THE RELATIVISTIC MECHANICS OF E=MC2 FAILS

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ABSTRACT. The relativistic mechanics of contemporary physics does not have a defined unit of force. It's definition of force as $F = \frac{d}{dt}(\frac{mv}{\sqrt{1-v^2/c^2}})$ does not define a real standard unit of force. A Newtonian unit of force, e.g. the SI newton, may not be used in any of the relativistic formulas; it is a real unit of force only with Newtonian mechanics which observes Newton's second law of motion as an axiom defining a unit of force as $mass \times acceleration$. Without a unit of force, the application of the work-energy theorem produces only a formula that evaluates only to a pure number which has no association with any real unit of energy. All values of energy from relativistic mechanics are, therefore, fictitious. The implication is grave. The well known equation: $E = mc^2$ and the central identity of relativistic mechanics: $E^2 = (pc)^2 + (mc^2)^2$ are now invalidated. The quantum electrodynamics, the Standard Model of particle physics are now highly questionable. At the Large Hadron Collider (LHC) of CERN where protons are propelled to near the speed of light, the purported energy of the relativistic protons is 6.5TeV, but the real value is only 470MeV - the reported energy being inflated by a factor of 15,000. The Kaufmann-Bucherer-Neumann experiments were not evidence for a mass varying with speed; they showed only a contradiction between the Lorentz force law with Newton's force law. The correct conclusion is not a failure of invariant mass of Newtonian mechanics, but evidence of failure of the Lorentz force law at relativistic speed conditions. Nature does not seem to favor any relativistic mechanics. We may have to fall back on our old Newtonian mechanics.

1. INTRODUCTION

[1] [Version 3.1]. When relativistic mechanics was developed a hundred years ago, there was an oversight on a very small change that was made to a simple formula of mechanics. It was a change that looked innocently innocuous, but which would have grave consequences for the world of physics. For the next hundred years, no one

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seems to have noticed the oversight - the meaning and implications of the small change went unnoticed. Nonetheless, relativistic mechanics was subsequently fully integrated into modern physics and has to date become the foundation of high energy physics, e.g. particle physics.

2. Newton's Laws of Motion

The small change was the introduction of a new definition of relativistic momentum for a particle with invariant rest mass m moving at velocity v from the simple $p = mv$ to the relativistic version of $p = mv/\sqrt{1 - v^2/c^2}$, c being the constant light speed in vacuum. Momentum in Newtonian mechanics had always been defined as : $p = mv$. Before going into the nature and meaning of the change, it is necessary first to go back to examine Newton's laws of motion, especially the second law.

In "*Mathematical Principles of Natural Philosophy*", the *Principia* of Newton, the English translations [1] of the three laws are:

> **Axioms Concerning Laws of Motion**
>
> Law 1. Every body remains in a state of rest or of uniform motion in a straight line unless compelled to change that state by forces acting on it.
>
> Law 2. Change of motion is proportional to impressed motive force and is in the same direction as the impressed force.
>
> Law 3. For every action there is an equal and opposite reaction, or, the mutual actions of two bodies on each other are always equal and directed to opposite directions.

On examining the nature of the three laws in greater depth, we would find that Newton's laws are not what we would customarily interpret as laws of physics in the sense that they are testable and falsifiable through experiments. The difficulty comes with the concept of force.

2.1. **The Concepts of Mass and Force.**

There are various fundamental physical dimensions in physics such as length L, time T, mass M, electric charge Q, temperature K. Such dimensions represent the basic physical qualities found of the physical world that may be observed, sensed and also measured; qualities that are not rendered easily quantifiable are of little use in a mathematical model of physics. Nearly all ancient civilizations have developed systems of units of measure for length, quantity of matter and time. In the *Principia*, mass is an exact synonym for quantity of matter.

Force as a concept should be as old as civilization itself, but it is not a fundamental dimension of physics. Before the discovery of electricity, the physical force known to man was gravity alone (magnetism then was minor). Surprisingly, although force is not a fundamental dimension, the ancients too have a measure for force - the measure of force is identical to the measure of mass! If the mass is the pound, the measure of force is the pound-weight; the weighing scales rely on weights due to the pull of gravity. So a body is always exhibiting its fixed and indestructible amount of matter (it was believed matter may neither be created nor destroyed). The same body would also be exhibiting an identical value of force through its interaction with gravity pulling it downwards. That's what Newton discovered when he experimented with similar shape pendulums made of different materials and observed their periods of oscillations :

> *It (mass) can also be known from a body's weight for - by making very accurate experiments with pendulums - I have found it to be proportional to the weight . . . I have tested this with gold, silver, lead, glass, sand, common salt, wood, water, and wheat.*

So there is a profound connection between force and mass that could not have escaped the insight of Newton. Force as a concept could not be quantity of matter itself! But the quantity of matter "can also be known from a body's weight...". The final form that Newton deduced to be the relation between force and motion is the second law of motions:

Force is proportional to change of motion.

The term *motion* here is our momentum : $p = mv$; Because mass of a body is an invariable, we now have our traditional formula:

$$F \propto \frac{dp}{dt} \quad \text{or} \quad F \propto ma; \quad a \text{ being the acceleration.}$$

For any body:

Force is proportional to mass $\times$ acceleration.

