n \rangle \Delta\phi_n + \Delta\underline{V}_n \langle \phi_n \rangle$

$$\therefore \quad (c^2 - \langle V_n \rangle^2)\,\Delta\phi_n = \langle \underline{V}_n \rangle \bullet \Delta\underline{V}_n \langle \phi_n \rangle \quad \text{or approximately:} \quad \Delta\phi_n / \phi_n = V_n\,\Delta V_n / (c^2 - V_n^2)$$

$$\text{and} \quad (c^2 - \langle V_n \rangle^2)\,\underline{V}_n\,(\langle \underline{V}_n \rangle \bullet \Delta\underline{A}_n) = \langle \underline{A}_n \rangle\,c^2\,\Delta V_n \quad \text{or approximately:} \quad \Delta A_n / A_n = c^2\,\Delta V_n / (V_n\,(c^2 - V_n^2))$$

6.4 ONE-DIMENSIONAL SOLUTIONS

This paper will only investigate the one-dimensional interaction between two electrons, as this will be sufficient to recover the well-known relativistic mechanics derived from Planck's Proposal for relativistic momentum (section 3.2) that only used a single spatial dimension (parallel to the velocity). The convention followed here will be that the direction of motion is termed the 'longitudinal' direction and is assigned to the 'z' axis, where the speed in this direction will be designated 'u'.

6.4.1 'THE TERRIBLE TWINS'

The T-T Model

The '*Terrible-Twins*' (T-T) model is a mathematical idealization consisting of only two negatively charged point electrons, sufficiently isolated from any other electrons, that the complete interaction only occurs between the two electrons. Both electrons are moving one-dimensionally initially towards each other at high-speed. The challenge is simply to calculate the trajectories across time. It is called the T-T model because it is an embarrassment to both classical and quantum physicists, as this is the simplest two-body problem involving linear motion that resists easy solutions by the standard models of EM. When this system is analyzed from the *Historical View* (single-time) then both electrons are slowing down as they approach each other, with both losing kinetic energy. After reaching their minimum separation, both reverse direction and accelerate away from each other regaining their kinetic energy. Field theory views the missing energy ('potential energy') as going into or out of the field surrounding the particles. Clerk-Maxwell had analyzed a similar ('axial') model in terms of Weber's instantaneous action-at-a-distance EM theory [164] and rejected this non-field theory simply on the grounds that it failed to conserve energy at **all** times, although Weber's theory was able to describe all the same EM phenomena as Maxwell's own theory. When physicists view 'energy' as an entity then they must logically conclude that the field is real – a conclusion that was universal amongst Maxwell's followers, such as Michelson, but seems to escape modern field theorists.

No Known Solutions

There appear to be no published calculations, either classical or quantum, that predict the minimum distance achieved when two equally charged electrons approach each other from a configuration where their initials relative speed equals *c*. As a corollary, there is no extant calculation of the time to complete the 'round trip' from initial configuration to the final one.

The Canonical Solution

The first interactions after reaching the closest separation (at time zero) occur at t_1 (or $t = \mathcal{T}_0$) when electron 'A' is at z_1, a distance $\mathcal{d}/2$ above the origin (on the positive z-axis) and electron 'B' is at a distance $\mathcal{d}/2$ below the origin (i.e. on the negative z-axis). The correlated interaction nodes for this interaction-pair occur when electron 'B' is at z_{-N} (or $-\mathcal{D}/2$) at the earliest time t_{-N} (or $t = -\mathcal{T}$) while electron 'A' has a final interaction when it is at z_N (or $\mathcal{D}/2$) at the latest time t_N ($t = \mathcal{T}$). The one-dimensional form of the two-electron '*Space-Time Integrity*' (STI) condition (see section 6.3.1) is defined in terms of the discrete speed values u_n (defined in the z-direction): $z_{n+1} - z_n = \Delta z_n = u_n \Delta t_n$ where $t_{n+1} - t_n = \Delta t_n$.

$$(c - u_n) \Delta t_n = (c - u'_k) \Delta t'_k \quad \text{(the two-electron } \textit{STI Condition}\text{) where: } k = -N + n - 1 \quad \text{where } \{n = 1, 2, \ldots, N\}$$

$$(c - u_n) \Delta t_n = (c - u_{N-n}) \Delta t_{N-n} \quad \text{(the one-electron } \textit{STI Condition}\text{) where: } \{n = 1, 2, \ldots, N - 1\}$$

The simplest impulse model (section 6.2.3) preserves the extended form of Newton's Third Law of Motion across each sub-interaction (i.e. it conserves momentum) simply by assuming that every impulse has the same magnitude $\Delta \mathbf{I}_0$, no matter how far apart the electrons are separated; in other words, this is a universal impulse characteristic of all electrons at all times. This impulse parameter is just another restatement of the finite nature of the minimum and maximum electron speeds: 'c' and 'b'; where 'c' is the *Interaction Constant* (see section 5.2.4) and the minimum speed 'b' has been defined (section 6.3.1) as the speed each electron first achieves after its change in direction at t = 0 when n = 1: $c = u_N$ and $b = u_1$

Alternatively: $N = c / b$ and $\Delta \mathbf{I}_0 = \Delta p_n = m \Delta u_n$ (for all n including n = 1) so: $\Delta \mathbf{I}_0 = m b = m c / N$

The speed increments Δu_n are all equal, so: $\Delta u_n = b$. This has the generic solution: $u_n = n b = c (n / N)$

Substituting into the one-electron STI condition produces the *Universal Temporal Interval* equation: $(N - n)\,\Delta t_n = n\,\Delta t_{N-n}$

For n = 1: $(N - 1)\,\Delta t_1 = \Delta t_{N-1}$ It is always assumed that: $N >> 1$ so that Δt_1 is much smaller than Δt_{N-1} or $\Delta t_1 << \Delta t_{N-1}$.

As Δt_1 is the smallest time interval, then this suggests its identification with the *chronon*, so: $\Delta t_1 = \tau$.

This finally provides two solutions to the *Universal Temporal Interval* equation: called here the 'linear' and 'harmonic'.

a) Linear: $\Delta t_n = n\,\tau$ b) Harmonic: $\Delta t_n = \Delta t_{N-1} / (N - n)$

Now if every time interval is required to be an integer number of *chronons* then the linear solution automatically satisfies this extra condition but the only way the harmonic solution can satisfy this condition is to assume that: $\Delta t_{N-1} = (N-1)!\,\tau$. If N is much greater than one (reasonable) then: $\Delta t_1(\text{Harmonic}) = (N-2)!\,\tau = (N-2)!\,\Delta t_1(\text{Linear})$ or $\Delta t_1(H) >> \Delta t_1(L)$. These will be investigated using the 'Sum-Diff. Identity' and the 'Equal-Difference' set results (see section 5.3.1):

a) Linear

$$z_{n+1} = z_0 + \Sigma^n \Delta z_k = d/2 + \Sigma^n u_k \Delta t_k = d/2 + b\,\tau\,\Sigma^n k^2 = d/2 + n\,(n+1)\,(2n+1)\,c\,\tau / 6N$$

Using the definition of the *luxon* (introduced in 6.2.1) $\Lambda = c\,\tau$, then: $z_{n+1} = n\,(n+1)\,(2n+1)\,\Lambda / 6N + d/2$

Now, for $n = N - 1$ then: $z_N = \mathcal{D}/2$ (and, as is likely, $\mathcal{D} >> d$), so: $\mathcal{D} \approx (N-1)\,(2N-1)\,\Lambda / 3$ or $\mathcal{D} \approx 2\,N^2\,\Lambda / 3$

$$t_{n+1} = t_0 + \Sigma^n \Delta t_k = \mathcal{T}_0 + \tau\,\Sigma^n k = \mathcal{T}_0 + \tau\,\Sigma^n k^2 = \tau/2 + n\,(n+1)\,\tau / 2 \quad \text{assuming } \mathcal{T}_0 = \tau / 2 .$$

Again, for $n = N - 1$ then: $t_N = \mathcal{T}$ (and, as is likely, $\mathcal{T} >> \tau$), so: $\mathcal{T} \approx N\,(N-1)\,\tau / 2$ or $\mathcal{T} \approx N^2\,\tau / 2$

This suggests an 'effective speed' (written $\mathcal{V}_{eff}$) for each electron to separate to their maximum speed 'c' from rest.

Definition: Effective-Speed $\mathcal{V}_{eff} \equiv z_N / t_N$ $\therefore$ $\mathcal{V}_{eff} \approx 2/3\ c$

This result indicates that the electron spends most of its time at high-speeds (close to 'light-speed') after the 'rebound'.

The single electron kinetic energy, in the SIRF, after time t_n is $K_n = \frac{1}{2}\,m\,(u_n)^2$; remembering that $u_0 = 0$ so that $K_0 = 0$.

As a 'zero-based equal-difference' set $\{u_k\}$: $\Delta[u_k * u_k] = 2 < u_k > \Delta u_k = (2\,k+1)\,b^2$ using $< u_k > = (k + \frac{1}{2})\,b$ & $\Delta u_k = b$.

$$K_{n+1} = K_0 + \Sigma^n \Delta K_k = \tfrac{1}{2}\,m\,\Sigma^n \Delta[u_k * u_k] = \tfrac{1}{2}\,m\,b^2\,\Sigma^n (2\,k+1) = \tfrac{1}{2}\,m\,b^2\{n(n+1) + n\} = \tfrac{1}{2}\,m\,c^2\,n\,(n+2) / N^2$$

The change in the electron's kinetic energy, in this model, is: $\Delta K_n = (n + \frac{1}{2})\,m\,c^2 / N^2$ hinting at Planck's SHM result.

The maximum 'below light-speed' kinetic energy occurs at $n = N - 2$ when: $K_{N-1} = \frac{1}{2}\,m\,c^2\,(N-2) / N = \frac{1}{2}\,m\,c^2\,(1 - 2/N)$.

The last term can be viewed as the <u>last</u> 'energy quantum' in transit (designated ε) exchanged in the interaction: $\varepsilon = m\,c^2 / N$.

Since the velocity is linear with the interaction count 'n' then $p_n = mv_n = n\,m\,b$ then: $\Delta K_n = b\,p_n$ for $n >> 1$.

b) Harmonic

In order to simplify the algebra the final interval will be replaced with a single symbol, so: $\xi_0 \equiv \Delta t_{N-1}$ & $\Delta t_n = \xi_0 / (N - n)$

$$t_{n+1} = t_0 + \sum_{k=0}^{k=n} \Delta t_k = \mathcal{T}_0 + \xi_0 \sum_{k=1}^{k=n} 1/(N-k) = \mathcal{T}_0 + \xi_0 \,(H_{N-1} - H_{N-n-1}) \quad \text{where} \quad H_n = \sum_{k=1}^{k=n} 1/k$$

Here, H_n is the 'Harmonic' function or n^{th} harmonic number, where: $H_n = \gamma + \ln(n) + 1/2n - 1/12n^2 + O(1/n^3)$ with the Euler-Mascharoni constant $\gamma \approx 0.577$ N.B. This is not defined for n = 0 but can be extended to this value with: $H_0 = 0$.

Thus, for $n = N - 1$ (and $N >> 1$) then: $t_N = \mathcal{T}_0 + \xi_0 H_{N-1} = t_1 + \xi_0 H_{N-1} \approx \xi_0 H_N$ or $\mathcal{T} \approx \tau\ N!\ \ln(N)$

This indicates that if all the interaction intervals must be integer multiples of τ then: $\mathcal{T}_H \approx \mathcal{T}_L\ N!\ \ln(N)$; so that the harmonic solution takes vastly longer for the electrons to reach their maximum speed 'c'; minimization would then indicate that the linear solution is the one found in Nature when electrons are free to participate in multiple, consecutive interactions. However, the small number range (e.g. N = 6) has some interesting properties based on the observation that $H_5 = 137/60$.

6.4.2 RECOVERING PLANCK

The discrete nature of the electron interaction means that all kinetic and dynamic quantities of each electron (e.g. V_n, P_n, K_n) can be calculated at either the interaction times T_n **or** at the mid-points between these times $\mathscr{T}_n = ½\,(T_{n+1} + T_n)$. In the present theory, by design, electrons may only interact at one of their interaction times when they are at the spatial location z_n (i.e. when they are 'on the light-cone' of their interacting companion, which may be the intervening 'measurement' electron) then the kinematical values are always calculated from the appropriate interaction times and locations. Planck assumed that the velocity changed continuously (as he proposed a constant force F_0 - see section 3.2.1) at each 'micro-time' $t_\mu = \mu\tau$. This continuum limit will only be taken here at the end of the calculation when the duration of the *chronon* goes to zero ($\tau \to 0$).

In order to compare these two models, it is only necessary that the unique speeds at each of mid-range points be equal as both theories are built around the real interaction points at T_n, when the electron is located at x_n. In the linear model, these temporal values are given by:

$$T_n = ½\,(n^2 - n + 1)\,\tau \qquad \text{while} \quad \Delta T_n = T_{n+1} - T_n = \eta_n \tau \quad \therefore\ \eta_n = n$$

$$\mathscr{T}_n = \langle T_n \rangle = ½\,(n^2 + 1)\,\tau = t_\mu = \mu_n \tau \qquad \text{so} \quad \Delta\mathscr{T}_n = \mathscr{T}_{n+1} - \mathscr{T}_n = n\,\tau = \Delta T_n \quad \therefore\ \mu_n = ½\,(n^2 + 1)$$

Although Planck assumed that the velocity (and momentum) changed continuously with time this will be processed here only discontinuously at first by a series of discrete impulses $\Delta \mathbf{I}_\mu$ at each micro-time t_μ that changes the electron's speed from $v_{\mu-1}$ to v_μ , where v_μ is the micro-speed in this model. Equivalence is achieved if: $v_\mu = u_n$ at $\mathscr{T}_n = \langle T_n \rangle$ and $\Delta t_\mu = \tau$. The two models are summarized in the following diagram.

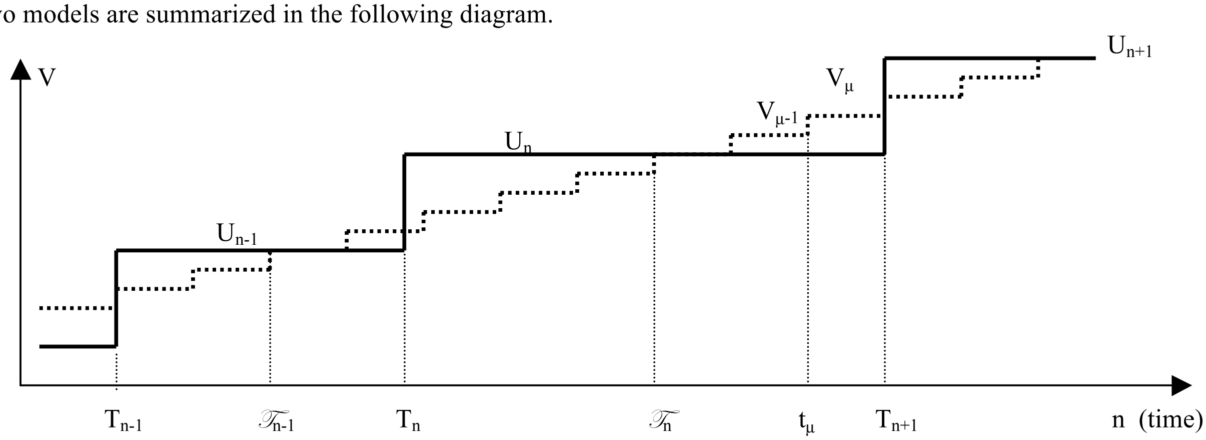

Fig. 10 Equivalent Impulses.

The limit process is based on the use of the symmetric '*chronon* difference' (operator $\mathfrak{D}$ introduced in section 5.4.4) operating on Planck's definition of the electron's relativistic momentum P (see section 3.2): $P_\mu = M_\mu v_\mu$.

$$F_0 [t = t_\mu] = d [P_\mu] / dt = \lim_{\tau \to 0}\{ \mathfrak{D} P[t_\mu - \tau/2] \} = \lim_{\tau \to 0}\{(P[t_\mu + \tau/2] - P[t_\mu - \tau/2]) / \tau \}$$

Planck's Proposal cannot be Linear

It will first be shown that Planck's model cannot be approximated by a series of equal impulses occurring at every possible micro-time. When these micro-changes are simply equal, they can be added together to produce the same, total change. Since, here, the speeds change discontinuously at each t_μ then Newton's (micro) Law II becomes: $F_0 \tau = \Delta\mathbf{I}_0 = \Diamond[P_{\mu-1}]$ **If** both v_μ and M_μ change **linearly** then they are both equal-difference series (see section 5.3.1):

$$F_0 \Delta\mathcal{T}_{n-1} = F_0 (n \tau) = n (F_0 \tau) = n \Delta\mathbf{I}_0 = \Delta\mathbf{I}_n = \Diamond^n [P_{\mu-1}] = n \Diamond[P_{\mu-1}] = \Delta[P_{n-1}] = \Delta[M_{n-1} v_{n-1}]$$

Using the finite difference results (5.3.1): $\Delta[M_{n-1} v_{n-1}] = M_{n-1} \Delta v_{n-1} + v_{n-1} \Delta M_{n-1} + \Delta M_{n-1} \Delta v_{n-1}$

Substituting the linear solution above with $\Delta\mathbf{I}_0 = m\, b$ and $\Delta v_{n-1} = b$ then: $n\, m = M_{n-1} + n \Delta M_{n-1}$
The 'rest' mass can be eliminated by assuming a solution of the form: $M_n = m F_n$ so this becomes: $n = F_{n-1} + n \Delta F_{n-1}$
Except for small n, this difference equation has the solution: $F_n = n / 2$ producing the incorrect result: $M_n = m\, n/2$. In effect, Planck needs the electron to accelerate at every *chronon* so that the velocity compounds continuously.