This result was known to Newton from the work of Galileo who confirmed that all bodies falls at the same acceleration rate irrespective of its mass.

Now, the three laws of motion involve the concept of force. What is the meaning of *laws* in Newton's *Principia*. Are not the laws meant to be directly testable and verifiable through experiments? They are not. But we have to note that our argument is only about direct verifications of Newton's laws of motion. Newton's laws have been well verified through its predictions - thus indirectly - to be fully consistent with the physical world.

The three laws of motion are axioms of truth.

As for the first law, there is no place in the universe where a body is absolutely free of external impress forces. It may not be practical to put the third law to a rigorous empirical test. A law like the second law may only be a testable law if both sides of the proportionality have independent definitions. The mass $\times$ acceleration ma is clearly defined with the dimension of $[M][L]/[T^2]$, but there is not an independent definition of force for which we might have assigned the dimension symbol $[F]$. A body's weight is also a good reference for force, but it has already been used since ancient time as a standard for mass measurements. Even today, our SI system of units is still using weighing balances when it comes to calibration of the kilogram standards; albeit, the balances should be highly sophisticated.

The nature of the concept of force may be the reason why it is difficult to treat force as a fundamental physical dimension that may be easily rendered measurable, measuring an amount of force through a standard unit of measure.

2.2. **Newton's Law of Universal Gravitation.** But fundamental physical forces of nature do move things. Newton was trying to understand the force of gravity as a fundamental force of nature - the first of nature's forces that classical mechanics has successfully modeled through a mathematical law, the familiar Newton's gravitational law:

$$F = GmM/r^2$$

Here we have a truly testable and verifiable law of gravity. For the force f on any body, it is just the quantity ma; the second law of motion now being a definition of force. So for the force acting on the smaller mass m:

$$\begin{aligned} ma &= GmM/r^2; \\ a &= GM/r^2 \end{aligned} \tag{1}$$

Theoretically, the law of gravity could be directly tested using different values of mass M and different values of separation r to verify if (1) holds by measuring a, the acceleration of mass m caused by the other mass M. As is well known, Newton's gravitational law is the first quantitative law and the most successful laws of physics to date.

2.3. **The Interpretation of the Second Law of Motion.** Within the confine of space and time, the three laws of motion of the *Principia* constitute the mathematical principles on which Newtonian mechanics is found. In the *Principia*, the only dimensions involved are length, time and mass. The three basic dimensions have their defined units of measure. Although the *Principia* has the second law stated explicitly as a proportionality between force and rate of change of momentum $\frac{dp}{dt}$, where $p = mv$, Newtonian mechanics had never treated force as a fundamental dimension which would have required an independent dimension symbol F as well as an independent implementation of a unit of measure of force.

> ***The paradigm of Newtonian mechanics has the second law as an axiom of definition of force; force = mass $\times$ acceleration.***

The interpretation of the second law has always been as an axiom since the beginning of Newtonian mechanics. It's definition of a force takes care of the unit of force which now has dimension $[M][L]/[T^2]$. In order to know force, it is only necessary to compute $mass \times acceleration$. In the SI system, the unit of force is the newton, symbol N and dimension $kg.m/s^2$.

3. Why Relativistic Mechanics Fails

It was mentioned earlier that the change of definition of momentum may have a significant implication to mechanics. Newtonian mechanics as a paradigm had worked perfectly for three centuries but was replaced with a new relativistic version of mechanics. It was believed that the new relativistic mechanics had repudiated classical Newtonian mechanics as the correct mechanics of the natural world. Though such an assumption has been fully accepted by the mainstream physics community, it is an assumption that has not any sound basis.

Special relativity brought with it its own paradigm of mechanics rejecting the basic axioms of Newton's *Principia*. When the axioms of absolute universal time and absolute Euclidean space are rejected, it should not come as a surprise that the three laws of motion too may need to be reinterpreted to accommodate the new paradigm. With special relativity, the transformation of coordinates between two inertial reference frames is now the Lorentz transformation replacing the Galilean transformation of Newtonian mechanics. What was found was that the Lorentz transformation between inertial reference frames did not preserve total momentum - the law of conservation of momentum would be violated if the same definition of momentum of $p = mv$ were to be retained. A new relativistic definition for momentum was needed in order that relativistic momentum may work well.

From "Introduction to Special Relativity, 2008, Stanford" [3, Sec 6.4]:

> *The Conservation Laws are very powerful in classical physics, and we would like to have similar laws in special relativity. To do so we will need to redefine momentum and kinetic energy.*

The fix adopted was to make a change by introducing a new relativistic definition of momentum:

$$p = \gamma mv; \qquad \gamma = \frac{1}{\sqrt{1 - v^2/c^2}} \tag{2}$$

This replaces the classical Newtonian momentum of $p = mv$. Indeed, this new definition of relativistic momentum does preserve the conservation of momentum for both inertial frames under the Lorentz transformation, but it becomes the very cause of the failure of relativistic mechanics.

With a new momentum, it was assumed that the second law of motion would give a cause-effect rule between force and motion by reverting to the original expression of Newton's second law as:

Force is proportional to change of momentum.