Planck's Model needs the Continuum

The previous analysis indicates that Planck's variable-mass model needs an increasing amount of each and every impulse to contribute to the increase in the assumed relativistic mass as the velocity increases, so that there will be less of the impulse 'left over' to simply increase the speed. This implies that this model needs to introduce variable change at the micro-time interval Δt_μ, not just once during each actual interaction interval ΔT_n. Thus, the discrete form of Planck's equation of motion becomes:

$$\Delta\mathbf{I}_\mu = F_0 \Delta t_{\mu-1} = \Diamond[P_{\mu-1}] \qquad \therefore\ F_0 \tau = \Diamond[M_{\mu-1} v_{\mu-1}] = \langle M_{\mu-1} \rangle \Diamond[v_{\mu-1}] + \langle v_{\mu-1} \rangle \Diamond[M_{\mu-1}]$$

Planck assumed that the work-done on the electron W by the 'external' force F_0 increased its total energy E (see 3.2), so over the 'micro-distance' $\Delta x_{\mu-1} = x[t_\mu + \tau/2] - x[t_\mu - \tau/2]$ which defines the average velocity $\langle v_{\mu-1} \rangle$ at t_μ :

$$\Delta x_{\mu-1} = x[t_\mu + \tau/2] - x[t_\mu] + x[t_\mu] - x[t_\mu - \tau/2] = v_\mu \tau/2 + v_{\mu-1} \tau/2 = \tau \langle v_{\mu-1} \rangle \quad \therefore\ \langle v_{\mu-1} \rangle = \Delta x_{\mu-1} / \tau = \Delta x_{\mu-1} / \Delta t_{\mu-1}$$

$$\therefore\ \langle v_{\mu-1} \rangle F_0 \tau = F_0 \Delta x_{\mu-1} = \Delta W_{\mu-1} = \langle v_{\mu-1} \rangle \{ \langle M_{\mu-1} \rangle \Diamond[v_{\mu-1}] + \langle v_{\mu-1} \rangle \Diamond[M_{\mu-1}] \}$$

Using the standard identity (twice): $\langle f_{\mu-1} \rangle = \frac{1}{2} (f_\mu + f_{\mu-1}) = \frac{1}{2} (f_{\mu-1} + \Delta f_{\mu-1} + f_{\mu-1}) = f_{\mu-1} + \Delta f_{\mu-1}$ & setting $\mu - 1$ to μ .

$$\therefore\ \Delta W_\mu = v_\mu \{ M_\mu \Delta v_\mu + v_\mu \Delta M_\mu \} + \text{Order}(\Delta^2) \qquad \therefore\ \Delta W_\mu \approx M_\mu v_\mu \Delta v_\mu + (v_\mu)^2 \Delta M_\mu$$

This final step illustrates the key requirement in this derivation that second-order changes can be ignored. Planck also assumed that the electron's total energy was related to its relativistic mass (see 3.2.1) or $E_\mu = M_\mu c^2$ or at the micro-level:

$$\Delta E_\mu = \Delta W_\mu = c^2 \Delta M_\mu \qquad \therefore\ \Delta M_\mu = M_\mu v_\mu \Delta v_\mu / (c^2 - v_\mu^2) = \tfrac{1}{2} M_\mu \Delta v_\mu \{1/(c - v_\mu) - 1/(c + v_\mu)\}$$

Using the 'log-diff' approximation from section 5.3.1 (if $\Delta v_\mu \ll v_\mu$): $\ln (\zeta_n / \zeta_0) \cong \sum_{k=1}^{k=n-1} \Delta\zeta_k / \zeta_k$ with $\zeta_k = c \pm v_\mu$ then:

$$\sum_{k=1}^{k=n-1} \Delta v_k / (c - v_k) \cong \ln (c / (c - v_n)) \qquad \text{and} \qquad \sum_{k=1}^{k=n-1} \Delta v_k / (c + v_k) \cong \ln ((c + v_n) / c)$$

$$\therefore \quad 2\sum_{k=1}^{k=n-1} \Delta M_\mu / M_\mu \;=\; 2\ln(M_n / M_0) \;=\; \ln(M_n / M_0)^2 \;\cong\; \ln(\, c / (c - v_n)\,) - \ln(\,(c + v_n) / c\,) \;=\ln(\, c^2 / (c^2 - v_n{}^2)\,)$$

Now, $M_n = M[v_n]$ and $M_0 = m[v_0] = m$ so, finally: $M[v_n] = m\,(1 - v_n{}^2 / c^2)^{-½} = m\,\mathcal{L}[v_n]$

This illustrates that Planck's Proposal **only** results in the relativistic mass formula in the continuum limit and not for finite changes in momentum. In other words, this is the mathematical result of applying differential calculus to a non-physical situation that uses a force, which is constant in magnitude and direction. This type of constant force **contradicts** both the inverse square Coulomb force or the Heaviside velocity-sensitive force that are central to electromagnetism. The use of a continuous force is also forbidden for inertial particles that only interact 'on their mutual light-cones'. This latter is just a re-statement of Einstein's misleading second postulate: that 'light' always 'travels' at the same constant speed. In other words, Planck's Proposal is a mathematical 'trick' for deriving a formula that has been used to explain Kaufmann's results. The fact that this formula seems to work for high-energy particles is a reflection of the reduction in the rate of absorption of periodic impulses rather than a confirmation of the time dilation effects of relativity.

6.4.3 RECOVERING EINSTEIN

The T-T model can be reformulated as a 'mass-transit' model in the *Historic View* that recovers Einstein's 'photon' idea. This uses the 1908 suggestion of Gilbert Lewis, that was discussed earlier (section 3.4.3), where a series of 'virtual' particles is transferred between the two electrons. Here, the second electron, say #2, at time T_k sends a '*photino*' to the target electron at time T_n so that it transfers at 'light-speed'. This *photino* (interaction) behaves like a particle of mass $\Delta\mathcal{M}_n$ with momentum $\Delta\mathcal{Q}_n$ and energy $\Delta\mathcal{E}_n$. When it is emitted, the sending electron loses mass while the receiving electron increases its mass by absorbing the *photino* for an enhanced mass of M_n and enhanced momentum P_n but with electron #1 still moving with a real speed of V_n with $P_n = M_n V_n$. The total aggregate of received *photinos* behaves like a single *photon* (but now spread over the total receiving time T_n). In the single-time, single electron view, at any time T_n there is only one electron moving at the observed speed V_n but if this electron has only its 'rest' mass *m* then there appears to be missing energy and momentum as the *photinos* are invisible. In this model, the photon 'dresses' the 'bare' electron, which behaves like a pseudo-particle with its mass increased by the preceding *n* received 'photinos', so that its effective mass and energy are M_n and E_n , where:

$M_n = m + \mathcal{M}_n$ and $E_n = K_n + \mathcal{E}_n$ Note: $\Delta M_n = \Delta\mathcal{M}_n$ as $\Delta m = 0$ and $M_0 = m$

The Lewis hypotheses (following Poynting) are:

$\Delta\mathcal{Q}_n = c\,\Delta\mathcal{M}_n$ and $\Delta\mathcal{E}_n = c\,\Delta\mathcal{Q}_n = c^2\,\Delta\mathcal{M}_n$

For the *photon* at time T_n (i.e. from n = 1, 2, … , n) : $\mathcal{Q}_n = c\,\mathcal{M}_n$ and $\mathcal{E}_n = c^2\,\mathcal{M}_n$

The 'bare' kinetic energy at time T_n is K_n so that: $\Delta K_n = m < V_n > \Delta V_n$ $\therefore$ $\Delta E_n = m < V_n > \Delta V_n + c^2\,\Delta\mathcal{M}_n$

<u>The next step is critical</u>: it assumes that when the pseudo-particle is subject to a near-instantaneous change in EM potential energy (i.e. a constant 'force') from the time $(T_n - \tau/2)$ through time $(T_n + \tau/2)$ then the 'dressed' electron is still subject to Thomson and Tait's 1879 impulse result for a point particle [165], so that: $\Delta E_n = < V_n > \Delta P_n$

This is equivalent to Planck's original assumption that the work done on the electron W by the 'external' force F_0 increased its total energy E (see 6.4.2). Around the time T_n (when the 'micro-time' is t_μ), where the 'micro-distance' $\Delta x_{\mu-1} = x[t_\mu + \tau/2] - x[t_\mu - \tau/2]$ defines the average velocity $< v_{\mu-1} >$, so:

$$\Delta W_{\mu-1} = F_0\ \Delta x_{\mu-1} = F_0\ \Delta t_{\mu-1}\ \Delta x_{\mu-1}\ / \Delta t_{\mu-1} = < v_{\mu-1} > F_0\ \Delta t_{\mu-1} = < v_{\mu-1} > \Delta P_{\mu-1} = \Delta E_{\mu-1}$$

At this particular time, this 'micro' result is now <u>assumed</u> to be comparable to: $\Delta E_n = < V_n > \Delta P_n$

But $\Delta P_n = \Delta[\, M_n V_n\,] = < M_n > \Delta V_n + \Delta M_n < V_n >$ while $< M_n > = m + <\mathcal{M}_n>$

$$\therefore \quad (\, c^2 - < V_n >^2\,)\,\Delta M_n = <\mathcal{M}_n> < V_n > \Delta V_n$$

The *linear* velocity solution of the above one-dimensional (T-T) model (see section 6.4.1) is now adopted: $V_n = n\,b$
The following discrete analysis illustrates all the approximations made in the standard continuum approach.

Here, $< V_n > = (n + ½)\,b$, so the following approximations will be assumed when $n >> 1$: $< V_n > \cong V_n$ and $<\mathcal{M}_n> \cong M_n$.

$$\therefore\ 2\,\Delta M_n / M_n \cong 2\,V_n\,\Delta V_n / (c^2 - V_n^2) = 2\,n / (N^2 - n^2) = 1/(N-n) - 1/(N+n)$$

The 'log-diff' approximation (see section 5.3.1) can be used here, as it has already been assumed that: $\mathcal{M}_n >> \Delta\mathcal{M}_n$.

$$\Delta\mathcal{M}_k / \mathcal{M}_k \cong \Delta[\ln(\mathcal{M}_k)] \quad \text{and} \quad 2\ln(\mathcal{M}_n / \mathcal{M}_0) \cong \sum_{k=0}^{k=n-1} 2\,\Delta\mathcal{M}_k / \mathcal{M}_k = \sum_{k=0}^{k=n-1} \{\, 1/(N-k) - 1/(N+k) \,\}$$

Now: $$\sum_{j=1}^{j=n-1} 1/(N+j) = \sum_{k=1}^{k=N+n-1} 1/k - \sum_{k=1}^{k=N} 1/k = H_{N+n-1} - H_N \cong \ln(N+n-1) - \ln(N) = \ln((N+n-1)/N)$$

And : $$\sum_{j=1}^{j=n-1} 1/(N-j) = \sum_{k=1}^{k=N-1} 1/k - \sum_{k=1}^{k=N-n} 1/k = H_{N-1} - H_{N-n} \cong \ln(N-1) - \ln(N-n) = \ln((N-1)/(N-n))$$

Here, the Harmonic function H_n (introduced in 6.4.1) has been used along with the 'large n' approximation (i.e. $n >> 1$).

$$\therefore\ \ln(M_n / M_0)^2 \cong \ln\{ N(N-1) / (N-n)(N+n-1) \} = \ln\{ N^2 / (N^2 - n^2) \} \quad \therefore\ (M_n / M_0)^2 \cong N^2 / (N^2 - n^2)$$

$$\therefore\ (c^2 - V_n^2)\,M_n^2 = m\,c^2 \qquad \text{So, finally:} \quad M_n = m\,(1 - V_n^2 / c^2)^{-½} = m\,\mathcal{L}[V_n]$$

6.4.4 UNRECOVERING MAXWELL (1D)

This section will briefly illustrate the impact of the one-dimensional model in the *Historical View* of EM potentials that was introduced in section 6.3.6. The central result of the '*Terrible-Twins*' model is that the longitudinal velocity V_n for one of the electrons at time T_n can be represented by the solution: $V_n = n\,b$, where 'b' is the smallest speed (yet to be established) and 'n' is the interaction index that runs from –N through – 1 to +1 and back up to +N. This means that the longitudinal component of the EM vector potential $\underline{A}$ tracks the changes in speed. Its value at time T_n for electron #1 corresponds to the sum of the incomplete impulses that have not yet been received from electron #2 (in effect, 'in transit'), thus:

$$-\,e\,\Delta A_n = m\,c\,\Delta\underline{V}_n = m\,c\,b = m\,c^2 / N \quad \therefore\ A_n = A[1{:}\,T_n] = -\sum_{j=-N+n}^{k=-1} \Delta P[2{:}\,T_j] = P[2{:}\,T_k] = mb\,(N-n)$$

$$\text{Also,} \quad -\,e\,\Delta\phi_n = ½\,m\,(V_{n+1}^2 - V_n^2) \approx m\,V_n\,\Delta V_n = n\,m\,b^2 = n\,m\,c^2 / N^2 = m\,c\,V_n / N = \Delta U_n$$

$$\therefore\ U_n = U[1{:}\,T_n] = -\sum_{j=-N+n}^{k=-1} \Delta K[2{:}\,T_j] = K[2{:}\,T_k] = ½\,m\,V_k^2 = ½\,m\,(c - V_n)^2 = ½\,m\,b^2\,(N-n)^2 = ½\,m\,c^2\,(1 - n/N)^2$$

The 'total' EM momentum (for electron #1) at time T_n is the momentum still to be received by electron #1 from electron #2, which is losing its own momentum at time T_k but still has an amount $\underline{P}_k$; so equating this expected (incoming) momentum with the EM momentum (while still remembering that: $\underline{P}_n + \underline{P}_k = m\,\underline{c}$):

$$e\,\underline{A}_n / c = \underline{P}_k = (m\,\underline{c} - \underline{P}_n) \quad \therefore\ e\,(\underline{c} + \underline{V}_n) \bullet \underline{A}_n / c = m\,(c^2 - V_n^2) = E_0 - K_n = U_n = -\,2\,e\,\phi_n \quad \therefore\ c\,|\,\phi_n\,| = ½\,(\underline{c} + \underline{V}_n) \bullet \underline{A}_n$$

Again, this fails to achieve the expected full Lorenz Condition: $c\,\phi_n = \underline{V}_n \bullet \underline{A}_n$ This is only valid if: $V_n = c$.
Note that Maxwell defined the vector potential $\underline{A}$ only from the magnetic energy received from all the magnetic sources, that is, those electric charges in relative motion but not in a straight-line. **A full three-dimensional solution is still needed**.

After a series of somewhat arbitrary assumptions, the analysis in section 6.3.6 resulted in: $\Delta\phi_n = \phi_n\,V_n\,\Delta V_n / (c^2 - V_n^{\,2})$

This difference equation resembles the form of the difference mass-formula in section 6.4.2, so by analogy, this gives:

$$\phi_n = \phi[T_n] = \phi[V_n] = \phi_0 (1 - V_n^2/ c^2)^{-½} = \phi_0 \mathcal{L}[V_n] \text{ with } c A_n = V_n \phi_n = V_n \phi_0 \mathcal{L}[V_n] \therefore A_n = A_0 \mathcal{L}_n \text{ and } A_0 = \phi_0 b/c$$

Failure of Coulomb's Model

The one-dimensional model fails to satisfy Coulomb's 3D electrostatic (instantaneous) model introduced in section 6.3.5 above. The correspondence is slight as Coulomb's potential is defined only in the continuum (force) limit, where the total number of interactions N goes to infinity as the smallest speed b goes to zero such that the limit n/N goes to V/ c. In this 'near continuum' case, $R_n = 2 z_n$ and the averages approximate to the values themselves for 'large' V, so the difference equation becomes:

$$(c^2 - V_n^2)\, \Delta[R_n] = R_n\, \Delta[V_n^2] \quad \text{with} \quad V_n = n\, c / N \quad \text{and} \quad R_n \cong 2\, n^3\Lambda / (3N) \;\; \text{when} \;\; n >> 1$$

Since: $\Delta[n^2] \cong 2$ n and $\Delta[n^3] \cong 3 n^2$ for $n >> 1$ then the 'solution' is: $V_n^2 \cong 3 c^2 / 5$ or $V_n \cong 0.78$ c

The Coulomb Approximation

The Coulomb 'Law of Electrostatics' is a statement of the force between two charged bodies involving only the two total charges and the spatial separation between their centers. This is a **timeless** summarization of <u>sets</u> of interactions averaged over a macroscopic measurement time between the two <u>groups</u> of electrons and between the electrons <u>within</u> each group during this time. Even in the case of two interacting electrons, it is important to introduce explicitly the time differences and the reaction of the source electron. It is an approximation to assume that the EM 'fields' of the source electrons only affect the target electron; this is only approximately valid when there are very many electrons at the source forming a large 'quasi-inertial' body. This view will be elaborated in a later paper that predicts the inertial masses of various 'elementary' particles.

No Static Electricity

The present theory of electromagnetism excludes the artificial situations referred to as 'static' electricity: interactions always imply dynamical relationships. Human measurements (like Coulomb's experiments) are conducted over time durations that involve enormous numbers of possible interactions. Accordingly, the classical idea of a spatially based electric potential can only be viewed as a statistical average over numerous source electrons – it's extension to two electrons is unwarranted.

7. CRITIQUE & RE-INTERPRETATIONS OF RELATIVITY

This section brings together the criticisms of SRT that were touched on in previous sections and merges them with the new insights suggested by the initial investigations of the two electron interaction covered in the last section. Einstein intuitively realized that our ideas of time were the foundation of problems with Maxwell's theory of EM. This central, metaphysical issue, along with other major ontological problems, has persisted for over one hundred years, re-inforced by 'the flight from philosophy' that has characterized physics in the 20^{th} Century, as physicists try to escape from the real paradoxes they have created. The reality of history is also restored here as it reminds physicists today that the original theories were riddled with contradictions and valid critiques that have been forgotten rather than answered. Not the least of the problems associated with Einstein's SRT is the massive reliance purely on mathematics and the use of 'acts of the imagination' – rather than the solid basis of real experiments that should always form the basis of progress in physics. The common thread throughout this section is the role and meaning of the concept of time; this is a difficult set of ideas but not one that physicists can escape from – perhaps, now is the time to re-invite professional philosophers and historians of science to come back to the table. It must also be said that the present theory is <u>not</u> trying to restore the concept of the æther – this is one concept that deserves to be buried deep in the garbage heap of the history of ideas: it was Newton who defined modern physics, not DesCartes.

7.1 PROBLEMS & PARADOXES OF RELATIVITY

This section begins appropriately with a summary of the major philosophical issues that have continued to challenge Einstein's SRT since, in this programme, concepts (philosophy) supersede symbols (mathematics). Disagreements on the fundamental significance of any theory of nature cannot be resolved by the formal manipulations of mathematics or logic: these are powerful tools but our common awareness of existing within the natural world that we have agreed to describe with words compels scientists to adopt this precedence – appeals to the 'mysticism of mathematics' are rejected. In fact, unstated disagreements over metaphysical assumptions are often found at the heart of most heated scientific disputations.

7.1.1 METAPHYSICAL PROBLEMS

Philosophy is always part of Physics

Although it is now fashionable to reject any role for philosophy in physics, it is always present implicitly in every theory's metaphysical assumptions. In fact, even when a person decides to ignore philosophy, that very act is itself a philosophical position: choosing ignorance is, in reality, self-defeating and even irrational. In fact, since philosophy is now increasingly recognized as the art of refining the meaning of words, it becomes impossible for any theoretical physicist to describe the significance of the symbols used in his equations without resorting to the use of natural language to communicate with his peers. Ignoring philosophy only reduces the clarification needed in all attempts at communication; as such, confusion and lack of progress become quite predictable.

Maxwell's Metaphysics

Maxwell began his major paper [23] with the words "The most obvious <u>mechanical</u> phenomenon in electrical and magnetic experiments is the mutual action by which bodies in certain states set each other in motion while still at <u>sensible</u> distances from each other." Although this resembled the physics of gravity, which Newton modeled as action-at-a-distance, Maxwell adopted a continuum approach, motivated primarily by personal religious and metaphysical reasons (see [6]).

Field-Cells versus remote Point-Pairs

Maxwell's EM field theory is an explicit 'contact' model, where only the six nearest 'cells' (i.e. the cubic neighbors) can influence the infinitesimal 'target field cell' (dx dy dz) that directly surrounds the 'field point' in any given infinitesimal duration of time (dt). This is the origin of the universal appearance of the vector gradient operator (∇) in all of Maxwell's Equations. Some of the remote, source cells are filled with an incompressible charged fluid, whose motions and variations generate all the results in the modern expositions of classical EM [6]. In contrast, in the present theory, only <u>one</u> remote 'cell', centered on one single, point electron interacts with a comparable 'cell', containing the 'target' electron. Each 'cell' is now only one single point electron, characterized by its inertial mass 'm' and its total electric charge 'e'. All of its so-called neighboring cells are simply empty space, never occupied by another electron, as this would generate an 'infinite' repulsion or attraction; always a problem for the continuous, 'charge-density' model of classical EM.

Metaphysical Assumptions of all Field Theories

A field theory in physics would only be valid if all the following assumptions were true. It is the obligation of proponents of a field theoretical view to justify why their model of EM meets each one of these criteria.

1 the physical phenomenon described in the theory covers all of space and varies continuously over time;
2 a continuous mathematical field ψ can be defined that maps one-to-one with the phenomenon;
3 the field function ψ can be identified with a physically measurable variable;
4 the value of the field function varies continuously with time for every point in space, i.e. $\psi(\underline{x}, t)$;
5 there exists a medium wherein measurements can be undertaken to determine ψ anywhere;
6 a speed c can be defined for relating a change between any two different space-time points;
7 the propagation effects are isotropic and constant in all spatial directions, i.e. $c(\underline{x}, t + dt) = c$;
8 for all locations not at the sources or sinks of the phenomenon: $\text{div}\ \psi = 0$;
9 the phenomenon can be readily measured in different inertial reference frames;
10 the measured speed of propagation is the same in all inertial frames, i.e. $c' = c$;
11 the form of the equations describing the phenomenon are independent of the reference frame;
12 the field function satisfies the Relativistic transformation between two reference frames.

Only on the Light-Front

Although one can imagine a spherical light wave emerging from a source point and eventually spreading throughout all of space, Einstein's derivation of the Relativistic transform was based on common points on the same wave front being viewed from two different inertial reference frames, with a common origin at the time and location of the emission. It has never been demonstrated that these relationships can be extended to any or all, arbitrary locations in space at times different from the arrival time of the wave-front at such points. There is no justification for applying these transforms to all points.

Kinematics versus Electrodynamics

Einstein derived the Relativistic transformation purely as a kinematical theory of relationships between **all** points in space and time as viewed from two reference frames in constant relative motion. In the first five sections of his famous ten-part paper in 1905, entitled *On the Electrodynamics of Moving Bodies* [29], light was only treated as a signaling device that is presumed to always move at the same, constant light-speed. Electromagnetism was first introduced in section six where a set of specific transformations was shown to preserve the Cartesian form (covariance) of the "Maxwell-Hertz Equations" in empty space. Electromagnetism reappeard in the ninth section when the approach used in section six was repeated but now with the addition of real convective current densities. The velocity addition law (derived in section five) was used again here along with another rule for transforming moving charge density to prove "the electro-dynamic foundation of Lorentz's theory of the electrodynamics of moving bodies is in agreement with the principle of relativity." It was only in section ten (sub-titled "Dynamics of the (Slowly Accelerated) Electron") that Einstein addressed the issue of actual *electrodynamics*. He considers the behavior of an 'electron' first at rest and then 'one instant later' when it has been accelerated by the arrival of a sharp, non-zero electric field. Subsequently, he viewed the electron from a frame of reference where its instantaneous velocity was non-zero followed an 'instant later' when it had been accelerated again by an 'external' electric field. This technique subtly moves from frames of reference that are in constant relative motion with respect to each other (where the relative velocity is well-defined) to non-inertial frames that are now accelerating as only instantaneous relative velocity is assumed. This approach allows Einstein to calculate Abraham's longitudinal and transverse mass-velocity formulae, noting that: "with a different definition of force and acceleration we could obtain other values for the masses." Since Einstein assumed that the electron was only slowly accelerated it would not emit any radiation so all "the energy obtained from the electrostatic field must be equal to the electron's energy of motion." The resulting equation becomes infinite when the electron's velocity reaches light-speed.

It can be seen from this excerpt that Einstein had to introduce accelerating frames of reference to derive this dynamic result by using the trick of instantaneous 'snapshots' at instants of time to appear to work in an infinite series of inertial frames. This approach contradicts the very foundation of the Special Theory of Relativity that left the study of accelerating reference frames to Einstein's General Theory of Relativity introduced eleven years later. This trick was also used by Zeno in one of his famous paradoxes to propose that an arrow never really moved, as one could always switch from one instant (snapshot) to another, with no movement appearing in either instant. In fact, as Maxwell showed, light is an example of EM force fluctuations over time and with their very small mass, real electrons respond rapidly to even very small EM fields. In fact, EM fields are the result of the relative movement of real electrons, exposing Einstein's 19th Century roots in ætherial EM.

Einstein's "Strange Electron"

Einstein's SRT paper claimed, in its conclusion, that his calculations of the longitudinal and transverse mass of his electron "are also valid for ponderable material points because a ponderable material point can be made into an electron (in our sense of the word) by the addition of an arbitrarily small electric charge." As the historian of science, Helge Kragh has pointed out, with some irony as real electrons always have a finite charge [166]: "This was a strange kind of electron."

Imagination (Gedanken) – not Experiments

Many of Einstein's foundational concepts are flawed, reflecting a mathematical rather than a physical perspective. Much of the analysis is constructed around 'thought (*gedanken*) experiments'. This was a rhetorical sleight-of-hand that associated the validity of physical *experiments* (involving objectivity, accuracy and measurements) with an approach involving pure *imagination*: a technique that is perfectly valid for mathematicians and novelists. This 'rational' approach was a throwback to the pre-scientific days before experiments grounded the progress of physics. Before Galileo, for example, the scholastics only had to imagine some angels on pinheads without ever having to devise experiments to actually count them. This point was made publicly by the British physicist, Burniston-Brown on several occasions [167]: "the first scientific societies, like the Royal Society, were *founded* to replace thought-experiments by genuine experiments. Thought-experiments can only produce conclusions from premises; genuine experiments yield conclusions from Nature." Although Newton was a first-rate mathematician, he always viewed mathematics as a distinct activity and, when used in natural philosophy, as a servant not a master. The British tradition in physics has mainly preferred an approach grounded in experiments, aided by visual imagination and confirmed by metrical comparisons of mathematical calculations: this is the approach taken in this research programme. This contrasts with the theological, mathematical tradition of the Continentalists inherited from the scholastics.

Einstein's conceptual model for spatial length was the '**rigid rod**' – this always implies that its whole extent, including its ends, can be moved simultaneously (this was the 'worm in his apple'). Einstein's model for 'time' was a *sea of contiguous point-clocks*. These were not only continuous across all of space but could vary continuously as their position (relative to the origin) varied. None of these concepts exists in the real world, strange for someone, like Einstein, who viewed himself as a Machian realist in 1905 and claimed that his theory was grounded on a realistic view of space and time.

Lewis & Tolman's Collision

Goldberg describes in detail [168] the analysis by Lewis and Tolman that derived the transverse mass formula of Lorentz and Einstein ($M = \mathcal{L}\ m$) by investigating the momentum conservation of two <u>perfectly elastic</u> particles. As usual, this was just another 'thought-experiment' that required either <u>rigid</u> spheres of finite size or point particles that do not interact until they occupy the same point in space. Obviously, this experiment has never been confirmed in any real laboratory. Although this derivation did much to generate support for the relativistic mass formula, the two authors were very uncomfortable with the proposition that light always traveled at the same speed, recognizing that this was the source of *the strange conclusions*. They chose to interpret the relativity of length and time only as changes in units of length and time and not in the quantities themselves, which would be a "scientific fiction" [169]. Each observer in his own reference frame considered himself to be at rest in the universe while "the physical condition of an object (moving relative to the observer) could not possibly depend on the state of mind of the observers." This belief in the objective reality of the world beyond measurement was the most widespread view of the world held by physicists at the beginning of the 20th Century; now quantum mechanics has severely shaken this faith in common sense. The present theory returns to this realist view of the world. Majestic 'Father Time' (*Chronos*) is restored to his ancient throne to control the evolution of the universe – throughout space, and for ever.

Relationships, not Points

Einstein, like most of his predecessors, chose to develop a theory of interactions that ignored the relationships between the interacting participants, instead focusing only on one of the pair of particles – ultimately only focusing on the single point, *whether this location in space was occupied by a real particle or not, at the time of interaction*. It was inevitable that this purely kinematical approach would encounter difficulties in trying to combine the dynamical effects of both gravity and electromagnetism; a fundamental difficulty that continues to plague all modern, massless field theories. The Special Theory of Relativity must always be about constant relative velocities, that is, only force-free space (with the EM fields appearing and disappearing, as needed). As a result, Einstein misnamed his most famous paper [29]; this purely kinematical approach would have been more accurately entitled "Space-Time Transformations on Maxwell's Wave Front" but then, probably, an informed referee would have pointed out that Larmor had already developed these equations several years earlier.

Errors from a Single-Point Focus

Einstein's concerns with the relative motion of the coil and magnetic at the beginning of his SRT paper demonstrated that a velocity-dependent force (the 'Lorentz' force) was involved with a velocity-dependent source (Ampère's law). Einstein's own analysis of simultaneity is based on the 'fiction of frames' while focusing on a single particle rather that the interaction between sources and interacting charges that was implied by Lorenz's innovative EM theory of 1867 [14]. It must also be said that statements that claim that SRT can accommodate accelerations is **not** acceptable – this was the basic motivation for Einstein creating his GRT: this was not simply a theory of gravity, even though Einstein was always unable to unify these two theories. As such, "Planck's Proposal" is fundamentally at odds with Einstein's basic programme of relativity.

7.1.2 PROBLEMS WITH TIME

Time is the central concept of SRT – it was Einstein's two-way 'measurement' scheme, when combined with his implicit entity model of light, that quickly led to the Relativistic Transforms of Einstein's newly defined kinematical variables.

Measuring Time

When Einstein introduced his 'relativistic express' in one of his numerous thought-experiments [170] he defined the 'proper time' as the time measured by a single clock carried on the train. All lengths on the train (including the length of the train itself) are 'static' lengths as they can be measured on the train, in contrast to measurement attempts from the platform that the train is passing through at a high but constant speed. If a second train is now introduced traveling at the same speed but on a parallel track to the first then travelers on the second train are in the same inertial reference frame as travelers on the first train but they are physically separated, perhaps by several miles. In this situation, the two sets of moving travelers must communicate their calculations of experiments to each other also by EM signaling. It is important to notice that each group of experimenters, on the platform and on both trains each has their own clock. This then suggests that, carried to its logical conclusion, the only 'proper time' is the 'clock' associated with each individual electron. Since these 'electron clocks' must be considered as equivalent and universal then all time is universal, as Newton proposed. The implicit assumption in SRT is that the relative speed of two moving frames of reference can be operationally determined, both uniquely and symmetrically – Einstein tried to achieve this in the first section of his paper using definitions centered on rigid bodies. In all cases, time was regarded as the foundation and all remote lengths were time-calculated (not measured with static comparisons) using the standard speed definition: $\Delta L = v\ \Delta T$. When time is **defined** as the average of two-way travel back to the emitter of the light, which is also hypothesized to be traveling at a universal constant speed, then the 'magic' FitzGerald length contraction becomes an inevitable consequence of the 'time dilation' that forms the heart of the SRT.

Measuring One-Way Time

It is a widespread view now that only the two-way measurement of time durations proposed by Einstein in his SRT paper is operationally feasible. However, the one-way approach is feasible as long as all participants agree that they are observing a common phenomenon that keeps the correct time. In the case of astronomy, Römer used the constant orbital motion of the moons of Jupiter as his clock. The six-monthly directional measurements of nearby stars in stellar aberration observations eliminate the speed of the sun relative to the distant star so that time delays from the star can be used to compute the ratio of the Earth's orbital speed to 'light-speed' [171]. Similarly, scientists can agree that the known emission frequency of atomic excitations form a universal clock when viewed by all observers. In order to eliminate any Doppler effects it is important that only transverse oscillations be observed; this will be sufficient to synchronize the rate that the 'master' clock 'ticks' in all inertial reference frames.

Simultaneity

A subsequent paper in this series will develop the '*Saturation Hypothesis*' which means that in this theory only the two electrons directly involved in a mutual interaction are 'aware' of the changes occurring in each electron's motion at the times of these two events. This agrees with Einstein's view that these two events cannot be measured simultaneously but adopts the more radical position that they can never be observed to be simultaneous from any single location. As a result, in this theory, no one electron can ever simultaneously 'observe' two of these remote events but not because of the arbitrary nature of measurements in different inertial reference frames, as he believed. Human measurements always involve myriads of 'receiving' electrons and the known interaction delays allow humans to calculate the times of the different remote events at known spatial separations using the 'light-cone' condition, which is independent of all relative motion and re-establishes the fundamental distinction between passive (Newtonian) space and active time.

Einstein's Twins contradict the Reality Principle

The conventional interpretation [172] of the 'Twins (or clock) Paradox' is that only one twin is in motion (i.e. accelerates relative to the fixed stars) and so it is only the moving twin, who must age slower. As Dingle continuously pointed out [173], the journey can be made symmetrical, with both twins moving in equal and opposite directions for the same (local) duration before returning to their starting point, each using only small but still equal accelerations. Since the Relativistic transform is only a function of the square of the (relative) speed the effect should apply equally to either twin: both should actually age relative to the other and see a contradiction when they meet again, hence the paradox. Einstein fully understood this 'paradox' and finally answered his critics in an article written in 1918. This little-known reply [174] did not repeat any of the standard asymmetric arguments put forth by his defenders (and repeated in textbooks today), with which Einstein was obviously unhappy. Astonishingly, his defense of his own special theory required his general theory of acceleration, as he wrote that only this additional element could break the symmetry of the 'twins' by having only one of the twins accelerate. However, Einstein still failed to realize that the acceleration effects could be minimized on very long journeys, as well as the acceleration phase could be made equally symmetric for both twins relative to the 'fixed' stars, so that even this late effort failed. This basic failure reflects Einstein's earlier philosophical 'positivism' – he could not accept that there might be a difference between reality and perception: all 'observations' had to be equally 'real': "Man is the measure of all things."

McCrea always misunderstood Dingle

Dingle's long-time rival, H. William McCrea (1905-1999) totally missed Herbert Dingle's central criticism of SRT, when he responded publicly in the pages of *Nature*, at the editor's invitation, in 1967. This polemical rebuttal has been analyzed line by line in a paper by Ricker [175], who concluded that: "McCrea's refutation was basically a fraud." Although the published argument was conducted in a mathematical manner, revolving around abstruse definitions of 'same event', and was difficult to follow even by mathematicians, McCrea totally failed to address Dingle's philosophical objections. The issue was never whether two events are the same or not. Dingle continued to point out that perfectly symmetrical physical situations can be imagined so that the time duration of each twin's journey should be identical (as the *Relativity Principle* would expect) but the SRT predicts that each remote twin should appear younger to the other twin, both on the outward and return trips. When the twins meet again, it must be an objective fact, particularly for a long journey, that either the twins have aged equally or each surviving twin sees the other twin as dead – a more than paradoxical result. This means that the theory is either wrong (no correspondence with reality: Einstein's definition of 'time' is not Nature's time) or it involves some concepts that do not correspond to normal interpretations of reality (weak physics of the mirage) or it is just an exercise in mathematics.

The 'clock paradox' is only resolvable within the theory of relativity if remote measurements are viewed as 'calculational mirages', reflecting the impossibility of conducting *actual* physical measurements involving spatial or temporal differences in two different inertial reference frames by the *same* observer. Remote 'measurements' then only become calculations based on accepted equations derived from a specific theory. These types of results should not be confused with repeatable facts derived from actual measurements performed in any one inertial reference frame, nor with the nature of time itself.

Einstein's own Rigid Rod Paradox

In 1907, Einstein continued to try to find a satisfactory derivation of the mass-energy formula [176], particularly as he felt the lack of a deeper understanding ('world-picture') of the *Principle of Relativity*. His new paper focused on the dynamics of an electrically charged rigid body. Einstein himself was unhappy with the exposition, recognizing that the use of "rigid rods leads to drastic difficulties". He imagined equal and opposite impulses being applied to the ends of such a rod in the rest frame traveling with the rod so there would be no net effect. However, in a reference frame moving with speed V the first impulse arrives after a time $\mathcal{L}$ LV / c^2, where 'L' is the length of the rod. Consequently, the moving observer should notice a change in the whole rod's velocity, as each impulse is not simultaneously compensated for by the other impulse. The far impulse performs mechanical work on the rod during the propagation time interval so the energy of the rod should increase during this time. However, the moving observer never sees any change in the rod's overall velocity so this violates the principle of the conservation of energy. Einstein tried to wriggle out of this paradox by suggesting that either a 'straining force' is generated in the rod that propagates instantly to the opposite end or, worse, that an "unknown quality" arises in the rod, traveling at a finite speed through the rod, causing the acceleration that compensates the other impulse. He correctly acknowledged that the first 'solution' would violate the *Principle of Relativity* while the second was too speculative for any real understanding the dynamics of rigid bodies. He still gave priority to his 'Relativity Principle' so that when a body is in equilibrium in one inertial system then it must always be in equilibrium in all other inertial reference frames. This paradox was never resolved by Einstein himself or any other relativist.

Ehrenfest's Rotating Cylinder Paradox

Paul Ehrenfest (1880-1933), reacting in 1909 to Born's unwarranted extension of the *Relativity Principle* to all reference frames (see above), proposed another paradox [177] involving a rigid cylinder spinning at constant speed, which should have its moving circumference shortened on all sides while its radius remains unchanged as there is no radial motion. Any radius of an end-face of the cylinder is directed normally to the direction of rotation so that the radius of each end-face must then obey two mutually contradictory conditions, constituting a paradox. Born tried to squeeze out of this fix by making the claim that "the rigid body of relativistic kinematics bears no relation to the classical rigid body." One can only agree.

Physicists accept Paradox

When mathematicians generate a contradiction, they are pleased to have derived a valid proof ("*reductio ad absurdum*"). But when theoretical physicists realize they have a contradiction they rationalize the situation with the name of a paradox and carry on, regardless: an error that philosophers are quick to point out, much to the embarrassment of the physicists. When these natural philosophers are also mathematical physicists (like Dingle), their criticism is acutely unwelcome as it is much harder to ignore. The solution is only too human – ostracism from the 'society of the informed'.

7.1.3 PROBLEMS WITH MATH

Mathematical Metaphysics

Mathematicians must abolish three important words that have colored their communications with the rest of the population. These three words are *exist, true* and *real*. Mathematical objects are claimed to *exist*, proofs are said to be *true* while some numbers are called *real* and others *complex*. Mathematical *existence* is never synonymous with physical reality and might better be replaced with a word like *definitional*, to indicate that "mathematicians have agreed to accept the definition of a concept". Similarly, the word *truth* in a mathematical context has nothing to do with mapping reality, as used in normal speech. It indicates that a result is consistent with the set of propositions that mathematicians have agreed to consider as a single area of mathematics; words like *valid* / *invalid* or any other arbitrary two-valued concept (like *black* and *white*) would be a great improvement. Science would benefit enormously from their replacement with philosophically neutral words such as *imagine, consistent, infinite-decimal* and *paired*. This will diminish the pernicious, religious programme of Pythagoras and Plato from the study of natural philosophy and restore mathematics to its original roots – free speculative imagination. Physicists will then begin to see that mathematical inventions, such as geometry and calculus, and physical concepts like *force*, *potential*, *field* etc are just powerful aids (tools) to calculation and not metaphysical objects with a claim on reality.