Mathematically:

$$force = \frac{dp}{dt}; \quad force = \frac{d}{dt}\left(\frac{1}{\sqrt{1 - v^2/c^2}}mv\right) \tag{3}$$

But the equation (3) above is not a valid mathematical expression of the second law as "*force is proportional to rate of change of momentum*". There are two mistakes inherent in equation (3).

(1) Firstly, the use of the equality sign in $force = \frac{dp}{dt}$ is only permitted provided the second law is an axiom of truth by definition; but equation (3) is now not interpreted as an axiom of truth. It does not define a new unit of force for the new relativistic mechanics.

(2) It treats the second law as a law of relation between a force on the one side and a resulting effect on the other side - a strictly cause-effect rule. A simple cause-effect example would be to calculate the motion of a proton when acted on by the electric force that is driving the protons in a particle accelerator. But the force, the cause of motion, has to be defined and known before equation (3) may be applied. But the force unit of electromagnetism is still the classical unit, e.g. the newton, which is in conflict with the new relativistic mechanics.

The change to a new relativistic interpretation of Newton's second law represented by equation (3) would now require that force be treated as another fundamental dimension on equal footing with L, T and M, say with a new assigned symbol of F. The dimension of force in relativistic mechanics would then be $[F]$, not $[M][L]/[T^2]$ of Newtonian mechanics. The oversight that went unnoticed for a hundred years is :

> ***The force in the new relativistic relation:***
>
> $$force = \frac{d}{dt}\left(\frac{1}{\sqrt{1-v^2/c^2}}mv\right)$$
>
> ***may not be in a unit of force of Newtonian mechanics, e.g. the newton, the SI unit of force***.

The relativistic mechanics of special relativity reinterpreted the axioms of the *Principia*; its new interpretation is in conflict with the classical interpretation of Newtonian mechanics. As it fails to come out with a unit of measure for its new fundamental dimension of force, force in relativistic mechanics is undefined. As this undefined force is used in the work-energy theorem to derive the kinetic energy formula[4, sec 14.8], energy in relativistic mechanics would also be undefined.

> ***The formula $E = mc^2$ does not evaluate to a value with a real defined unit of energy.***

3.1. **Total Relativistic Energy.** Applying the work-energy theorem to the new definition of momentum and based on Newton's second law, the kinetic energy T of a particle is now:

$$T = \gamma mc^2 - mc^2; \qquad (4)$$

m being the invariant rest mass, $\gamma = \dfrac{1}{\sqrt{1-v^2/c^2}}$. A new relativistic total energy concept is found with an added assumption that, for the invariant rest mass m of a particle, mc^2 too represents *rest* energy - that invariant mass is inherently equivalent to energy. By adding together the kinetic energy and the rest energy, a total energy E for a particle is assumed:

$$E = T + mc^2; \quad E = \gamma mc^2$$

Conventionally, γm may be interpreted to be a relativistic mass that varies with speed giving rise to the popular form of the well known equation:

$$E = mc^2$$

From equation (4) above, a more general relation for a particle involving total energy E, momentum p and invariant mass m is derived[4, sec 14.8]:

$$E^2 = (pc)^2 + (mc^2)^2 \qquad (5)$$

As relativistic energy is now fictitious:

> ***The central dynamical identity of relativistic mechanics $E^2 = (pc)^2 + (mc^2)^2$ is invalid.***

This identity underlies all relativistic physics including quantum electrodynamics, the Standard Model of particle physics rendering such physics invalid.

4. Galilean Relativity and the Laws of Nature

A law of nature is only a law if it is immutable and universal. Yet, students of physics still come to hear about laws of physics being true only in certain type of frames, usually the so called inertial frames moving with uniform rectilinear speed. Mathematical formulation of physical theories has to begin with a fundamental framework; even the tool of physics, mathematics, has set definitions and meaning. So, one cannot expect to have the same mathematical expressions of Newtonian dynamics working relative to a stationary car as well as with a moving car in a roller coaster - but the laws of nature is always the same.

> ***The physical laws of nature are immutable, but the mathematical expressions of the laws are governed by mathematical principles.***

Galileo was probably the first to observe that motion in general is relative. A person below the deck of a ship cannot feel or detect any difference whether the ship is stationary or moving smoothly along a straight path. Rest and rectilinear motion have a kind of physical equivalence with regard to motion. It was Newton who finally formalized the *Principle of Galilean Relativity* with the first and second laws of motion in his 1687 *Principia*.

In his *Principia*, Newton's law are also referred to as axioms - statements of truth of nature. Besides the three laws of motions, there are also two axioms, the axioms of absolute space and absolute time. The five axioms of truth are the basic framework within which the mathematical laws regarding the phenomena of the natural world are to be formulated. Galilean relativity, or Newton's mathematical principles, have been very successfully applied for more than three hundred years. To date - right up to this very 21st Century - not a single instance has been found that Galilean relativity fails.

> ***No empirical evidence has ever been found that contradicts Galilean relativity.***

But if Galilean relativity has been working perfectly, why has the world replaced it with Lorentzian relativity, or special relativity, on which all of modern physics are now based. It all begins with Maxwell's theory of electromagnetism, the present form due mainly to Olivier Heaviside.