The definition of a field is simply a mathematical concept, first seen (and exemplified) by the concept of 'real' numbers. If this concept is to be used in theoretical physics then additional metaphysical hypotheses must be added. Thus, for example, Maxwell posited the real existence of the *æther*, a continuum of imponderable matter; distortions in this medium were then <u>represented</u> by mathematical fields. The discovery of the particulate nature of electricity was contingent on the observation of this new form of matter, which simultaneously destroyed the continuum concept of the æther. In contrast, hypothetical concepts like magnetic fields and photons have remained unobservable; only their proposed effects **on** electrons have ever been observed. Accordingly, electrons are level-one observables, while fields, photons, etc must remain only theoretical (abstract) intermediaries. Even a knowledge of the *signified* and the *signifier* (simple concepts to a student of philosophy) would be a great aid in improving the clarity of thinking of the modern student of theoretical physics, who (without any benefit of education in any area of philosophy) is always in danger of reifying his mathematical symbols.

The mathematics of SRT can only be viewed as a calculational device (see Jefimenko, section 4.1.5) that must be introduced whenever remote asynchronous interactions are described by differential equations acting on a continuous medium (such as 'charge-density') at a **single** point in space. The Relativistic transform is then needed to compensate for the discontinuous interaction of the system's inertial components. It is a huge philosophical error to interpret the transformed space and time variables in this transform as having any real (i.e. ontological) significance.

SRT needs 2D & 3D Space for Pythagoras Theorem

It is central to Einstein's derivation of the Relativistic transformation that the transverse direction be included so that the Pythagorean theorem can be used to generate the 'mysterious' square root that appears in the Lorentz factor, $(1 - v^2/c^2)^{-½}$. It is also significant, in all relativistic analyses of interference measurements, that it is the phase velocity, *c* that appears and not the group velocity of a cluster of electrons (electric charge density). This important feature implies that the basic EM interaction always involves only a single electron emission and single electron absorption. This is never made explicit.

Einstein sets Zero equal to Zero

Einstein's most successful popularization of relativity, which he only wrote to provide "a clear explanation that anyone can understand", went through fifteen editions from 1916 until 1954 [178]. Einstein always included, as the first appendix, a 'Simple Derivation of the Relativistic Transformation' that contained a gross mathematical error. He began this derivation with the simplest equation ($x - c\,t = 0$) to describe a light-signal emitted from the origin and traveling along the positive x-axis. He 'views' this same light signal from a second reference frame that is moving parallel to the original at a constant speed. He represents the propagation of light from this alternative perspective by the comparable equation: $x' - c\,t' = 0$. He then innocently introduces a simple linear relationship between these two equations using an arbitrary constant λ, writing the equation: $x' - c\,t' = \lambda\,(x - c\,t)$. He next applies a similar consideration to light rays which are being transmitted along the negative x-axis to obtain the corresponding equation: $x' + c\,t' = \mu\,(x + c\,t)$. These 'trivial' steps are then followed by some simple algebra and a "snapshot" of unit lengths in one reference frame taken from the other to solve for λ and μ with the Relativistic transformation appearing one page later. What Einstein fails to point out to his trusting reader is that it is mathematically fraudulent to write equations where both sides are equal to zero (as is the case on the light wave fronts): such equations are equally true **and** meaningless (zero always equals zero), all the subsequent derivations in this exposition following this error are therefore without value. In his scientific expositions of his SRT, Einstein always used two (or three) spatial dimensions to describe his model of light propagation [179], where the shape of the expanding 'light-wave' remained unchanged, no matter how an observer might 'observe' the process from any inertial reference frame. In effect, he was still trying to use the simple Pythagoras triangle theorem to prove that on the wave front: zero equals zero. He repeated this same error in his most popular exposition of relativity [180] for the 'layman'; it is still being repeated by textbook authors.

Electrons at the Origin

Einstein's thought (*gedanken*) experiment introduced in section two of his SRT paper discussed 'light-waves' emerging from 'light-sources' without any discussion of the actual physics involved. It is now known that 'light' is a momentum exchanging interaction between remote charged particles. When examined from this more modern perspective, one must identify the source of these interactions with either a single electron that is viewed from both frames of reference (two real observers?) or as two different electrons, one associated with each observer. Again, Einstein does not make it clear whether the remote electron (in the mirror or splitter) is interacting with the same electron at the origin or with two separate sources. It would seem that there are inherent dangers with *gedanken* experiments and to assume that these correlate one-to-one with real experiments, like those of Michelson and Morley, should be too great a leap of the imagination for the physicist.

7.2 ANALYZING RELATIVISTIC TIME

7.2.1 RE-INTERPRETING MICHELSON-MORLEY

The Michelson-Morley style of optical interferometer may be viewed (abstractly) as an example of the famous 'three-body' problem, where the motion of the electrons in the light-source are important relative to those in the interference target atoms and relative to the motion of the experimental observer. In the actual experiment, all three sets of electrons are not moving relative to each other (in the lab frame). It is only in a hypothetical world, where light is imagined to be traveling through a moving medium (as in Maxwell's EM theory) that any relative motion is introduced. It was only by focusing on the target location (the 'field point') that the source of the EM interaction could ever be ignored, replacing the activity of the source electrons with EM potentials defined at the field point. When the electrons in the target atom are reduced to a mathematical point the problem is reduced (artificially) to a one-body problem: the electromagnetic field. Experiments say otherwise.

In the MMX set-up it is important to note that in any inertial reference frame there is no relative motion between the five basic components of the equipment: the light source, two fully reflecting mirrors, the semi-silvered central mirror and the observation lens. **When viewed from the perspective of asynchronous action-at-a-distance, there will be no changes in interaction times between the various groups of electrons involved in each of the five macroscopic components, so that this type of EM theory would always predict no fringe shifts – exactly what was observed.** The MMX null result only rules out a medium-type of EM wave theory, such as Maxwell's EM theory of light where 'light ripples through a fixed æther' or the MMX rules out a realistic EM propagation model, where EM energy propages across space like a bullet. The only invariance exhibited in this experimental setup is that shown by the relative parallel displacements occurring between the various sets of interacting electrons. Accordingly, there is no need to introduce the Relativistic transformation between any of the points in this experiment and the relative motion of any third-party observer (including any accelerated motion) should never produce any observable changes.

Interactions, not Observations

In the present approach, light is viewed as an interaction between electric charges. Accordingly, it is not viewed as an entity that "travels" from one point to another, as would a wave or a moving particle. Therefore, it cannot be affected either by the acceleration of an observer or by any 'third-party force', such as gravitation. As EM interactions always involve correlated pairs of events between two electrons then each interaction must be independent of the rest of the universe, in particular, it must be independent of how any third-party observer might subsequently view each interaction. Focusing on only one side of the EM interaction (like Maxwell's 'field point') not surprisingly leads to some bizarre interpretations. Longitudinal light signaling, as proposed by Poincaré and Einstein, can therefore never be viewed as a suitable technique for establishing a universally appropriate experimental chronology in any frame of reference because (as shown in section six) of delays in 'getting on the light-cone'; however, transverse signaling still remains a valid technique for synchronization.

Light is not a Traveling Object

The fundamental error invalidating the theory of Special Relativity is the metaphysical assumption that 'light' is an *entity* (either a wave in a medium or a mass-less photon) with independent existence so that it can travel freely from its time of creation to the time it is destroyed. Obviously, if this were to be the case, then for any such object to maintain a **constant** velocity independent of all inertial reference frames, both space and time would have to behave quite differently to all these different observers: this is the function of the Relativistic transformation. All of these bizarre peculiarities disappear when light is viewed as a *process* or *relationship* between the emitting and absorbing electrons. Each electromagnetic interaction is the result of an 'agreement' between an electron at the *here and now* with another at the *there and then*; all of which are finitely different but must occur 'on their mutual light-cones' i.e. the space and time differences are exactly defined by the light-speed parameter *c*, as described in section 5.2.4.

The Observer's Role is Crucial

Einstein's theory of Special Relativity is an axiomatic derivation of the Relativistic transformation (a theory of principles) relating the points on an expanding EM wave-front between two inertial frames of reference. This transformation generates a theory of constant velocity motion (no accelerations) that is known as kinematical (or change of viewpoint): this type of mathematics only involves relationships between the space and time parameters. However, the most dramatic consequences of relativity theory are dynamical, involving such concepts as real mass and energy. All such dynamical theories introduce acceleration (or forces); hence the paradox: dynamical results emerging from a kinematical theory. This paradox is readily resolved when it is realized that the dynamical component (the interaction between the electrons) has been abstracted away leaving 'light' only in the role of a 'signaling' device for synchronizing 'clocks' at a distance that are in relative motion. Observations in these optical theories are therefore viewed as *independent* of the interaction between the electrons in the observed object and the electrons in the observer. Einstein realized he had developed a theory of principles, not of physics.

7.2.2 MINKOWSKI VELOCITY

The Ambiguous Lorentz Factor

Goldstein, in his best-selling textbook on classical mechanics [181] has emphasized that Planck's Proposal for the definition of relativistic momentum ($\underline{P} = \mathcal{L}\, m\, \underline{v}$) is ambiguous; this is reflected in the various texts on relativity. Here, the relativistic correction factor ($\mathcal{L}$) can be associated with either the mass (Einstein: $M = \mathcal{L}\, m$) or the velocity (Minkowski: $\underline{V} = \mathcal{L}\, \underline{v}$). In this second interpretation, inertial mass always remains invariant but the relativistic velocity $\underline{V}$ forms the spatial part of a relativistic (Minkowski) 'four-velocity'. Obviously, these two different assignments are associated with very different physical interpretations but this is almost never discussed, as the mathematics remains the same. However, in order to define a velocity four-vector V_μ it is necessary to extend the L-factor for motion in one direction (say x) to all three space directions if the velocity is no longer constrained to only one dimension, as it is not with the 'Lorentz' force. So these two, equally feasible choices lead to two very different interpretations of the physics: in one mass varies, in the other, velocity in the transverse directions are different – hmm? In the moving frame:

$$x' = \mathcal{L}\, x,\ y' = y,\ z' = z\ ;\ V_x' = \mathcal{L}\, V_x\,,\ V_y' = \mathcal{L}\, V_y\,,\ V_z' = \mathcal{L}\, V_z\,, \qquad \text{so that:}$$

$$(V_\mu')^2 = \mathcal{L}^2 c^2 - (V')^2 = \mathcal{L}^2 c^2 - \mathcal{L}^2 V^2 = \mathcal{L}^2 (c^2 - V^2) = c^2 = V_\mu^{\,2} \quad (\text{when } V = 0)$$

7.2.3 HIGH SPEED PARTICLE EXPERIMENTS

Remote High-Speed 'Clocks'

The interaction with remote, high-speed 'clocks' (e.g. GPS cesium atoms) assumes that the time mechanism (clock) "ticks" at the same rate as it would with local measurements and therefore needs the relativistic time transformation to alter the time differentials, Δt (i.e. the intervals between the temporal events or 'ticks'). These observable effects are interpreted in the present theory as due to differences in the interactions between local electrons and high-speed electrons. The number of consecutive events possible between interactions involving the high-speed electrons and those in the stationary 'measuring' reference frame **miss** some of the interaction possibilities that would have occurred if there had been no relative motion between the two sets of electrons: those in the satellite and those in the laboratory. Physicists have simply assumed that the rate of decay of excited states is independent of the motion of the remote (measuring) electrons that interact with the excited (atomic) electrons.

High-Speed Particle Decay

In the case of high-speed elementary particle decay, once again, theoreticians have jumped on a simple mathematical formula to 'explain' a physical phenomenon. Until physics has a model of particle decay, it should not stop the search for a suitable explanation. The present theory will offer such a model in a later paper that will use the time synchronization results developed here to provide a more comprehensive view of this mysterious 'decay'.

7.3 CHALLENGING RELATIVISTIC MASS

7.3.1 REVIEW OF KAUFMANN'S EXPERIMENTS

The need to introduce a velocity-dependent mass into relativity was initially motivated by the early research on high-speed electrons. During the period 1901-1906, Kaufmann published the results of a series of experiments designed to measure the variation of the charge to mass ratio of the electron. Classical EM has always viewed the charge *e* of the electron as one of the constants of nature but the theories of electro-dynamic mass, popular around 1900, all predicted variations with speed. Kaufmann's experimental setup was quite primitive and subject to poor accuracy and much interpretation of results. This situation has been described in detail by Cushing, who used this famous experiment to show how theoretical physicists do not readily give up on a good theory when it is contradicted by the 'facts' [182]. The original 1901 results were incorrect due to an algebraic error, which was corrected in 1902, along with additional data. He continued to refine his results with papers published in 1903 and 1905 so that experiment could decide between the three theories of Lorentz and Einstein or Abraham. In his 1906 review of all his experiments, he finally declared that Abraham's theory was the best fit. Even so, Planck soon wrote that he was not too impressed with the accuracy of any of these measurements and Kaufmann's complex methods for adjusting his calculations (fifty measurements were grouped into nine data points). Lorentz accepted them completely and felt they had eliminated his own ellipsoidal theory of the electron. This confusing situation was resolved in 1908 by Alfred Bucherer (1863-1927) who used a much more accurate technique that avoided complex data analysis; as a result he claimed that he had verified the predictions of the Lorentz-Einstein theory. In 1938, all of these experiments were checked when Zahn and Spees [183], using a Geiger counter, eliminated the observational errors from micro-photometric measurements and reduced the need for high intensity electron beams. They concluded that all of the early experiments "**proved very little**" except that there appeared to be a large qualitative increase of mass with velocity.

7.3.2 CHALLENGING PLANCK'S PROPOSAL

Since all of standard physics is based on the continuum hypothesis, it is never realized that Planck's Proposal is based on the assumption that the accelerating interaction occurs continuously. Mathematically, this is equivalent to assuming that there are forces acting continuously between the electrons rather than discrete impulses. As the previous paper in this series has demonstrated [4] there can be no continuous forces between inertial particles like electrons when the interactions occur 'on the light-cone'. This result voids all continuous relativistic mechanics that describes real phenomena involving electrons.

The relativistic mass formula for a point particle ($M = \mathcal{L}\, m$, see section 3.2) has only been derived using either Planck's longitudinal and fixed mechanical force or was derived from Lewis's relativistic mechanics (see 3.2.4) based on mechanical, perfectly elastic collisions at zero spatial (and therefore zero time) separation. Neither of these mathematical 'derivations' involve the actual EM 'Lorentz' force, so they cannot be assumed to apply to real electrons. They remain elegant exercises in 'transformation mathematics'. The interpretation of these equations will vary with the metaphysical assumptions applied.

Integrals imply Acceleration

Planck's derivation of the variable mass formula involved continuous integrals summing over the continuous change in velocity. However, this implies the existence of an infinite number of intermediate inertial frames of reference, each one separated by 'dt' (or equivalently, 'dv'). Planck was making the same conceptual error as Born (see section 4.5). In other words, the presence of such terms implies the necessity of acceleration – a situation that contradicts the basic assumption of special relativity. The controversies surrounding the so-called Sagnac effect continue with the impact of acceleration on light. Relativists have always viewed the use of acceleration in SRT with very mixed feelings.

Longitudinal Mass & Transverse Acceleration

In Planck's Proposal the relativistic momentum was defined for a 'ponderable' particle (i.e. one subject to gravity) in terms of a velocity-sensitive **longitudinal** mass, M(v); that is, momentum is defined in the direction the applied mechanical force. This should be contrasted with Einstein's 1905 results (following Abraham) that calculated both a longitudinal mass M_L and transverse mass M_T. Mathematically, these results were: $M = \mathcal{L}\, m$; $M_T = \mathcal{L}\, m$; $M_L = \mathcal{L}^3\, m$, where m is the invariant mass and $\mathcal{L}$ is the 'Lorentz' factor, $\mathcal{L} = (1 - v^2/c^2)^{-1/2}$. In other words, in 1907 Planck derived Einstein's <u>transverse</u> result through a <u>longitudinal</u> derivation. This was strange, but also convenient, as all Kaufmann's measurements were made on high-speed electrons using only <u>transverse</u> EM forces, resulting in a constant (circular) speed.

Only Longitudinal Forces

The relativistic quadratic relationship between a particle's energy (E) and momentum ($\underline{P}$) is a direct consequence of Planck's Proposal based on the critical, usually unstated, assumption that the change in momentum ($d\underline{P}$) is **parallel** to the external force $\underline{F}_0$ at all times. In analogy with simple, classical mechanics, Planck defined the rate of change in total energy as the mechanical work done by this force on the particle when its velocity is $\underline{V}$, thus, using $M(v) = m\,\mathcal{L}(v)$:

$$dE/dt = \underline{V} \bullet \underline{F}_0 = \underline{V} \bullet d\underline{P}/dt \quad \therefore \quad M\, dE/dt = M\, \underline{V} \bullet d\underline{P}/dt = \underline{P} \bullet d\underline{P}/dt = \tfrac{1}{2}\, d(\underline{P} \bullet \underline{P}) / dt = \tfrac{1}{2}\, d(P^2) / dt$$

Using the earlier result (3.2.1): $E = M c^2$ Differentiating: $dE/dt = c^2\, dM/dt$ so $d(P^2)/dt = 2\, c^2\, M\, dM/dt = c^2\, d(M^2)/dt$

Integrating: $P[V]^2 = c^2\, M[V]^2 + A \;\therefore\; P[0]^2 = c^2\, M[0]^2 + A = c^2\, m^2 + A = 0 \;\therefore\; E[V]^2 = c^2\, P[V]^2 + c^4\, m^2$

Planck was trying to extend Einstein's SRT to particle dynamics, which involves forces and accelerations. However, special relativity is a theory of light propagation in vacuo in inertial frames of reference **without** any acceleration. Since there can be no accelerations (which Einstein analyzed in 1915 in his GRT) there can be no forces present, even infinitesimal ones or, indeed, EM fields which are force intensities that would cause an acceleration – seemingly, a logical contradiction. This has not prevented physicists from using SRT in dynamical situations over the last 100 years, probably because Planck's major dynamical Proposal makes <u>no use</u> of any of Einstein's SRT features.

Longitudinal Momentum

The relationships between the energy and momentum of a **single** relativistic particle arising from Planck's Proposal (3.2) can now be given a new interpretation. The momentum $\underline{P}$ (or $\mathcal{L}\, m\underline{V}$) can now be seen to be the continuum approximation of the average longitudinal momentum of the single electron in the direction of the interaction between the 'target' electron and its 'source' (the other half of the interaction); in other words, $\underline{P} = \langle P_z \rangle$. The key symbol E (used in either $E = \mathcal{L}\, m\, c^2$ or in Planck's formula $E^2 = P^2c^2 + m^2c^4$) now represents the kinetic energy of the **two** electrons **plus** the interaction energy that is still 'incomplete' and which is needed to complete the interaction. The relativistic mass M (or $\mathcal{L}$m) is the parameter needed to linearly relate the average longitudinal momentum to the average velocity over any small but finite period of time 'around' time 't'; i.e. $\langle P_z \rangle = M(t) \langle V_z \rangle$. This is a direct consequence of using continuous, differential equations in a physical situation where discontinuous interactions describe the actual reality. It is not that the electron's inertial mass changes but that as the relative speed between the two interacting electrons increases it takes longer and longer for the two electrons to get back 'on their mutual light-cones' while retaining the invariant frequency of possible interaction. The key issue of timing (when?) has been simplified into a simple change in the characteristics of the electron to resist change.

7.4 INERTIAL MASS IS NOT ENERGY

7.4.1 MASS and ENERGY CONCEPTS

The dual concepts of mass and energy involve switching between the unchanging and changing viewpoints applied to the concept of a particle. Here, the concept of mass must be viewed as the particle's inherent resistance to change by another particle while the concept of energy may be viewed as the results of change on the particle or its urge to change another particle. These complementary viewpoints are necessary components of the holistic concept of interacting particles.

Mass & Energy

The fundamental concepts of mass and energy are implicitly related through their Newtonian definitions involving a classical point particle of mass M subject to an external force $\underline{F}$ that increases the particle's kinetic energy K. Newton's second Law of Motion is usually formulated as: Force = Mass * Acceleration, while the work done on the particle by the force moving it through an infinitesimal distance, $d\underline{x}$ is defined as: $dW = \underline{F} \bullet d\underline{x}$, which is also defined as the reduction in potential energy, ϕ that is the source of the force. Since the acceleration, $\underline{A}$ is always defined as the instantaneous rate of change of velocity, $\underline{V}$ with the 'total' energy of the ***system*** defined as E, then:

$$dW = M * \underline{A} \bullet dx = M * d\underline{V} / dt \bullet d\underline{x} = M * d\underline{V} \bullet d\underline{x}/dt = M * \underline{V} \bullet d\underline{V} = \tfrac{1}{2} M * d(V^2) = d(\tfrac{1}{2} M * V^2) - \tfrac{1}{2} V^2 dM$$

$$\therefore \quad dW = dK - \tfrac{1}{2} V^2 dM = -d\phi \quad \therefore \quad \tfrac{1}{2} V^2 dM = dK + d\phi = d(K + \phi) = dE \qquad \text{So} \quad dE \propto dM$$

Although, mass and energy are related, it is a conceptual error to equate these two distinct concepts and make them equivalent. This is compounded by the 'lazy' mathematical technique of simply setting the speed parameter 'c' to unity.

The popular view, even among many physicists, is that Einstein showed that energy **is** mass. Philosophically, this is a very unsophisticated position, as it would make these two ontologically different concepts identical – a view that the originators of these two fundamental concepts, Leibniz and Newton, would strongly disagree with. One of the rarer modern physicists who has taken a more philosophical view of physics has agreed with these intellectual forefathers. Mendel Sachs, in his study of the basic disagreements between Einstein and Bohr [184], explicitly rejects this popular view recalling that in all ordinary experiments that measure energy, it is only the difference that is measured, as this is the quantity transferred while mass is an absolute measure of an object's quantity of inertia. It is ironic that modern physics is focused on mass and energy, which are always computed results that are calculated from the more fundamental measures of reality, such as the position in <u>space</u> of **particles** at different points in <u>time</u>.

Mass-Energy independent of Relativity

The mass-energy relationship can be treated as mathematically equivalent to the exchange of a finite impulse between two particles interacting 'across the light-cone'. The reference to mass in this relationship occurs when the impulse is formally treated as an intermediate or virtual particle, like Einstein's 'photon', with a corresponding mass, ΔM_0 that transports energy ΔK_0 and momentum ΔP_0 (but not mass) at speed *c* between the particles (labeled here #1 & #2).

$$K = P^2 / 2M \qquad \therefore \ \Delta K = \underline{P} \bullet \Delta\underline{P} / M = \underline{V} \bullet \Delta\underline{P} \quad \text{and} \quad \Delta\underline{P}_0 = \underline{c}\, \Delta M_0 \quad \therefore \ \Delta K_0 = \underline{c} \bullet \Delta\underline{P}_0 = c^2 \Delta M_0$$

At each interaction node, Newton's law of reaction means that: $\Delta\underline{p}_1 = -\Delta\underline{P}_0 = \Delta\underline{p}_2 \quad \& \quad \Delta K_1 = -\Delta K_0 = \Delta K_2$

So, even asynchronously, both energy and momentum are conserved: $\Delta K_1 = -c^2 \Delta M_0 \quad \& \quad \Delta K_2 = c^2 \Delta M_0$

It is most important to note that for both electrons (#1 & #2): $\Delta K_1 \neq -c^2 \Delta M_1 \quad \& \quad \Delta K_2 \neq c^2 \Delta M_2$

Thus, the mass m of either electron is **not** changed by the interaction (contra Planck). This analysis does <u>not</u> need any EM theory, like Maxwell's, where the Poynting vector is the 'mechanism' of mass and energy transfer via the propagating EM fields (see 2.4.3), nor does it require any field theory concepts, like QED, or actual intermediate particles, like 'photons' – it is simply asynchronous action-at-a-distance (AAAD). In particular, contrary to relativists, like Pais [185], the famous mass-energy relationship in its EM interaction form ($\Delta K_0 = c^2 \Delta M_0$) does <u>not</u> require special relativity or Relativistic transforms.

7.4.2 E ≠ Mc^2

Newton could have created $E = mc^2$

If Newton had adopted Leibniz's definition of energy and defined the further algebraic combination of 'speed * change in momentum' as 'change in energy' then he too could have started his analysis of the two-body interaction with: $\Delta K = \underline{V} \bullet \Delta \underline{P}$. By combining this with his concept of action-at-a-distance and using the finite speed of light (that was published in 1677 by Ole Römer, after observing the eclipses of Jupiter's moons) Newton could have readily derived (see above) $\Delta K_0 = c^2 \Delta M_0$. It is unlikely that he would have gone further and proposed that the real mass of particles was variable. i.e. $\Delta m = \Delta M_0$.

Einstein's Dissatisfactions

It will come as a great shock and surprise to most physicists, to discover that Einstein never successfully proved to his own satisfaction that mass and energy were related through that most well-known of all physics equations: $E = mc^2$. Soon after completing his now famous SRT paper, Einstein realized [26] that "the principle of relativity in conjunction with Maxwell's fundamental equations requires that the mass of a body is a direct measure of its energy content – that light transfers mass." This thought resulted in his final *Annalen* paper of 1905. In this short paper (only three pages), Einstein imagined the case of a moving body that emitted pulses of EM radiation both at a finite angle to its direction of motion and in the opposite direction. Using only the transformation equation for the average energy of a light pulse (defined by the square of its wave amplitude) he compared the energy of the emitter before and after the emission to second order in the speed ratio v/c. This was sufficient, using the results of section seven and eight of his SRT paper, to conclude that: "If a body gives off the energy L in the form of radiation, its mass diminishes by L/c^2. Einstein must have realized that his electro-dynamical results in the SRT paper were based on slowly moving electrons and now he was dealing with electrons subject to accelerations sufficient to generate EM radiation. Indeed, in the rest frame of the electron before emission he had shown that the total energy was mc^2, so that after emitting light and losing optical energy the electron had gained a finite velocity and so had gained total energy – an obvious 'paradox'. As Arthur Miller describes [186], Einstein published three more derivations of the mass-energy equivalence during 1906 and 1907, each time attempting to find an approach that was both mathematically rigorous and physically plausible. The first paper [56] used the principles of conservation of energy and momentum. The final result (to first order in v/c), was based on preserving the center of momentum of a rigid rod with perfectly reflecting mirrors at each end; this has been recreated in a simplified form by Rothman [187]. This derivation assumed that all changes occurred instantly across the whole system – a consequence of using rigid rods in the construction of this simple *gedanken* experiment. His next attempt [58] again used unphysical components: the first involved a rigid, non-rotating, macroscopic charged body while the second model involved a collection of mass points that required 'mysterious', internal stresses to generate collective cohesion. Almost in an act of desperation, Einstein's final attempt [59] was based on a deformable 'envelope' containing charged bodies – this envelope needed to be impermeable to radiation but could be acted upon by external EM forces. It is not a surprise to discover that Einstein was frustrated with all these 'extreme' acts of the imagination to establish such an important foundational result.

Einstein & Planck guessed Wrong

Einstein's greatest blunder was committed in his final 1905 'Inertia' paper [188] where he assumed that the mathematical equivalence ($\Delta K_0 = c^2 \Delta M_0$) was real. Miller quotes a letter from Einstein, written prior to the publication of this paper, where he declares [189]: "that light transfers mass". Planck compounded this mistake with his proposal for the relativistic dynamics of a single particle that was equivalent to: $dK_1 = \underline{V}_1 \bullet d\underline{P}_1$. Thomson and Tait, in their well-known 1879 text on mechanics [165], had already shown for impulsive forces that: $\Delta K_1 = \underline{W}_1 \bullet \Delta \underline{P}_1$ with $\underline{W}_1 = ½ (\underline{U}_1 + \underline{V}_1)$; so that Planck's 'Proposal' was an incorrect continuum limit process of $\Delta t \rightarrow 0$, such that as the final velocity $\underline{V}_1$ approaches the initial velocity $\underline{U}_1$ then the change in momentum $d\underline{P}_1$ goes to zero. The third paper [150] demonstrated that this limit cannot be approached for inertial particles, leaving interactions only in the form of finite impulses (the subject of this paper).

7.5 THE RELATIVISTIC TRANSFORM: JUST MATHEMATICS

7.5.1 INVARIANCE IN FIELD THEORIES

Fundamental principles in physics should be generalizations suggested by many experimental observations, they should impose methodological constraints on all relevant theories: this view must also be extended to the *Principle of Relativity*. Since both the location of the origin of the reference frame and its orientation (relative to distant stars) is quite arbitrary then neither of these settings must appear in any formulation of any theory of material dynamics. Similarly the value chosen for when the master-clock is initialized should not be relevant; these constraints form the basis for the *Principle of Reality* (or Galilean Invariance). This can be reformulated as a universal 'Relativity' Principle first proposed by Poincaré in 1899 [190] wherein only differences of spatial and temporal separations should appear in any mathematical formulations, since activity in the world is independent of how we describe or measure it. These requirements are known as invariant co-ordinate transforms. This research programme will show that Newton's scheme is a self-consistent approach for representing the real-world dynamics of all objects constructed from electrons and complies with the Galilean/Poincaré 'Reality' principle.

Physical Invariance versus Covariance

The realistic version of the *Galilean Principle of Relativity* is that no experiments or observations can **detect** rectilinear, constant relative motion; it is **not** the mathematical requirement that physics equations must remain invariant under Galilean transformations. Nature has no interest in the latest symbolic forms used by humans in their attempts to represent reality; only the resulting experiments have any objective significance. In particular, redefining theoretical variables from a purely mathematical perspective so that equations between these variables remain unchanged (covariance) will obviously appeal more to mathematicians than to physical scientists.

The 'Lorentz' Force needs a Relativistic Transform

The idea that Galilean relativity implies that Newtonian mechanics can be formulated independently of all co-ordinate reference frames (which are in uniform relative motion with respect to each other) is only valid for certain types of forces. This is most obviously true for local impact forces (so that all activity occurs at a single point in space) and for spatially-symmetric, point-to-point instantaneous forces like gravity, where the two body system can be reduced to an equivalent single location situation. Galilean invariance is only valid for systems where the interactions are independent of velocity. By introducing an explicit velocity into 'his' EM force law on a point charge, Lorentz was implicitly introducing a special inertial frame of reference, namely the one where H is defined for the moving charge. Electromagnetic theories that include the 'Lorentz' force law must inevitably fail this class of transformations. The inclusion of this component (even without an ætherial medium) compels EM theories to comply with the Relativistic transformation. In other words introducing 'invisible intermediaries', like inertia-less force fields, generates relativity. Einstein wrote in his famous 1905 paper that (in his view) electrodynamics was based on the Maxwell-Lorentz EM theory. This addition of Lorentz reflected the additional hypothesis that the force on an electrical particle was specified by what is now called the 'Lorentz Force Law' that aggregates all the charge on a particle to a single, scalar value. This addition was sufficient for Lorentz to link Maxwell's fields at a fixed point in the observer's frame to the inertial motion of the 'target' electron. This blend of fixed and variable motion, at one instant of time at one location in space, ultimately required the introduction of the relativistic transformation to compensate for the explicit omission of the relative motion between the sources of the EM fields and the effects on the observable detector, represented by the motion of real, inertial electrons.

All Field Theories need the Relativistic Transform

Finite propagation field theories all suffer from the relative nature of space and time – the co-ordinate values inevitably change with the relative velocity of the 'observer'. The observed constancy of the phase velocity of the interaction, as in the MMX, means that no such field theory can satisfy the classical Galilean transform, which assumes an invariant rate of time evolution, independent of all relative motion. The additional requirement of 'source-sink' symmetry will inevitably compel the use of the Relativistic transformation for the fundamental space and time parameters in different frames of reference. If these parameters are interpreted as corresponding directly to reality then this Procrustean 'solution' must revolutionize the meaning of the most fundamental concepts of all human thinking, as Einstein realized. This 'solution' is **not** necessary.

The Wave Equation implies a need for a Transform

Any continuous medium theory of a physical phenomenon (like Maxwell's theory of EM) must imply that when wave motion in the medium is viewed from a perspective wherein the medium is seen to be moving at a constant speed, then the relative speed of wave propagation will vary with both speed and direction. The "postulate" that this is **not** the case will inevitably result in the need to use the Relativistic Transform for points on the wave front, as Einstein's SRT demonstrated.

Only Einstein viewed the Relativistic Transform as Real

By 1905, Larmor, Lorentz and Einstein had each developed the same mathematical equations that are referred to here as the Relativistic Transform (there is no reason to give Poincaré's ahistorical designation to Lorentz any long-term significance). Although the equations were identical, they had very different physical interpretations. Both Larmor and Lorentz worked with a stationary æther model and remained close to Maxwell's original conceptions. This compelled both of them to adopt FitzGerald's contraction hypothesis to comply with the results of the MMX. Larmor and Lorentz only differed in their own models of the electron, while both viewed the æther as the medium for propagating EM effects between electrons. Larmor viewed his electrons as points in the æther while Lorentz proposed that the electron was a small rigid sphere covered with electric charge that deformed into an ellipsoid when moving at high-speed. Larmor, Lorentz and Poincaré all interpreted the use of these equations merely as mathematical transformations as they were all working with Maxwell's EM theory and saw that an æther was a logically necessary medium for this type of field theory. In contrast, Einstein viewed these transformed equations as all equally valid representations of reality (space and time) when viewed from different reference frames.

No single Reference Frame across Interaction

Due to the finite time-difference occurring between the start and end of a single interaction between two remote electrons (emission and absorption) there can be no time-invariant Lorentz reference frame that applies at all times in such situations. There is no single inertial frame of reference in SRT, which is suitable to describe the interactions between two electrons (the actual situation in the real world). In the Lorentz model of an inertial point-charge, which is interacting with an EM field, there is no single reference frame, which is suitable to describe the motion of the target charge both before and after the interaction. This is *contra* to Einstein's exposition in section 10 of his SRT paper, where he had to make the electric field vanishingly small. Maxwell's EM theory was consistent: his 'field point' was embedded in his *non-inertial* æther but this changed when Lorentz populated this special location with one of his *inertial* electrons that would react to the local EM fields. Einstein built on Lorentz's electrodynamics (his section 9); this is why he introduced this paper and, indeed titled it, as extending Maxwell's EM theory for bodies at rest to one <u>centered</u> on *moving bodies*. This critically ignored the fact that an electron subject to EM forces will always be accelerated and, therefore, cannot form the basis for any equivalent inertial frame of reference. It is this changing focus: from the empty field-point of Maxwell to the real electron of Lorentz, subject to the interaction with Maxwell's fixed æther, that leads to the contradictions of SRT.

The Spatial Origin is Irrelevant

The principle of Galilean invariance recognizes that the world is **spatially** and **temporally** relational, while the rate of time evolving is **universal**. The spatial location of the origin is irrelevant, as is the starting value showing on any 'clock', so that the transformation equations ($t = t' + T_0$; $\underline{x} = \underline{x}' + \underline{D}_0$) are actually expressing the change in the relationship <u>between</u> **any** point $\underline{x}$ and two arbitrary spatial origins, $\underline{O}$ and $\underline{O}'$ where the second origin, $\underline{O}'$ ($\underline{O}' = \underline{D}_0$) is an arbitrary distance D_0 away from the first origin ($\underline{O} = 0$) in a fixed direction. This linear equation can be given a dynamic perspective by defining an arbitrary pair of variables $\underline{V}$ and T through the relationship $\underline{D}_0 = \underline{V}T$. This may then be interpreted as the second origin $\underline{O}'$ moving away from the original origin $\underline{O}$ at a constant velocity $\underline{V}$ such that after T seconds it is at a distance D_0 away in the direction $\underline{V}$ ($\underline{O}' = \underline{V}\,T$). In other words, the Galilean transform is separable: ($t' = t - T_0$; $\underline{x}' = \underline{x} - \underline{V}\,T$) but it is important to note that these are **fixed** space and time displacements, not dynamic ones as is often (and mistakenly) presented in many texts with T = t: ($t' = t - T_0$; $\underline{x}' = \underline{x} - \underline{V}\,t$). This mistake is usually made because this 'dynamic' version supports the invariance of Newton's Second Law of Motion in its continuous form, for <u>constant</u> forces $\underline{F}_0$; i.e. $\underline{F}_0 = m\, d^2\underline{x}/dt^2$.

It is only the 'static' form that provides invariance of the spatial interval **between** two points, $\underline{x}_1$ and $\underline{x}_2$, whether this is evaluated at the same time (t) or at two different times (t_1 and t_2), so that: $\underline{x}_1'(t_1') - \underline{x}_2'(t_2') = \underline{x}_1(t_1) - \underline{x}_1(t_2)$.

This 'static' viewpoint supports the invariance of the 3D spatial interval, it also supports the 4D Natural Vector version:

$$\mathbf{X}_{12}'(t_1' - t_2';\, \underline{x}_1' - \underline{x}_2') = \mathbf{X}_{12}(t_1 - t_2;\, \underline{x}_1 - \underline{x}_2)$$

Discrete Galilean Invariance

Credit should be given to Miles Mathis [191] for pointing out that a more insightful view of the Galilean transform is not the conventional continuous form: ($t' = t$; $\underline{x}' = \underline{x} - \underline{v}\, t$) but the discrete (or difference) form: ($\Delta t' = \Delta t$; $\Delta\underline{x}' = \Delta\underline{x}$). In other words, the origins of space and time in any inertial reference frame are never significant. It is important to note that the single-point spatial transform 'mixes' space and time without justification; as a result this generates, spatially: $\nabla' = \nabla$, but temporally: $\partial/\partial t' = \partial/\partial t + \underline{v} \bullet \nabla$. It is this second result that leads into the 'morass' of the convective derivative.

Space & Time: Relative not Absolute

The concept of the interaction between two point electrons is the foundation of this new theory of EM; it is grounded in the finite spatial separation of the two electrons between the 'send' time at one electron and the different 'receive' time at the other electron. Thus, unlike Newton's metaphysics that were founded on the concepts of a single particle moving through absolute space and time [192] or field theories, with their obsession with the singular 'field-point', the present theory only relies on spatial and temporal <u>differences</u> between two electrons; in other words, it is a purely 'relational' theory.