Under the original paradigm of mechanics in line with the original interpretation of Newton's *Principia:*

> ***A law of physics is true only if it obeys Galilean relativity.***

The Maxwell's equations were found to be not Galilean invariant. Neil Graneau[2]:

Heaviside's field equations had a rocky start in the early 1890's when it was discovered that they were not Galilean invariant for all observers. This meant that one could detect one's velocity by making measurements of the local field quantities which meant that the laws of physics would depend on the motion of the observer which is considered to be unacceptable.

What this implies is that the laws of physics as embodied within the Maxwell's equations are not truly valid laws of physical nature. Instead of trying to examine the validity of the four equations extract of the real work of Maxwell, physicists of the time accepted Heaviside's formulation without question and, instead, repudiated Galilean relativity replacing it with Lorentzian relativity simply because Maxwell's equations are found to retain invariance under the Lorentz transformation. The invalidity of electromagnetic theory in general may be due to the fact our current formulation of physics based on the concepts of the magnetic field is not tenable. The Biot-Savart law may also be invalid as it is clearly not Galilean invariant.

5. Special Relativity Has No Physical Reality

A very good idea of how the present mainstream physics world views the status of special relativity versus Newtonian mechanics may be found from the following snippets:

- From Marion & Thorton, *Classical Dynamics*[4, Sec 14.1]: "*. . . it was pointed out that the Newtonian idea of the complete separability of space and time and the concept of the absoluteness of time break down when they are subject to critical analysis. The* ***final overthrow of the Newtonian system*** *as the ultimate description of dynamics was the result of several crucial experiments, culminating with the work of Michelson and Morley in 1881 - 1887...This (a fundamental reorganization of the structure of dynamics) was provide during the period 1904 - 1905 by H. Poincare, H. A. Lorentz and A. Einstein, who formulated the theory of relativity in order to provide* ***a consistent description of the experimental facts***".
- Professor Gerard 't Hooft, Nobel Laureate and current Editor of "*Foundations of Physics*". The journal has a policy of not accepting any paper that questions the validity of the relativity theory. It would reply to the effect that special relativity is one of the best tested and verified physics theory.
- Gordon Kane, in the introduction to his book "*Modern Elementary Particle Physics*"[5], wrote: "The theory fully incorporates special relativity"; the "*theory*" here means the Standard Model of particle physics.

The book by Marion & Thornton is a well recognized text that has served many generations of undergraduate students. Gerard 't Hooft and Gordon Kane are physicists with the highest standings. From snippets, it is conceivable that many unwary students of physics would form the view that special relativity has incontrovertibly been tested and verified, conclusively replacing Newtonian mechanics - that Newtonian mechanics has finally been "*overthrown*" as the correct physics describing the "*experimental facts*" of the natural physical world.

The sections following present a clear argument that shows such views as untenable. Contrary to the present widespread belief, Newtonian mechanics has not been incontrovertibly refuted empirically:

> ***To date, Newtonian mechanics has not been incontrovertibly refuted by experiment.***

We will discuss this in more details below.

Special relativity is Lorentzian relativity. Any physics theory based on the Lorentz transformation cannot be physical[15] and, therefore, must be invalid. A theory of physics with no physical reality cannot do any predictions about how real physical phenomena work and develop. The reason why the Lorentz transformation has no place in physics comes down ultimately to the fact that Lorentzian relativity has relative space and relative time. By repudiating absolute space and time of Newtonian mechanics, it in fact rejected the Galilean physical reality of Newtonian physics. If Lorentzian relativity has any physical reality, it has to be independent of the physical reality of Newtonian physics.

> ***The physical reality of Lorentzian relativity and Newtonian physics are independent of each other.***

A common misrepresentation in contemporary physics is that the correct mechanics now is relativistic mechanics; it has replaced Newtonian mechanics which is "*incorrect*". That, for small non-relativistic speed, relativistic mechanics approximates to Newtonian mechanics and it is this near approximation that makes Newtonian mechanics correct for three hundred years without its general invalidity being detected. This assertion has no basis at all as the two mechanics are based on completely independent paradigms.

> ***A physics based on absolute space and time cannot be compared in any way with a physics based on relative space and time.***

Quote[14]:

> *The reality of space time is metaphysical, absolute, unknowable and without attributes. We have set forth a system on how metaphysical space and time may be represented as physical space and time measurable with*

standard units. Such a system is based on the adoption of set of conventions and rules. In this manner, it may be said that there is physical reality only because of an implied covenant on what physical reality mean.

There is a covenant of physical reality which sets forth in a determinate way what constitutes a physical quantity.

The manner of measure of a standard length has been set forth and agreed upon. What a unit of time in second is also set forth clearly.Only such measures of length and time are physically real - not otherwise.

Physical reality has absolute three dimensional Euclidean space and absolute universal time.

...

Special relativity dismissed the Newtonian paradigm, reinterpreted Newton's second law, dismissed absolute space and time. As Lorentzian relativity is essentially at variance with our natural world, there is no possibility of it to be a system of physics with its own defined physical reality. It therefore simply assumes that its physics would work with the same physical reality of the Newtonian paradigm, using the same standard of units defined based on Newton's original *Principia*. As is shown in a later section, any attempt to introduce relativistic mass would lead to indeterminacy in physical reality. There is a principle of physical reality.

Physical reality is determinate.

Length contraction and time dilation of special relativity, too, lead to indeterminacy in physical reality. Let's consider a fixed distance L on the ground between two points AB. According to special relativity, the Lorentzian "*physical reality*"[2] of the length AB is L' to a moving observer; $L' < L$ due to length contraction. But the physical reality of the Galilean world is that an observer may travel at will between inertial reference frames:

In the real Galilean physical world, an observer is free at will to move amongst all inertial frames.

When he comes back to the fixed ground and measures AB, he would find the length to be L, not L'. So Lorentzian relativity presents him an indeterminacy about physical reality. It just shows that Lorentzian relativity cannot be a correct physical theory for our natural world. The same reasoning applies to time dilation.

[2]the concept of variable reality is highly dubious

Length contraction and time dilation of special relativity violates the principle of physical determinacy.

Lorentzian relativity cannot have any real relation to the physical world that we know of and of which we can experience.

6. Verification of Special Relativity and Repudiation of Newtonian Mechanics

It is now common to find that, whenever special relativity is discussed, it is accompanied by the assertion that it is one of the best tested and verified physics theory to date. Although the Wikipedia cannot be taken as an authoritative source for citations by the academia, it nevertheless could be the first source of reference in this internet age. It has pages on the experimental verification of special relativity and they do have a significant impact in forming the public's view on the relativity theory. These pages have long lists of experiments purportedly verifying special relativity. The Kaufmann[8], Bucherer[9], Neumann[10] and Rogers et.al(1940)[11] experiments(the KBNR-experiments) from the beginning of the 20th century have always been represented as conclusive experimental verification of relativistic mass, thereby, indirectly also repudiating Newtonian mechanics and verifying special relativity. Such conclusions were the result of a fatal misinterpretation of the experiments.

6.1. **The Kaufmann Prenatal Repudiation of Special Relativity.** The acceptance of special relativity came about with the discovery of the electron by J.J. Thomson in 1897 and the later attempts to build models of the electron to explain inertia mass as having an electromagnetic origin. Such models beginning with J.J. Thomson predicted that electromagnetic mass is not an invariant, but varies with velocity - thus the beginning of relativistic mass. There were competing models, mainly the models of Abraham and Lorentz-Einstein. In order to verify the expected variation of mass with speed, experiments were designed and carried out beginning with the Kaufmann experiment of 1901. Such experiments did confirm the variation of mass with velocity.The charge-mass e/m ratio was measured and found to decrease with speed. As charge was accepted to be constant, it was mass that was interpreted to increase with speed. Unknown to the physicists of the time - a great misfortune to the development of physics - these early experiments were misinterpreted as a repudiation of invariant mass. The correct interpretation of the experiment is that the variable e/m ratio was clear experimental evidence of the failure of electromagnetism for charge particles at relativistic speed - it was a fatal indictment of the Lorentz force law. From then on, the mistaken notion of a relativistic mass repudiating the invariant mass took root and it gradually gained universal acceptance as being the correct concept of mass.

In the "*Introduction to Special Relativity*"[6], the well known author Robert Resnick shows the Bucherer experiment as "*proof*" that the idea of an invariant mass was contradicted by experiment - mass was verified to vary and even fits the γ-factor as predicted in special relativity. We will examine the Bucherer experiment as described by Professor A.K.T. Assis[7].

6.2. **The Bucherer Experiment, 1908.** We need not go into the actual details of the 1908 Bucherer apparatus here. It may be considered as a capacitor with a linear dimension L much greater then the separation of of the two oppositely charge plates with charge distribution of $\pm\sigma$. The x-axis is perpendicular to the plates from $-\sigma$ to $+\sigma$. Classical electrodynamics shows that there is a uniform electric field $\mathbf{E}_x = -(\sigma/\epsilon_0)\hat{\mathbf{x}}$ between the capacitor plates. The axes origin is a radium β-particle(electron) source at the center of the capacitor between the plates. The y-axis is the path an electron would leave the capacitor after traversing the distance L leaving the capacitor with a velocity $\mathbf{v}_y$. A uniform magnetic field $\mathbf{B}_z$ in the z-axis direction is superimposed on the capacitor. Only those electrons in the y-direction could leave the capacitor when the electric deflection and the magnetic deflection in the x-direction are in balance and the initial electrons has no velocity component in the x-direction else they would collide with the capacitor plates.

$$\mathbf{F_x} = -e(\mathbf{E}_x + \mathbf{v_y} \times \mathbf{B_z}) \tag{6}$$

Equating force to be zero, we have:

$$v_y = \sigma/\epsilon_0 B_z \tag{7}$$

The Bucherer apparatus is also a velocity selector as changing the magnitude of the voltage across of the capacitor and the magnetic field would allow electrons of varying speed to leave the capacitors. Five runs of the experiment were made giving data points for speed from about 0.3c to 0.7c. After the electrons leave the capacitor it would only be under the deflection of the magnetic field and it would travel in a circular path with a constant speed as in (7) until it strikes a photographic plate at some known distance away. From the coordinate of the point on the photographic plates and the other dimensions, the radius r of the circular path could be computed. Equating the Lorentz magnetic force with the the centripetal force of circular motion, we have:

$$|e(\mathbf{v} \times \mathbf{B})| = ma = mv^2/r \tag{8}$$

a being the centripetal acceleration and v is the constant speed equal to the speed in (7). Combining equations (7)and (8):

$$e/m = \sigma/r\epsilon_0 B^2 \tag{9}$$

The RHS of (9) could be evaluated as all quantities are from the measured variables of the experiment. The values of e/m changes with velocity and showed that mass is not invariant, but increases with velocity. Equation (9) has an excellent agreement if the mass m is substituted with the relativistic mass defined by:

$$m_r = \frac{m_0}{\sqrt{1 - v^2/c^2}} \tag{10}$$

m_0 being the invariant rest mass of an electron. The textbook of Professor Robert Resnik [6] gives a table of the data for the experiment.