Only the Lab Frame is Real

In the real world, all experiments are always performed in the 'lab' frame; all others (whether inertial or not), including the 'Center-of-Mass' frame, the 'Moving-Electron' frame etc are just mathematical fictions, based on theoretical extrapolations.

Einstein chases his 'Light-Waves'

Einstein's 1905 SRT paper frequently uses the phrase 'observing the light wave', which is never defined (as it is 'obvious'). The present theory interprets Einstein's teenage insight of 'running with a light wave' as a situation where the electrons in the excited light source are <u>only</u> interacting with <u>his</u> electrons, as there are no other electrons in the nearby empty space; in other words, there is nothing else to 'see'. In this regard, Lorentz was more insightful than Einstein when Lorentz referred to 'his' transform as <u>just a calculational device</u> for transforming the EM field variables between a moving and a stationary reference frame, while the concepts of space and time remain completely Newtonian.

7.5.2 RELATIVITY AS A MATH THEORY

SRT's all-math Concepts

Andre K. T. Assis is one of the few non-retired professional physicists who risked his professional reputation by challenging the orthodoxies of EM and relativity. In his book promoting relational mechanics [193], Assis summarized the current state of the theories of relativity. "The theoretical concepts of length contraction, time dilation, Lorentz invariance, Lorentz's transformations, covariant and invariant laws, Minkowski metric, four-dimensional space-time, energy-momentum tensor, Riemannian geometry, Schwartzschild line element, tensor algebras in four-dimensional spaces, quadrivectors, the metric tensor, proper time, contravariant four-vectors and tensors, geodetic lines, Christoffel symbols, space curvature etc have the same role as the epicycles in the Ptolemaic theory." At the very least, this long list of new concepts illustrates that applied mathematicians have been very busy; indeed, it is not an exaggeration to say that they have been having quite a field day in the last 100 years.

Sacrificing Reality for Mathematics

The theory of special relativity sacrifices the invariance of reality (differences in space and time interval measures as viewed by different 'observers') on the altar of continuum mathematics; that is to say, the uncritical acceptance of the universal use of the differential calculus and the desire to preserve the mathematical <u>forms</u> of its resulting field theories. Even the modern approach to teaching relativity is simply a different mathematical technique that essentially repeats Einstein's manipulation of zero quantities (see section 4.7.2). Today, a Minkowski 'space-time interval' is 'rotated' in a 4D 'space' or a direct hyperbolic transformation is performed, in all cases ignoring the fact that this invariant 'object' is always zero 'on the light-cone', so that preserving its principal characteristic value (nothing) is never a valid mathematical operation.

Einstein constructed his whole relativity theory on the concept of a rigid body (and its link with co-ordinate schemes), which he viewed as absolutely critical, writing in the introduction (line 40): "Insufficient consideration of this circumstance is the root of the difficulties with which the electrodynamics of moving bodies presently has to contend." Here, Einstein ignored the <u>non-physicality</u> of reference frames, the mathematical <u>idealization</u> of Euler's rigid-body concept and the physical <u>state</u> of every electron must be independent of distant, third-party 'observers' who are simply traveling at a constant relative speed.

8. SUMMARY & CONCLUSIONS

In this final section, the results and conclusions from this paper are briefly summarized to draw out the major implications from the material. The paper concludes with summaries of some of the future publications in this programme. The eventual comparison of the analytic predictions of this theory with experiment will be the justification for the assumptions made here.

8.1 OBJECTIVES

The objective of this paper was to demonstrate that after 100 years Einstein's special relativity theory (SRT) is only a weak approximation of reality. The experimental phenomena that are 'explained' by SRT are here given a new and alternative physical explanation. As this paper has clearly demonstrated, SRT was totally grounded in the classical theory of EM first proposed by Maxwell over 140 years ago. Maxwell's EM theory was built on the central concept of the EM æther, which has since 'disappeared' into a more mysterious 'field' theory that believes it no longer needs any explicit carrier of the EM fields. Maxwell's mathematics has still been preserved in the modern version of the theory of classical EM, which is now centered on the concept of continuous charge density. An earlier paper [6] has shown that the mathematical definition of electrical charge density is not only a self-contradiction but it is even a poorly defined limit for real electrons, so even this theory can only be viewed as a statistical approximation. None-the-less, Maxwell's Equations are still thought appropriate as the basis of all single-point micro-theories of EM and have always been considered as a suitable foundation for quantum electro-dynamics (QED).

This research programme is centered on the experimental observation that electricity is based on **electrons** that have been found to have **no finite size**; in other words, they can be viewed like ideal, mathematical points. Experiments have also shown that electrons have a finite amount of inertial mass that constrains their response to changes in their state of motion when involved together in EM interactions. The previous paper [4] has shown that this inertial constraint means that the asynchronous action-at-a-distance interaction, described colloquially as "being on the light-cone", must prevent all electron interactions from acting continuously. This implies that no form of the differential calculus can be used to represent this basic EM interaction. All field theories constructed upon similar assumptions of continuous interactions between inertial particles must also be abandoned. At the most fundamental level of physics, the mathematics used to represent reality must reflect the discreteness found in nature, not the seductive mathematics of the continuum that have been used. This paper has continued the investigation of the EM interaction between two electrons **when the interaction itself is discontinuous**.

Haag's Theorem

The conclusions of the previous paper have occasionally surfaced in the history of physics but they are too embarrassing to be acknowledged. A recent book on quantum field theory [194] recalls Haag's theorem [195] that claimed to prove that there is no known (continuous) mathematical formalism capable of representing an interactive QFT. This challenging result has not been refuted – it has just been ignored. Haag's critique of QFT is the position taken up by this research programme; the objective is to replace all field theories – this project will be investigated in a further series of research papers.

8.2 ELECTRODYNAMICS & MOTION

This paper reviewed the evolution of classical electrodynamics emphasizing the changing ontological views on the nature of electricity, from Maxwell's æther model, to Lorentz's electron 'paint' model, to the present (Helmholtzian) charge density. All of these electrical models require the use of the Relativistic Transforms to preserve the form (covariance) of Maxwell's Equations that remain the one common feature throughout all of these theories, since each theory still retains the inertia-free 'medium' concept to 'carry' the variations in the EM (force) field intensities between their manifestation of electricity.

Maxwell's Equations can only be viewed as statistically valid, that is, as a description of EM interactions between large numbers of charged particles over very many units of time (*chronon*s); in all classical models, the electric field intensity behaves like pressure on small volumes of fluid. Each theory was deliberately constructed in an asymmetric manner: the effects of many source charges being averaged into a complex force intensity at the target point, where these forces can be aggregated onto a single, charged body or at an empty 'field point'. When only two charged particles are involved, this classical theory fails to focus on the symmetric nature of the interaction. This failure hides the inherent two times involved, which is reflected in the symmetric 'delayed' and 'advanced' solutions to Maxwell's Equations. Each pairwise interaction can be viewed from its own inertial reference frame but these must all be averaged together for any macroscopic theory.

This paper takes the view, eventually adopted by Einstein, that the Special Relativity Theory (SRT) is ultimately about the Relativistic Transformation (frequently referred to as the 'Lorentz' transformation), as this ultimately appears in every formulation of SRT. The evolution of these equations was described here by embedding them in their historical context to illustrate what their originators were trying to achieve and the interpretations these authors placed on them. It was shown that the only commonality between Einstein's *kinematical* theory of moving reference frames and Planck's *dynamical* theory of relativistic particle dynamics was the appearance of the square root (Lorentz) factor in both mathematical theories; this is critical as it is only real, dynamical situations that can be measured experimentally: Planck now justifies SRT.

Lorentz always referred to light-speed c in a 'resting' system (that is co-existant with the immovable æther, to all followers of Maxwell). Einstein only focused on the receiver and totally ignored the motion of any emitter (conveniently ignored in all field theories) and he also referred to a *ray of light*, while his derivation of the Lorentz transform (like Larmor) focused on expanding spherical EM waves emitted from a point source. It should also be pointed out that Einstein only stated that the velocity of light is independent of the velocity of its source and not, as the subsequent textbooks write, independent of the velocity of the inertial frame in which it is measured. This would only be true if a massive (non-inertial) 'light' source defined and remained at the origin of the reference frames. Optical emitters are now known to be small, inertial electrons.

The mathematical analogy of retaining the invariance of an object's length under rotations around an axis (in two or three spatial dimensions) was never valid for 'optical' or EM intervals when the corresponding quantity had a zero value. This 'elegant' mathematical approach was always invalid as an example of real invariance but this is never challenged today. This fundamental error in logic corresponds to the *Empty* syllogistic fallacy, where because there are no unicorns in the real world and because there also are no dragons, then it must be true that all unicorns are dragons.

Light-Speed Invariance Hypothesis

Einstein's second hypothesis ("the speed of light is the same in all inertial reference frames") is rejected because here 'light' is never viewed as an independent entity (wave-like variations in a medium or as a virtual-particle) that 'travels' from one interacting electron to another. Rather, the foundational hypothesis of the present theory is that all EM interactions between electrons are universally constrained to occur across spatial separations that bear a constant relationship to their temporal separations – the so-called 'light-cone' constraint; action-at-distance theories do not invent 'carriers of the interaction'.

Lorentz Electron Theory

The perspective of history now allows scientists to see the impact that Lorentz's electron theory had on the direction of fundamental research around 1900. This theory was widely seen by many of his contemporaries as the most promising solution for merging the new, microscopic discoveries in 'atomic' matter (particularly, the electron) with the most widely accepted theory of light: Maxwell's EM æther theory. Unfortunately, this was a 'marriage bound to fail' as it combined Newton's instantaneous force concept with the intrinsic, asynchronous interactions between electrons across space and time. Through a clever set of mathematical transformations, Lorentz was able to blend these two incompatible theories, as long as Maxwell's æther was considered at rest. This implied various, 'second-order' optical effects would appear on the Earth as it moved through the resulting 'æther wind'; in effect, in a moving reference frame where Maxwell's Equations would no longer remain valid. These 'relativistic transformation equations' (that Poincaré generously named after Lorentz, ignoring the pioneering work of Voigt and Larmor) were more readily re-established by Einstein in 1905 using only a purely formal approach (a so-called 'principle' theory based on two questionable hypotheses). In this radical approach, Einstein ignored Maxwell's æther without explaining how to conceive of Maxwell's EM fields in the absence of an existential stratum to carry these fields. This approach was too radical for most of his contemporaries, who simply viewed Einstein's approach as a new mathematical way to justify Lorentz's theory of the electron. The present generation of mathematical physicists no longer requires any metaphysical foundation of fundamental physics so the relativistic transformations are now 'relativity'.

Electron: Particle or Wave?

In the present theory, 'light' is always defined as a series of interaction between two electrons; it is therefore meaningless to speak of an electron interacting with itself: it would be like asking if a person could conceive himself. In terms of the hard-edged logic of Classical Greece, there are only four possible answers to the question: "Is an electron a particle or a wave?" These four possibilities are: 1) a particle 2) a wave 3) both 4) not either. Traditional quantum mechanics has chosen the paradoxical third choice but, perhaps, not always at the same time – a decision that has not helped physicists understand the electron in eighty years. The present theory unequivocally makes the first choice: an electron is always viewed as a discrete, point particle. A subsequent paper will demonstrate how 'wave-like' phenomena arise in such a particle-based theory.

Experiments confirm Particles

The view taken here, that electrons are particles, is derived from experimental results (i.e. reality) whereas the attribution of electrons as waves is based on a mathematical interpretation. This realist view also reflects the undeniable fact of counting scintillations by a detector whereas 'real' numbers are based on the concept of ratios (a mathematical operation) implying the reality of something else that is the basis for calculating the ratio. Ontologically, 'waves' must consist of some thing.

By ignoring the real source of the interaction, local field theories (i.e. those constructed around a single space time point) **need** to introduce relativistic transformations between different inertial frames of reference to compensate for the use of artificial, non-inertial frames, each constructed around its own space-wide view of 'time' and the fantasy of 'rigid bodies'.

8.3 REACTIONS TO SPECIAL RELATIVITY

Section three described the reaction of Einstein's contemporaries to his special relativity theory (SRT) as the modern views on this important theory do not square with the historical reality. There were many, very good reasons why Einstein was not awarded the Nobel Prize for this theory. Today, this theory is taught primarily as an exercise in mathematics. The meaning and assumptions underlying this theory are rarely discussed – this has provided a false sense of security to modern physics.

Planck's Contributions to Relativity

In the modern mythology, Albert Einstein is credited with 'discovering' SRT; in reality, his mentor Max Planck played a very significant role in the creation of a high-speed alternative to Newtonian mechanics. In particular, it was really Planck, who first developed the modern derivation of the relativistic mass formula. It is this formula that actually justifies the most famous equation in physics ($E = Mc^2$) and which provides much of the experimental justification for SRT. This section showed how Planck's major role in German physics became the most powerful political force in the promotion of SRT. The detailed analysis here exposed the subtle (directional) assumptions that lie behind the momentum derivation (referred to here as "Planck's Proposal") – these assumptions have meant that the type of force that Planck assumed for this derivation has no correspondence in reality, especially in the key area of electromagnetism. Einstein was never happy with Planck's use of the concept of force and tried several times, unsuccessfully, to re-derive the 'inertia of energy' without using this continuous concept that required Newton's Second Law of Motion and failed to satisfy relativistic invariance.

Resistance & Acceptance of Relativity

These sub-sections summarized the history of the resistance and acceptance to Einstein's SRT in order to correct the current but erroneous impression that this revolutionary theory swept away all competitors soon after it was published. The actual evidence, increasingly left to specialists, is quite to the contrary. This persistence of factual errors and the omission of valid criticisms of original assumptions results from the neglect of the study of the history of science and the subsequent repetition of these failings by generations of textbook authors. Until 1919, Einstein's contributions to "the Lorentz relativity theory" were almost totally ignored by his peers. It was only with the world-wide newspaper publicity (particularly in *The New York Times*) surrounding the overly optimistic "confirmation" of Einstein's shrewdly entitled "general" theory of relativity that opposition to the "special" theory began to wane, as most scientists then, and now, mistakenly believed these two theories to be closely related. With the death of all of Einstein's original critics by 1960 and the triumph of the mathematicians in their take-over of theoretical physics, reinforced by the powerful cultural role of textbooks in establishing the implicit Platonic orthodoxy that characterizes modern physics, it has now become professional suicide for a physicist to challenge relativity. The history of SRT is an exemplary case study in how the methods of politics are also used in science to consolidate a 'revolution' once a new idea has taken over. In spite of this 'blanket of silence', serious challenges to SRT continue to be made. Most of these (nearly 4,000) have been listed, with commentary, in an online document [108]: *95 Years of Criticism of the Special Theory of Relativity (1908-2003)*. This research programme views SRT as fundamentally wrong. SRT, like quantum mechanics, also illustrates the dangers of introducing radically new ideas into physics following a 'mathematics first' methodology – generations of physicists have been left to divine the meanings hidden behind the abstract symbols. This programme returns to the original 'philosophy first' approach that was pioneered by Newton with great success.

Experimental Confirmation

Although physics is supposed to be an empirical science, there is surprisingly little evidence for the validity of SRT. The focus here was on the dynamic (or temporal) evidence, such as the decay of high-speed 'elementary' particles, as this little understood phenomenon is usually quoted as direct evidence for the impact of the temporal component of the relativistic coordinate transformations. Mathematical formulae are not viewed here as sufficient explanation for empirical physics.

8.4 METAPHYSICS OF SPECIAL RELATIVITY

The fourth section of this paper approached SRT from the philosophical perspective that is no longer in fashion amongst modern theoretical physicists who are quite happy to follow a purely mathematical analysis. This metaphysical approach is justified on the basis that fundamental physics is about developing a shared understanding of the real world; before 1900, this understanding was always grounded in both verbal descriptions (philosophy) and visual representations (imagery). All attempts to describe the world purely symbolically leave the physicist acting like an uninspired cook (or technician) who simply follows the recipes (or formulae) to develop a pre-defined 'mess of pottage'. The major benefit of returning to the original approach to theoretical physics (or natural philosophy), particularly when combined with a historical analysis, is that long-standing assumptions are re-examined, often with fruitful results; the alternative leaves these assumptions implicit and unexamined. As logicians have long known it is errors in the assumptions that result in logical analyses failing to match reality. This new electromagnetic programme readily acknowledges that both Maxwell's EM theory and Einstein's SRT have become the accepted foundations for the latest field theoretical approach to the description of nature. It is this very fact alone that means that their philosophical foundations must be challenged if they are ever to be replaced by any new theory.

Continuity in Classical Physics

This research programme takes direct aim at the "Continuum Hypothesis". This assumes that all interactions in the world occur continuously over time and can, therefore, be appropriately represented by calculus: Newton's calculational technique for evaluating discontinuous interactions in the limit where 'smoothness' is an adequate approximation. This continuous view of the impact of time was extended by Euler into a corresponding vision of space when he introduced the concept of rigid bodies. Both of these concepts form the explicit foundation of Einstein's SRT. Each of these concepts was examined here and found to be tied implicitly to the Continuum Hypothesis; the discrete view of the world discovered by experimental scientists has shown that these mathematical tools are not an accurate model of fundamental reality.

Theoretical Rigid Bodies & Point Clocks

Since Einstein formulated his special theory of relativity around the purely fictitious concepts of rigid rods and point clocks it is not surprising that this theory has little contact with reality. This programme is forced to agree with Bridgman's 1927 statement concerning relativity [131] that: "In view of all our present difficulties it would seem that we ought at least to try to start over again from the beginning and devise concepts which come closer to physical reality."

Unbearable 'lightness' of Being

Implicit in all models of EM is the assumption that light is an entity, a real object that moves through space from emitter to receiver, whether this object is a wave, a propagating EM field or a 'localized bundle of energy' (photon). Like Bridgman, the present theory rejects this additional, metaphysical hypothesis as a "pure invention" – indeed, a very wrong invention.

A Point Theory

As a field theory, Maxwell's Equations are the summary of force-field intensities at a single point; admittedly, any point – the 'field point', nonetheless, it is only ONE point where the EM effects are to be determined. The activity at all the other source points (at least one!) is completely ignored. These famous differential equations are derived from the mathematical conversion of finite fluxes through macroscopic surfaces surrounding the field point. The covariance problems arise from ignoring the relative changes in separation over time between the source charge(s) and the field point, particularly when accelerative motion is introduced, which is inevitable when the field point is occupied by a real electron that is subject to experimental measurements. The finite time delays between changes in location and motion of the source charges and the time they are manifest at the target electron are all absent from local field theories, like Maxwell's. The attempt to model electricity by the concept of 'charge-density' to eliminate Maxwell's æther only compounded the divergence from reality. Einstein's SRT was an attempt to resolve this false image with a mathematical transformation scheme that inevitably had to alter the values of the local parameters in this theory. These had been first introduced as a representation of the local space and time parameters, viewed as unchangeable and passive since Newton's scientific revolution. As Oleg Jefimenko has shown (summarized here in section 4.1.4), the relativistic transformation is necessary to make the electric charge on an electron invariant to all observers when electricity is represented continuously. The present paper cuts this 'Gordian Knot' by eliminating this incorrect continuum model of electricity and represents each electron directly as a mathematical point with the phenomenon of EM viewed as a direct, inter-particle theory of asynchronous interactions.