6.2.1. ***Interpretation of the Bucherer Experiment.*** The result of the experiment does have profound implications. Prima facie, it repudiates invariant mass and verifies the relativistic mass of special relativity. It is neither. For whatever reason, the physicists then had electron models that predicted mass increasing with speed; they were not willing to forego their models and to assume otherwise. Some were quick to accept the Bucherer experiment as a conclusive repudiation of the invariant mass.

None cast any suspicion on (8) which is the basis of experiments such as that of Bucherer. Electrons were deflected in a circular path and the Lorentz magnetic force of $e(\mathbf{v} \times \mathbf{B})$ is equated to the $mass \times acceleration$ of Newton's second law. As shown in earlier sections, the application of this definition is based on the concept of mass being an invariant - it is an axiomatic condition that must be adhered to before the definition may be used and applied.

> ***The Newtonian definition of force = mass $\times$ acceleration is found on the concept of mass being invariant.***

As the results of the experiment contradict the strict condition that mass had to be invariant, it shows that certain assumptions and physics underlying the Bucherer experiment are incorrect. The experiment basically involves electromagnetism, the Lorentz force law and Newton's second law. Newton's second law interpreted as $f = ma$ being the cause of the contradiction may safely be put aside. It is a law fundamental to classical physics and have been put to the test rigorously for three centuries without any failure to date. That it is invalidated through the Bucherer experiment is not conceivable. So the contradiction lies with electromagnetism and the Lorentz force laws. The year 1909 is not long after the discovery of the electron and radioactivity of beta-decay. So the treatment of such electrons moving at speed comparable to that of light is something very new to physics -

electromagnetism and the Lorentz force law have never been verified for charge particles moving at relativistic physics. It is here that the physics fails.

> ***The Kaufmann-Bucherer-Neumann experiments were experimental proof of the failure of electromagnetism and/or the Lorentz force law at relativistic speed conditions.***

6.3. **A Mass Definition Is Not Testable.** The invariance of mass in Newtonian mechanics is a definition - defined as an absolute "*quantity of matter*" in the *Principia*. Even the relativistic mass of special relativity is based on this same mass, but as a "*rest mass*" m_0 with a γ-factor added:

$$m_r = \frac{m_0}{\sqrt{1 - v^2/c^2}} \tag{11}$$

The formula (11) is just a new definition for mass giving rise to a new formulation of mechanics of special relativity.

Experiments in the scientific paradigm is meant only to verify or test predictions of a theory, not any of its defined concepts. As an example, the invariance of mass in Newtonian mechanics is not testable, but the prediction that planets orbits the sun in elliptical orbits is verifiable.

> ***In the scientific paradigm, only predictions of a theory are verifiable or testable by experiment; a definition in a theory is not testable.***

So neither the invariant Newtonian mass nor the relativistic mass of special relativity is testable.

6.4. **Light Speed as a Limiting Speed.** There is again a misrepresentation that, somehow, the functioning of particle accelerators around the world constitutes a "*living*" proof of special relativity.

> Fermilab [3]: "*Over the past few Physics in a Nutshell columns, we have talked about Einstein's theory of special relativity and how the operational experience of particle accelerators shows that the theory is true* "

> John S. Reid, University of Aberdeen [4]: "*. . . This concept (*the implication of the γ-factor*) has been tested again and again in pretty well every particle accelerator that has been built.*"

[3] Don Lincoln, Fermilab Today. Friday, May 16, 2014

[4] Einstein 1905 Relativity. Report of Public Meeting held in Aberdeen University on March 21 2005. John S. Reid, University of Aberdeen

> Fermilab [5]: "*Some relativity skeptics are aware that laboratories such as Fermilab and CERN have demonstrated that the speed of light is a limitation in particle accelerators. They have an (incorrect) explanation, and it goes like this: Particle accelerators use electric fields to impart a force on (say) a proton. These electric fields, which accelerators use to propel the protons, are composed of photons, according to the theory of quantum electrodynamics. Thus, they reason, particle accelerators shoot photons at protons, and if a proton traveled faster than a photon, it would no longer feel the photon's force. They claim this is the reason that protons can travel no faster than light.*
>
> *This reasoning does not explain how the tiny difference in the proton's speed between the Fermilab Booster and the Tevatron results in the beam's energy increasing by 125 times. So the explanation is wrong, but it is a common one. Be aware of it.*

The issue here is that no particle has been detected to go beyond the light speed c no matter how the power of an accelerator is increased; protons may go at almost the speed c but never beyond. This observation in itself, however, does not "*prove*" special relativity. It only confirms that, under the operating environment of the accelerators, special relativity has not been violated; if any particle were found to go beyond the speed c, then, of course, special relativity would have been invalidated. As for Newtonian mechanics, despite the fact that it has no upper limit on a particle's speed, the observed limiting speed c within accelerators does not "*disprove and overthrow*" Newtonian mechanics. It just shows that the conditions for protons to go faster than speed c may not have been met within the accelerators.

There are differing views about what is actually the true states when the protons are accelerated near the speed c. The typical official view (as expressed above by Don Lincoln of Fermilab) is that there was a 125 times increase in the energy of the proton despite a very small increase in the proton speed which was already almost at speed c; that this disproves the claim by the relativity skeptics that the electric force that propels the protons tends towards zero when the proton speed approaches c. The author holds a different view here. The article has shown earlier that the relativistic kinetic energy formula applied is fictitious; that the only valid kinetic energy formula is still the classical: $\frac{1}{2}mv^2$. It is the proton's kinetic energy that has an upper limit of about $\frac{1}{2}mc^2$ or 470 MeV; the electric force propelling the protons indeed tends towards zero as others have argued [13] as

[5]Don Lincoln, Fermilab Today. Friday, May 16, 2014

well as the proof earlier that electromagnetic forces fails for relativistic particle, $\mathbf{F} = q\mathbf{E}$ may tend towards zero as the particle's speed approaches that of light.

> ***Within the accelerators, the electric force propelling the protons tends towards zero as the proton approaches the light speed. The actual kinetic energy of the proton is classical and is limited to about 470 Mev.***

To date, there is no incontrovertible calorimetric test of the actual kinetic energy of the protons within the CERN accelerators despite claims that the protons have reached energy levels as high as 7 TeV.

7. Newtonian Mechanics or Special Relativity

Essentially, special Relativity does not yet has need for any experimental verification. A theory needs experimental verification only after it has cleared the stage of being free from theoretical errors - here special relativity fails. It is shown earlier that special relativity does not have a real definition for force thus rendering it only as a fictitious theory with no physical reality. As such, it is categorically dismissed as a theory in physics. Although the argument dismissing special relativity is on very strong ground, there is a practical need to put special relativity to the tests of experiments because of its universal acceptance at present.

Newtonian Mechanics and Special Relativity are two independent formulations of mechanics following different foundational paradigms. They give very different representation of how the physical world works. A new formulation of a mechanics does not automatically repudiate the old. The only way to decide which of the two mechanics correctly represents physical nature is through empirical evidence or experimental tests of their predictions where they differ.

Newtonian mechanics and special relativity have different formulas for kinetic energy giving enormously different values when speed reaches that of light speed. So one test that could incontrovertibly decide which mechanics is correct is by direct experimental verification of the kinetic energy formulas. High speed electrons could be used. The speed of the electrons should be measured by the direct time-of-flight method. There are only two ways the kinetic energy of the electrons could be directly measured:

(a) through total conversation to radiation and measuring the radiation energy. This method is not feasible in general.
(b) stopping the electron in matter and measuring the heat energy through calorimetry. Such experiments have been tried.

7.1. **Calorimetric Test of Special Relativity.**

As we have shown, all the commonly cited proofs of special relativity have no sound basis.

Calorimetric experiments could decide incontrovertibly between the two mechanics if the experiments could be done reliably. To date, only two such experiments have been conducted.

(1) The 1964 Bertozzi Experiment. [12]
In 1964 at the Massachusetts Institute of Technology, William Bertozzi accelerated electrons in the linear accelerator facility of the MIT to relativistic levels from 0.5 to 15 MeV. For the runs at 1.5 and 4.5 MeV, the energy was verified through calorimetry. The conclusion was that the relativistic kinetic formula is verified with about 10% accuracy, clearly rejecting the classical formula.
(2) The 2009 Liangzao Fan Experiment. [13]

Together with his colleagues, Liangzao Fan, Senior Research Fellow of the Chinese Academy of Sciences conducted three experiments with the femto-second Linac accelerators, Shanghai Institute of Applied Physics. The experiments provided data to check the traditional electromagnetic acceleration theory and the formulas of moving mass and kinetic energy. Their conclusion was at odds with that of Bertozzi, clearly refuting the relativistic kinetic energy formula. Their claim was that the purported 7 TeV energy of protons of the LHC of CERN have real kinetic energy of only 663.36 MeV.

7.2. **A Simple Beta-decay Experiment.** Up to this point, even the calorimetry experiments have failed to resolve the question concerning a decision regarding the two competing mechanics. Even if CERN were to come up today with a claim that a calorimetry experiment have just been done proving the relativistic kinetic energy formula, it is still a bad proof in physics. A natural *weakness* in big physics is that experiments with the Large Hadron Colliders (LHC) cannot be independently corroborated by others - we simply have to accept the official statements of CERN at face value - no way of challenging their claims. It is of course true that CERN does not exist to please all and sundry, but if there is a very simple way to completely put to rest the claims of the relativity skeptics, why not give it a try.