The Importance of Time

Today, it can be seen that the multiple meanings of the word ‘time’ have contributed to the misunderstandings surrounding relativity. SRT is not about the *nature of time* (as Minkowski believed) but how *light-signaling* could be used to construct experimental schemes for measuring space and time *intervals* in different inertial reference frames based on synchronization in a **single**, inertial frame of reference. Ironically, Einstein’s radical scheme is never implemented in practice but this view is assumed to be the basis for the metaphysical definitions of the space and time parameters in modern field theories. The present lack of philosophical training demonstrated by students of physics means that there are ongoing confusions between ideas of physical reality and the mathematical representations used to model their theories of the world. For example, the axes in orthogonal frames of reference are simply *mathematical representations* of space and time measures, they are not *metaphysical analogues* of aspects of reality.

No Universal ‘Now’

Human conceptions of reality are centered on the idea of a ‘universal now’ – everything is reduced to <u>our</u> present; this is almost certainly a reflection of the very high speed of light (3 x 10^{10} cm/sec) compared to our scale of daily activity. This simplification has been repeated throughout the history of physics, where the global symbol ‘t’ represents time, everywhere. In practice, this has meant that the mathematical representation of reality has been greatly simplified as there is now only a need for one single scalar parameter that controls the evolution of even widely distributed systems with delayed interactions. In reality, everything else is ‘spherical’ around the ‘unique now’ of each electron, with all interactions with other electrons defined on spheres of past and present, ‘on the light-cone’, such that (always): $(\underline{r}' - \underline{r})^2 = c^2 (t' - t)^2$ for all t′ not equal to t.

Relativity Principles

Section 4.5 described how Poincaré’s ‘*Principle of Relativity*’ evolved into Minkowski’s final ‘covariant’ formulation; this showed how an empirical injunction became a purely mathematical constraint on the abstract form of equations in physics. However, Poincaré’s original (1899) formulation (“the æther wind cannot be detected”) is viewed as completely unsuitable in the present theory as all æther concepts are totally rejected here in favor of discrete electrons. Furthermore, Einstein’s 1905 re-formulation of this principle (“the mathematical equations of physics are the same in all inertial reference frames”) is completely rejected whenever these equations focus on only ONE <u>single-point</u> view of the world and not the fundamental interactions <u>between</u> electrons. Only the Galilean or physical principle of relativity (“the outcome of any EM experiment is independent of the inertial frame where it is performed”) is an empirically acceptable constraint.

As a direct action-at-a-distance theory, the present research programme abstracts only from the known observations into the alternative view that the mathematical representation of the fundamental interaction between electrons should always leave the predicted <u>relative motion</u> of these electrons unchanged when viewed from any inertial reference frame. This Galilean perspective is reflected here in the ‘Light-Cone Condition’, which is not proposed as an axiom or as a hypothesis but as a mathematical representation of the behavior of real electrons. The *Principle of Relativity* may be interpreted in the present theory as the requirement that changes in relative displacement resulting from each interactive impulse between the two electrons are independent of all third-party observers and all inertial reference frames.

Reference Frames

Section 4.6 discussed the artificiality of reference frames in theoretical physics, as this concept has taken on an increasingly central role in modern physics. This is ironic, as physicists seem to have forgotten that Einstein defined such frames using the artificial concept of rigid-rods. This mistake was compounded by the thoughtless confusion between the concepts of ‘observers’ and ‘reference frames’. The latter form the mathematical background to the formulation of theories describing activity in the world while ‘observers’ imply experiments and the perceived reality. This confusion again demonstrates the negative impact of failing to discuss the philosophical meaning of modern theories in physics. Einstein must share some of the responsibility for this philosophical confusion between metaphors and literalism. In his canonical 1905 paper on special relativity, he only mentions the word ‘observer’ in the first two sections and then once again in the final section, while reference frames are used throughout, without any explicit distinctions being drawn between these two important concepts.

8.5 DISCRETE CLASSICAL PHYSICS

The fifth section is an exposition of the philosophical and mathematical foundations of this research programme's approach to a new model of electromagnetism. This theory returns to Newton's original particle model of matter, which is identified here with the electron: a stable, fundamental object that has resisted all efforts to determine its physical size – so here it is treated simply as a mathematical point. The widely adopted approach to modeling electrons first as 'free' particles, which then have their interactions 'gradually' turned-on, is rejected here from the beginning. The interaction between electrons is now assumed here to be their all-defining characteristic. The previous paper [4] in this series explored the consequence of the hypothesis that electrons interact with each other only 'on their mutual light-cones'. This approach confirmed the power of the *Natural Vector* space-time point representation of electrons, which always require the universal space-time scaling parameter *c* that has been widely misinterpreted as indicating that force-densities propagate across the void in the form of 'light-waves'. That paper also showed that there could be **no** continuous forces between inertial particles like electrons when the interactions occur 'on the light-cone'. The present paper returns to Newton's original impulse model of interactions that implied that the continuous 'force' model was only introduced as a calculational aid. The central idea in this paper is that electrons interact with each other 'on their mutual light-cones' both ***asynchronously*** (requiring finite time differences) and only acting ***discontinuously*** over time. This view is explored in two stages, with this section closely following Newton and focusing on just **one** single particle. The next section then investigated the full symmetry of the real situation by returning the focus to the interaction itself, which requires examining the discontinuous dynamics of **two** interacting electrons when the complementary impulse view of the interaction between the two particles acts both asynchronously and discontinuously. These are classical analyses - quantizing this interaction, in three dimensions, will be explored in the next paper.

Continuum Physics

Section 5.1 of this paper demonstrated that it was primarily the dramatic evolution of continuum mathematics, prior to the 20^{th} Century, that actually powered the construction of theoretical models of matter. New experimental results were only interpreted in terms of this class of mathematics, centered on the differential calculus and the representation of nature by differential equations. It was not an accident that the metaphysical ideas of the *plenum* and the 'infinite' (that have been popular since Plato) were continually 'smuggled' into physics throughout this whole period. The appearance, in physical theories, of non-physical infinities was the direct result of using these mathematical techniques in the physics of continuous interactions (e.g. field theory). The present theory is constructed around true *instantaneous*, finite impulses, i.e. defined over time intervals of zero duration; so that this theory does not need to use the continuum operators (like grad and curl) that inevitably lead to field concepts. The new theory only uses the mathematics of finite differences defined across finite intervals of time and avoids all use of the differential calculus. Ideas of the infinite have been banished back to theology.

Electron Metaphysics

The metaphysics underlying classical EM were analyzed critically in an earlier paper [6]. The metaphysics of the electron, as it is viewed in the present theory, were reviewed in section 5.2 in an explicit three-level model of physics that described reality (level 1) in terms of our mental models (level 2) and the idealized experiments (level 3) connecting these two. This section gave a brief argument for using simple Euclidean geometry as part of our imaginary schemes to represent reality. In rejecting all forms of field theory, the present research programme returns to Newton's metaphysical approach where space is viewed purely as a passive backdrop to the drama of particle dynamics unfolding over time. The present EM theory is a materialist model of reality: only matter forms real 'things'. The ultimate form of matter in this theory is the electron (and only the electron); the independent existence of 'energy' is totally rejected throughout. This sub-section discussed some of the characteristics that define the nature of electrons in this theory and how they are assumed to interact amongst each other.

Although mathematical physicists have reluctantly admitted that matter itself is discrete and not continuous, they have always (after Newton) assumed that the interactions in the real world act everywhere continuously. It is this metaphysical assumption, referred to here as the '*Continuum Hypothesis*' that has preserved the universal use of the differential calculus. The other central concept that has remained unchallenged until now is the concept of *instantaneous velocity*. The new, rival concept is that of a series of instantaneous and finite changes in an electron's velocity, resulting in a view of the electron's trajectory as a sequence of distinct velocity segments changing at points in time under the interactions with other electrons. The present theory is constructed around the '*Light-Cone*' condition, which constrains the interaction between two electrons. This condition is viewed as inherently superior metaphysically to one based on the assumption of a non-observable entity that always travels (mysteriously) at the same speed with respect to all inertial observers (Einstein's second 'postulate').

Finite Differences

Most (rare) instances of the use of finite difference mathematics in physics have followed Newton and assumed that all the time differences were equal. The previous paper [4] demonstrated that this was never possible for inertial particles, like electrons, that interacted asynchronously 'on their mutual light-cones'. Section 5.3 introduced two new extensions to the concept of a finite difference operator, dividing it into an *extended* component and a *point* component. This separation was needed to isolate the instantaneous change in velocity at a series of interaction points (that could be represented by the point-differences) from those time-intervals where no instantaneous changes occur (represented by the extended-differences). A graphical analysis of difference-sequences showed the close similarities to 'virtual particle' space-time diagrams, illustrating the extra metaphysical assumptions that have usually been added to 'explain' activity in quantum electro-dynamics (QED). A similar analysis demonstrated that the time-based ideas of 'retarded' and 'advanced' interactions could be given a simple explanation of processing ordered lists of discrete values in either ascending or descending values of the ordering index.

Discrete Physics

Section 5.4 investigated the *Chronon Proposition*, which defines when any electron may interact with any other electron. This hypothesis imposed a regular microstructure on the continuous concept of time that is assumed to underlie all of reality and means that all temporal intervals are defined as only **integer** multiples of this universal interval of time: the *chronon*. This careful approach allowed an unambiguous definition of an electron's velocity, valid down to the smallest, finite interval of time. This approach also replaced the continuum concept of acceleration with distinct, instantaneous changes in velocity even though the electron's trajectory always remains continuous over all of time. This section also included a brief historical review of Newton's actual dynamics and the views of two major physicists, who have studied this work very closely. This was included to demonstrate that the present approach was actually introduced by Newton at the very beginning of *Principia* and these key physical and mathematical ideas were lost soon after, when mathematicians instead seized on the power of the differential calculus. The similarities and differences in the resulting continuum concept of *force* with the present theory's definition of *impulse* are important as almost all physicists today just assume that 'force' is the given basis of all of physics.

The emphasis throughout this new theory is on the central role of time and not space. Unlike field theories, there is no need here for Maxwell's 3D spatial vector differential operator ∇ (or 'nabla') in any of its specialized forms (gradient, curl, etc). This section, therefore, concluded with an identification of the (incorrect) discrete assumptions that must be made to recover the continuous form of Newton's Second Law of Motion, which this paper has shown cannot be extended to represent the asynchronous interactions between even classical electrons: only the momentum formulation can be extended as Planck recognized.

8.6 TWO-ELECTRON DISCRETE DYNAMICS

Section six moved the new theory of two-electron asynchronous interactions along its extensive evolution. The previous paper eliminated the possibility of continuous interactions between particles so the standard techniques of forces or fields have had to be replaced with a model that recognized the centrality of discrete impulses acting discontinuously over time. The central result here is that the time intervals between impulses must be unequal - both for the 'emitting' electron, as well as the 'receiving' electron. This is proposed as the physical explanation for the bizarre predictions of relativity theory.

Interactions

Adopting the principle of least change in fundamental ideas, the present theory extended Newtonian particle mechanics in section 6.1 by focusing on the asynchronous interaction itself rather than on just one 'target' particle. The experimental observation that the EM interaction between two electrons, separated remotely in space and never occurring simultaneously, replaces the traditional ideas of 'force' with the concept of the interaction as always occurring between the two electrons, in the form of a series of instantaneous impulses (and their matching reactions). In rejecting spherical 'broadcasting' simply as a many-body summarization, the emphasis here is on point-to-point activity always exchanging finite and equal amounts of momentum during each event. The present theory also uses the history of classical EM research to revive the centrality of the concept of Maxwell's vector potential, which is now identified with the exchange of (mechanical) momentum between the electrons. These impulses are restricted to only occur when each electron is 'on each others light-cone' and at a suitable instant of every electron's universal activity cycle. This restriction is proposed as an alternative to the standard continuous EM model of spherical *light-waves* always traveling at a constant speed to the end of the universe.

Discrete Interactions

The focus on the changes induced in the two interacting electrons leads to a more symmetric view of the two remote events associated with a single interaction, integrating cause and effect at the fundamental level of reality. The recent *Anthropic Principle* was invoked here to justify the cyclic nature of the possibility of interactions between electrons over time: of the four logical possibilities only this option and the continuous interaction can result in a world we humans inhabit. The present theory rejects the continuous interaction option (referred to here as the *Continuum Hypothesis*) based on previous results and the fact that this model, after being investigated thoroughly for over 350 years, has finally run into fundamental difficulties when applied to the foundational objects of nature. The discrete character of all the basic physical constants also suggested that the fundamental interaction between electrons occurs on a digital temporal basis: this has resulted here in the *Chronon Hypothesis*, which is partially described now in this paper and more completely in the next (quantum) report. The timeless Coulomb interaction and the continuous 'force intensity' (electric and magnetic 'fields') are both rejected in this new theory of EM interactions, which is constructed around a proposed universal, invariant impulse that was introduced in section 6.2.

Two-Electron Interactions

Section 6.3 began the investigation of the dynamics of two electrons interacting according to this new model. In this paper, no restrictions are imposed on the magnitude of the impulse (or momentum exchange); it was only required that this impulse be invariant. The next paper will impose a discrete restriction on the degree of change possible in each exchange that will introduce the comprehensive quantum electro-dynamical model of the electron. In this paper, the objective was to produce a more realistic and physical explanation of various classical EM situations that have been given 'relativistic' explanations since 1905. The *Symmetric Interaction Reference Frame* was used here to analyze the dynamics of a theoretical world of only two electrons, where the previously derived *Space-Time Integrity Condition* was used to constrain their post-interaction velocities and define <u>when</u> their next interaction events can occur. This was sufficient to identify a new universal speed constant, denoted as 'b', which is the <u>smallest</u> change possible in an electron's speed (this is related to the universal impulse and the maximum electron speed or light-speed constant 'c'). This section also contrasted the traditional, single-time (or *Historical*) view of the interaction with the fully symmetric or *Interaction* view adopted here. This approach illustrated how the asymmetric and singular nature of the *Historical* view produces a partial (and, therefore, distorted) model of the full interaction and, in fact, it is this artificial perspective that lies at the heart of all 'relativistic' interpretations in classical and quantum physics.

One-Dimensional Interactions

Section 6.4 reported on the investigation of a sub-set of the two-electron interaction model; this restricted the full range of possibilities to only a 'head-on' collision and repulsion in one dimension. Even this 'toy' model has proved intractable to conventional EM theory, whether classical or quantum. In fact, there are no analytical solutions to the full 3D model, which incorporate the asynchronous nature of the EM interaction. This will be the focus of the next paper in this series, when the mechanical action will also be quantized (there is still one free parameter in the more limited version presented here). This 1D model is rich enough to illustrate the role of 'potential energy' in a situation involving asynchronous interactions. It is also powerful enough to generate fresh insights into Planck's approach to 'deriving' the relativistic-mass formula. In this case, there is no need for a fictitious, constant force to accelerate the electron continuously but the present discrete analysis makes explicit the critical approximations being made implicitly in the standard continuum approach. This model uses the *Space-Time Integrity* condition (resulting from the Light-Cone condition and Newton's inertial view of motion) to derive the key equation that defines the ratio of the temporal intervals between successive interactions at each electron. There are only two solutions to this equation: the linear or the harmonic. Only the linear solution is reasonable if these interaction intervals are required to be an integer number of *chronons*. The linear solution showed that the time interval between each successive interaction increases by one *chronon* per interaction while accelerating and decreases by one *chronon* per interaction while decelerating. This means that the accelerating electron must cover a longer and longer spatial interval, proportional to the square of its velocity, to achieve the same increment in speed. In contrast to the continuum models, this also means that in any given finite time interval, the accelerating electron will receive fewer impulses than would have been expected from a continuous energy source. Historically, relativists have interpreted this increasing difficulty to accelerating a high-speed electron as an indication of the change in the electron's inertial mass. It was also Planck's relativistic mass formula that was the source of the view that inertial mass can be inter-converted with EM energy; it was never the relativistic transformations of space and time that resulted in $E = mc^2$. This section included a very detailed discrete analysis of Planck's relativistic momentum model using the difference mathematics developed in section five. The first model provided a purely formal (algebraic) approach based on "Planck's Proposal" for relativistic momentum and showed the necessity for discarding all second-order terms if the famous, relativistic results were to be achieved.

This analysis showed that Planck's relativistic mass formula was the direct result of applying differential calculus to a non-physical situation involving an artificial force, which is constant in magnitude and direction. This type of constant force also contradicts both the inverse square Coulomb force or the Heaviside velocity-sensitive force that are both central to classical electromagnetism; even worse, the use of a continuous force is also forbidden for inertial particles that only interact 'on their mutual light-cones'. The fact that Planck's mass formula appears to work for high-energy particles can be seen as a reflection of the reduction in the number of periodic impulses rather than a confirmation of the time dilation effects of SRT.

Section 6.4 also presented the 'Terrible-Twins' one-dimensional model in terms of 'hot-mud' being transferred from the decelerating electron to the accelerating electron, now with the transfer of mass as well as momentum at 'light-speed'. This model recovered Einstein original 'photon' idea but now the photon is seen as the result of very many consecutive transfers ('photinos') between the two interacting electrons over the total interaction time. This explains why it would be impossible to localize the photon concept in space or time; such 'virtual' particles (unlike the real particles found in nature) can never be localized. Unfortunately, the complete 'Terrible-Twins' model of the one-dimensional electron-electron interaction will have to remain a 'thought-experiment' in this theory. Any observing ('third-party') electron would either be ignored (as it is too far away) or if it did interact with either of these electrons, it would destroy the straight-line motion if it were 'off to the side' or it would introduce dramatic changes if it were somewhere in between on the axis of interaction. This illustrates the three-level scheme used throughout the present research programme. In our imagination (Level II), we can visualize in our minds the proposed motions of electrons as they move in the real world (Level I). It is only when we attempt to measure this activity (Level III) do we need to establish links across these different levels.

The final part of section six showed the results of applying Maxwell's definition of EM momentum using the magnetic or vector potential. A series of somewhat arbitrary assumptions enabled the present approach to generate the standard equation for the relativistic scalar potential energy at the 'target' electron defined in terms of the electron's speed in the usual Lorentz formula. This analysis, along with a brief critique of Coulomb's electro-static force formula, indicated here that a full three-dimensional analysis will be needed to include the 'twisting' effects that are usually interpreted as magnetism; this will be included in the next paper.

8.7 CRITIQUE & RE-INTERPRETATIONS OF RELATIVITY

Section seven brought together the criticisms of SRT mentioned in all the earlier sections and reviewed them in terms of the new insights suggested by the initial investigations of the two electron interaction covered in section six.

Relativistic Problems

The discussion in section 7.1 centered on the contradictions and paradoxes arising from Einstein's use of poorly defined concepts. Problems with the mathematics used in SRT were also re-examined to show the shaky foundations of this 'basic' theory. In developing his SRT in 1905, Einstein made five fundamental errors: the first physical, the second conceptual, the third methodological, the fourth logical and lastly, philosophical. Firstly, Einstein constructed this theory, both implicitly and explicitly, on Maxwell's EM theory of light. This older EM theory was developed 40 years earlier based on Maxwell's metaphysical assumption that light consisted of fluctuations in a continuous, real medium (the æther), reacting to stresses originating in other parts of the medium. These foundations were totally obsoleted by the experimental discovery of the electron as the real carrier of electricity. By 1905, even the model of electricity, as a continuous fluid was no better than a simplifying mathematical approximation. Secondly, Einstein assumed light was an entity (a wave in the æther) that travels independently from the emitter to the absorber. All that is known experimentally is that light is a small frequency range of variations between agitated collections of electrons; there is no evidence to propose any moving entity between these real existents. Thirdly, Einstein based the 'construction' of his reference frames on the fixed origin of the expanding spherical wave-front followed by reflected waves from a distant mirror to define his spatial separations based on the two-way travel times of these waves. Since this origin consists of electrons (the emitters and final receivers) that participate in interactions with the electrons in the mirror, their emissions must cause a reaction so that they will have moved away by the time the EM 'wave' returns back from the mirror. Fourthly, Einstein defined his reference frame, in terms of a 'sea' of reference clocks whose relative positions could be fixed by 'rigid' rods that never change their length. However, all rigid rods can transmit information and energy instantaneously: this contradicts Einstein's own assumption that light-speed is the fastest measure of communications between real objects in the world. Finally, the postulate that the form of theoretical equations must remain invariant is not a physical statement but a mathematical proposition, reflecting the ancient Pythagorean metaphysics. The invariant parameter in Maxwell's Equations is not a measurable parameter as it is a phase velocity, nor an observable group-velocity; as such, it relies on further theoretical assumptions about matter and light to define interference conditions.

SRT is Maxwellian Electrodynamics

Einstein's SRT is a direct consequence of assuming Maxwell's theory of EM is a fundamental description of reality. The view that light is some kind of mysterious entity that always travels at a constant speed, independent of the inertial frame of reference, must inevitably result in the relativistic transformations of single-point descriptions of the world. The present theory rejects all fundamental theories of nature based on the concept of continuous forces (or force intensities, in other words, field theories). This concept is incompatible with the ideas of inertial particles and asynchronous interactions that are confirmed directly by experiment. SRT is either a zero-body (EM) theory or a fictitious one-body (Planck) exercise.

Relativistic Time

Like SRT, time is viewed here as the central concept of all fundamental theories of physics. However, the present theory retains Newton's approach that always viewed time as distinct from space, unlike Einstein's two-way 'synchronization' scheme that, when combined with his implicit entity model of light, led to the Relativistic Transforms of Einstein's newly defined kinematical variables. The infamous 'Twins Paradox' was resurrected here, in section 7.2, as all the traditional interpretations, except as a mirage, are still rejected. The present theory makes a clear distinction between the universal evolution of time at a constant rate for all electrons and the differential number of impulses generated per unit time at each electron involved in a pair-wise interaction.

The present theory returns to Newton's impulse model of particle dynamics, where the interaction causes a change in motion irrespective of whether the impulse on one electron arising from the other electron occurs at a time before or after the time of the change at the other electron. In other words, this theory views the direction **of** time as asymmetric but the nature of the interaction as symmetric **in** time. In other words, all electrons move forwards through time from one location in space to another location in space always at a later time, independent of the sign of their charge. As will be shown in a later paper, positrons are defined by their abundance in the nuclei while negatively charged electrons are also found outside the nucleus. Both types of electron travel forwards in time as velocities only change instantaneously in this theory, so that positional changes are only linear in time, in contrast to continuum theories where forces induce changes that are quadratic in time.

Relativistic Mass

Section 7.3 challenged the long-held view of relativistic mass that began with Kaufmann's experiments that inspired and has justified SRT ever since. This summarized the major objections to "Planck's Proposal" for redefining momentim focusing on Planck's weak physical and mathematical assumptions. The observed reduction in observed acceleration with increasing relative speed has always been interpreted as evidence that the inertial mass of a high-speed particle increases with (relative) speed. The present theory shows that a far-more physical explanation can be found in terms of a direct reduction in the number of interactions exchanged between the electron and its interacting partner, ultimately reducing to zero as their local relative speed approaches light-speed. This viewpoint is simply the temporal analogue of decreasing strength of interaction with increasing spatial separation (the inverse square law).

Mass & Energy

The failure to distinguish philosophically between the concepts of mass and energy underlies Einstein's repeated failure from 1905 through 1907 to derive the famous mass-energy equation in a rigorous manner; his failures led to "Planck's Proposal" becoming the standard derivation, which is why this latter approach was the subject of major criticisms here. There is no reason to view mass as anything more than the property of a material object – it is not some existential real substance that is transferred between electrons by some other mysterious entity, such as 'light'.

There is also no evidence that energy is anything more than a calculated quantity associated with the relative motion of particles. It was shown that when asynchronous interactions are examined then the concept of potential energy may be introduced, as a 'book-keeping' device, to create a new calculated quantity ('total energy') that is conserved at all times throughout the duration of the total interaction. This approach restores the long-standing invariant concepts of space and time as the passive background to the original physics of Isaac Newton. In particular, every electron's mass is identical and unchanging. Inertial mass is not seen as interchangeable with energy – a concept, whose values vary with the viewpoint adopted (specific reference frame). The false ontological view of energy is the ghost left behind when DesCartes' æther was forced by experimenters to leave the stage: the idea of action-at-a-distance is still too repugnant to these ancient Platonists.

Relativistic Transformations

The relativistic transformations of the space and time parameters that are used in differential equations describing single-point models of nature are not required in descriptions of asynchronous interactions between pairs of electrons, especially when discrete mathematics are used for this description. These equations have been justified historically by demonstrating the invariance of Maxwell's Equations with respect to moving inertial reference frames, even though this theory of EM is still based on the incorrect model of continuous electric charge density rather than real, distinct, point-charge electrons.

Just some more Math

It is ironic, given all the physical and metaphysical problems of the SRT (reviewed in this paper) and the frustrating 40 years of his failing to develop a unified field theory based on the most sophisticated 19th Century mathematics, that Einstein on his deathbed is reported have lamented [197] : "If only I had more mathematics!" The history of the last 50 years in theoretical physics might have reconciled Einstein to the conclusion that this was never the most productive way forward in physics.

Alternatives to Special Relativity

The key components of the present theory of EM, as it pertains to questions of relativity, can be described as follows.

1. All interactions only occur between pairs of remote, point electrons, that are at different locations at different times; only the differences between these parameters are significant, i.e. this is a relational mechanics.
2. The interaction may only occur when both electrons are "*on each other's light-cone"*.
3. The interaction is an example of asynchronous action-at-a-distance; there is neither a medium nor a 'photon'.
4. The interaction is cyclic in time and may only occur at integer multiples of the temporal quantum (*chronon).*
5. Each interaction exchanges one quantum of velocity (or momentum) from one electron to the other.
6. The interaction alternates between an electron 'sending' and 'receiving' one quantum of momentum.

Invisible Tachyons

It is only the SRT formula for combining velocities (in a single direction) that actually predicts that the maximum velocity of any real object in a given frame of reference is limited to light-speed, c. The present reformulation of finite impulses confirms that no single electron can transfer any further kinetic energy to another electron once their joint relative velocity exceeds the speed of light and they are no longer 'on their mutual light-cone'. This does not mean that systems involving more than two electrons cannot transfer energy electromagnetically through a cascading process of intermediate exchanges. It is thus possible for one electron to accumulate sufficient energy from this process for it to achieve a speed exceeding that of light relative to some of the other contributing electrons. These 'supra-optical' speed particles have been given the name of *tachyons* (first conceptualized by Sommerfeld and named by Gerald Feinberg in 1967). It is important to realize that all such particles will be literally invisible to all other particles when their relative speeds exceed the optical limit. This implies that the number of **measurable** electrons in any inertial frame of reference is not a conserved quantity but the total number of actual electrons in existence is conserved: another result demonstrating that 'man is not the measure of all things'.

New Stars Appearing

This research programme shares the metaphysical perspectives of Newton *contra* Einstein, recognizing the priority of dynamics (interactions) over kinematics (imaginary co-ordinates) in physics. The very concept of measurement (which distinguishes physics from mathematics) is grounded in the ideas of real, existing objects (entities) that can be compared with other real objects by macro collections of other real objects (observers): the whole process implying the necessity for interactions between entities. The central role of interactions 'on the light-cone' (differences in spatial locations must always be related to differences in the interaction times at the particles in the same universal ratio, *c*) also implies that no two electrons ever interact if their mutual velocity just prior to a possible interaction exceeds 'light-speed' *c*. As a result, not only are such electrons invisible to each other, they effectively no longer exist relative to each other, while this hyper-velocity (relative speeds exceeding *c*) continues to persist. Since, the present theory does not preclude this situation, this will ensure that any future hyper-speed vessels only have to avoid objects traveling at relative sub-luminal speeds. Any future travelers will see stars disappearing behind them and new stars appearing in the direction of their cosmic journeys.

8.8 FINAL REMARKS

Conclusions

In the last section of his most famous paper [29], Einstein switched from a study of kinematics (pure motion) to dynamics (requiring mass and forces), which implied real changes in velocity (or acceleration), so that there was no common inertial reference frame that could be used for the analysis both before and after the acceleration. This was a much more complex situation that Einstein chose to analyze separately in his later 1916 "General Theory of Relativity". The physicist, Herbert Ives, one of America's leading optical experimenters at Bell Labs and a life-long critic of relativity, wrote a detailed critique of Einstein's derivation of the Mass-Energy equation, demonstrating how Einstein had assumed the result he was seeking in the premises he began with [196]. Even the re-emphasis of this "logical illegitimacy" by as eminent a philosopher as Max Jammer [92] has been equally greeted with a resounding silence. The criticisms collected here will likely meet the same fate.

Summary of Problems in SRT

The special theory of relativity suffers from multiple problems, which are summarized below from the earlier discussion.

1. SRT is based on Maxwell's EM theory of light, which was erroneously constructed on the metaphysical reality of propagating oscillations in a luminifrous æther.
2. The special theory is not compatible with accelerations; these are addressed by Einstein's General Relativity Theory.
3. As a consequence, SRT must logically exclude all forces (inducing accelerations), which are the heart of dynamics.
4. Planck's Proposal generates dynamic predictions (e.g. energy and momentum) based on only a theoretical 'force'.
5. All of the evidence, like mass increase and extended lifetimes of unstable particles (all observed at high speed), interpreted as supporting SRT actually supports Planck, as it is not kinematical but dynamical (needing interactions).
6. Maxwell's 'optical' theory was all about EM forces with variable magnitudes that propagated at light-speed.
7. Einstein's SRT was constructed in terms of non-physical concepts, especially co-ordinate systems defined in terms of rigid rods and a continuum of point-clocks, using an unrealistic scheme for clock synchronization.
8. Einstein's time-synchronization is based on averaging over two-way light travel (using mirrors) when most optical phenomena are only associated with one-way, expanding spherical waves in a single ('lab') measuring frame.
9. The SRT assumes a continuous form of electricity (æther stress or electrical fluid) while electricity is particulate, so that it is illogical to extend it to domains that require quantized charge (e^2) and action (as in QED).
10. SRT is self-contradictory, generating problems like the 'twins paradox' in completely symmetric situations.
11. Light is not a traveling metaphysical entity (wave or a particle) but asynchronous interactions between many pairs of electrons separated across time and space.
12. SRT cannot be used to describe even the classical interaction of two charged particles.
13. The MMX confirms that the motion of 'third party' observers is irrelevant to the interaction between electrons.

This research has shown that it is possible to construct an extended Newtonian-based theory that provides an alternative to the Maxwellian EM theory that was the basis for relativity, as Einstein admitted in one of his final scientific papers [1]. A central emphasis in creating this alternative has been the focus on the Relativistic (or so-called, 'Lorentz') Transformation, which (as Einstein also admitted at the beginning of the same paper) forms the real basis of special relativity theory. An attempt has been made here to document how Lorentz's 'constructionist' approach had begun a suitable investigation of the electron after it was first discovered but this theory still needed to dispense completely with Maxwell's ætherial connections. Einstein's 1905 'theory of principle' halted this research programme and substituted a purely mathematical approach that has generated paradoxes and controversy ever since. The mathematical and metaphysical foundations of Einstein's theory were also re-examined here as many of the original criticisms of Einstein's contemporaries died with them and remained unanswered. The present theory picks up this century old programme and adds some new perspectives.

It has also been emphasized here that the central physical results of relativity, such as relativistic mass and energy, are based on "Planck's Proposal" of 1906/7 for redefining a particle's momentum rather than the Relativistic Transformation and need a hypothesis independent of special relativity. The detailed analyses in this paper have shown that Planck's relativistic mass formula was the direct result of applying differential calculus to a non-physical situation involving an artificial force, which is constant in magnitude and direction. This type of constant force also contradicts both the inverse square Coulomb force and the Heaviside velocity-sensitive force that are at the heart of classical electromagnetism; even worse, Planck's use of a continuous force is also forbidden for inertial particles that only interact 'on their mutual light-cones'.

The focus here has been on the discrete interaction between two electrons and this paper has reported on some of the major consequences of the hypotheses that this interaction is directed, discrete, cyclic and aperiodic. The central result is that the time interval between consecutive interactions increases linearly with increasing speed, resulting from a fixed exchange of momentum from its decelerating partner whose interaction intervals are decreasing linearly with its own speed. The fact that Planck's mass formula seems to work for high-energy particles can be seen as a reflection of the reduction in the number of periodic impulses between the interacting electrons rather than a confirmation of the time dilation effects of relativity. An additional benefit resulting from the present research reported here is a clearer understanding of the role that the Relativistic Transformation plays in constraining mathematical descriptions of nature. This research has shown that only single-point theories, focused on fixed co-ordinates in inertial reference frames must satisfy the Relativistic Transformations in order to accommodate the fact that real electrons interact inertially across remote spatial separations at two different times.

It was shown here that the conventional approach to the special theory of relativity has been based on an implied merger of two distinct but incompatible theories. The continuous electric charge model (now used to develop Maxwell's Equations of classical electromagnetism) leads directly to Relativistic Transformations of the space and time co-ordinates; while Planck's 1906/7 Proposal for redefining an inertial point particle's momentum came to replace classical Newtonian mechanics with its central concept of invariant particle mass. However, both of these theories are fatally flawed: electricity is not continuous but is particulate (point electrons with finite and discrete charge and mass values) while Planck's relativistic derivation relied on a mysterious constant force that contradicts both the inverse square Coulomb force or the Heaviside velocity-sensitive force that are central to electromagnetism. An alternative model is now proposed here for the basic interaction between pairs of electrons that is shown to be consistent with classical electromagnetism and provides an alternative (but now readily understandable) physical explanation for the dynamical results of relativity without requiring the Relativistic transform to redefine the foundations of space and time. Physicists now must make a choice: they can continue to use continuum mathematics (grounded in the traditional calculus used to describe local but mass-less field theories that cover all of space and time, subject to the bizarre interpretations of relativity). Alternatively, theoretical physics can return to the physical models of impulse interactions between point particles (described by the mathematics of finite differences acting within the passive, but common-sense, view of space and time introduced by Newton in the *Principia)*.

Einstein knew his Weakness

It is now known that Einstein was well aware of the *Achilles' Heel* in his approach to physics. Mendel Sachs has quoted a private letter Einstein wrote near the end of life to David Bohm [197]: "When one is not starting from the correct elementary concepts – if, for example, it is not correct that reality can be described as a continuous field – then all my efforts are futile, even though the constructed laws are the greatest simplicity thinkable."

Effective Science is always Empirical

Science has proven most effective when experimenters work with systems or situations that can be directly manipulated, when there are only a few variables to be varied (e.g. temperature), when the variables can be represented by numeric values, when the objects are all identical (e.g. atoms), when the errors are small and the observations do not alter the actual values (e.g. astronomy). Whenever science deviates markedly from these characteristics then it is in danger of taking on the metaphysical features of religion. When mathematics was introduced into the study of natural philosophy around 1600 it was clearly seen as the servant of a powerful new science that was to be grounded in the incontestable facts of experiment. However, beginning with Maxwell, this servant has now become the new master of this science and the triumph of applied mathematics in the 20th Century has returned physics to the fruitless arguments of the imagination: a situation that Francis Bacon clearly rejected when he criticized 300 years of medieval scholasticism. As Shakespeare recognized with Henry IV: "Uneasy lies the head that wears a crown" – rulers must deliver value to their subjects if they are to keep their authority.

Science is always Tentative

The key distinction between science and religion is not that science is experimental while religion is not. This certainly distinguishes experimental science from religion but not theoretical science. The major difference is that real science never claims that it has discovered a 'theoretical truth' – it must always admit that its theories are always tentative and may well be superseded at some time in the future. Theoretical physicists today should study the history of their own subject to realize that earlier generations of great scientists have repeatedly claimed that the 'Final Theory' had been achieved.

Future Research

The focus in this programme up until now has been on analyzing continuous interactions that have always been central to physics ever since Newton. However, the previous paper showed that the concept of continuous asynchronous interactions is incompatible with point particles that have intrinsic inertial mass – the universal property of all real fundamental particles. As a result, this programme has now been extended to non-continuous interactions where each of the time intervals between consecutive interactions always remains finite. This has now involved extending the mathematics of *finite differences* to represent discrete (or discontinuous) variables that change instantaneously on a finite number of occasions to form a discrete theory of interactions between pairs of point electrons.

The next paper will extend the motion of two interacting electrons across all three dimensions of space, while the amount of action generated during each exchange will also be quantized. This will require extending the Natural Vector representation to span discrete time intervals to fully model the 'twisting' effects of the EM interaction; these extensions will lead to a new theory of *quantum electron mechanics* (**QEM**). This first QEM paper will also show that the introduction of interactions that are symmetric in space and time (i.e. the inclusion of both 'transverse' and 'advanced' effects) forms an understandable explanation for the Dirac relativistic theory of the electron, including a simple model of the '*positron*' – Dirac's famous positively charged 'anti-particle' of the electron.

Another QEM paper will introduce a richer model of the 'photon' concept that will provide a mechanical explanation for discrete electro-optical experiments like the photo-electric effect, Bragg and Compton X-ray scattering.

A further paper will return to the central problem of providing an explanation for the 'wave-like' characteristics of 'light' (such as diffraction and interference) that does not use the Huygens' wave model - the foundation for all continuum explanations of this intriguing phenomenon of nature for over 300 years. This final paper in the classical electromagnetic series will describe a collective micro model of the dynamical motion of pairs of electrons that reduces to the standard form of Maxwell's Equations when averaged over a *mesoscopic* collection of electrons.

The QEM series will include a paper on how the macro collections of electrons constituting human beings interact with micro sets of interacting electrons. This will offer an interpretation of the problems of quantum measurement and provide a physical model for the 'wave/particle' dualism that has been lying at the heart of quantum mechanics since 1925.

The final paper in the QEM series will use the *Saturation Hypothesis* to calculate the dynamical effects of multi-electron atoms and molecules, concentrating on providing analytical solutions for the first few elements in the periodic table.

The addition of positive electrons provides the opportunity to create stable repetitive patterns involving small numbers of positive and negative electrons moving in very close proximity. This will form the basis for a series of paper on elementary particles and nuclear physics using this model for *nuclear electron mechanics* (**NEM**).

9. REFERENCES

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