There is a simple experiment that could easily be done that could incontrovertibly prove which of the two mechanics is correct. This experiment is very simple by today's technological standard and it is also an easily replicable experiment. Many radioactive elements undergo natural beta decay ejecting electrons with a range of energies ranging from zero to a definite maximum or endpoint energy; the end point energy is usually greater than 0.26 MeV. For such relativistic electrons, the prediction of Newtonian mechanics is that they would go faster than the light speed. On the contrary, the prediction of special relativity is that no electron could go faster than the light speed. The experiment only need to do a direct time-of-flight measurement of the electrons speed and to determine the maximum speed with which electrons may be ejected. There could be only two indisputable outcomes:

(1) If no electrons are detected to go faster then light speed, Newtonian mechanics is incontrovertibly repudiated.
(2) If electrons are detected to go faster then light speed, special relativity is incontrovertibly repudiated.

To date, despite its simplicity, no one has conducted the experiment.

8. There May Not Be Any Relativistic Mechanics

We have shown earlier how the formulation of a new mechanics of special relativity fails as the new definition of relativistic force cannot be implemented in any real world system of units of measure. It could easily see that any attempt to introduce any manner of relativistic mechanics where mass varies with speed to be problematic. Our original definition of: $force = mass \times acceleration$ is only for an invariant mass; the definition itself *is Newton's second law*. It should not come as a surprise that changing it in any manner - even seemingly slight - may bring about surprising consequences. We would attempt at redefining a relativistic force with a mass varying with speed and examine its consequences.

We define relativistic mass to be $m_r = \gamma(v)m$ where $\gamma(v)$ is any scalar function of velocity. We define our new force as $force = relativistic\_mass \times acceleration$. We would assume that such a definition may enable a relativistic force to have physical reality, i.e the same physical units in the Newtonian paradigm may be used. The dimension of this force is the same Newtonian $[M][L][T^{-2}]$. It seems nature do set constraints that we may not suspect yet.

Let's consider a thought experiment that involves an enclosed amount of gas in a perfectly insulated apparatus and the gas may be compressed by a piston - the compression would mean work is done on the gas that would result in a temperature rise. Let the apparatus be in a fixed frame K (on the ground) and let another moving inertial frame K' be moving at relative velocity to K in the x-axis direction. We would examine the force F in the x-axis on the piston by the gas in frame K and how the force transforms under the Galilean transformation to F' in the frame K'.

We examine only a representative general situation, that of a single gas molecule that collides perpendicular to the piston face and reflects back along the same direction with no loss of kinetic energy. In the K frame, the molecule speed is u along the x-axis. When it reflects,its speed must be $-u$ otherwise the collision would not be perfect. We assume that the small time interval for the speed change to take place and complete to be $\triangle t$. So the acceleration here is: $a = 2u/\triangle t$; and the force on the piston in the K frame would be:

$$F = m_r a = \gamma m a = \gamma m(2u/\triangle t) \tag{12}$$

In the moving K' frame, the velocities before and after collision would be $(u - v)$ and $-u - v$; the the force in K' would be:

$$F' = \gamma' m((u - v) - (-u - v))/\triangle t = \gamma' m(2u/\triangle t) \tag{13}$$

We have two different gamma's as the molecule has different speed in the frames K and K' and therefore different relativistic masses.

Now assume the piston is moved and compresses the gas a little distance and does an amount of work W in the fixed K frame. For the frame K', the work would be W'; $W' \neq W$ since F' and F are different. If the initial temperature of the apparatus is T_0, then the equilibrium temperature after the compression would be an increased T in the K frame. For a moving observer in the frame K' using the same valid physics, the predicted equilibrium temperature of the apparatus after compression would be T'; $T' \neq T$ as the work does not transform identical.

As an observer in the real Galilean world is free at will to travel between different inertial frames, when he goes from frame K' down to frame K, he would find that the temperature of the apparatus is not as he predicted; he uses correct physics, yet the result comes out incorrect. There is an indeterminacy in physical reality. The cause of this indeterminacy in physical reality is because of a change in our definition of mass and force - effectually a dismissal of the paradigm of Newton's original *Principia*.

Mass is *quantity of matter* which is another dimension of physics in equal footing with space, time, electric charge and temperature. If electric charge is found not to vary with speed (as it is now believed), why is it less credible that mass too may also not vary with speed; it is only because we have not examined mass as an invariant but preferred a version of mechanics which treats a fundamental dimension of physics as a non-absolute capable of having properties which may be treated within the purview of physics theory in the same manner spacetime physics allow space and time to be distorted within its physics theory. Besides the fourth and fifth axioms of Newton's laws of motion, there should be a sixth that has been neglected:

NEWTON'S SIXTH AXIOM

Mass, the quantity of matter, is absolute and invariant.

The physics world made a bad turn and took a fruitless detour for a hundred years when Einstein introduced his special relativity. We may finally have to come back to what nature has dictated on how the principles of physical reality really work, going back to the original "*mathematical principles of natural philosophy*" of Newton which includes the axioms of absolute space, absolute time and absolute mass.

9. Conclusions

The argument of this paper shows that relativistic mechanics fails.The implication is grave as we now have to reexamine the foundation of all modern physics based on relativistic mechanics. The quantum electrodynamics, the Standard Model of particle physics become highly questionable. At the Large Hadron Collider (LHC) of CERN where protons are propelled to near the speed of light, the reported energy of the protons computed using the relativistic formula may be 6.5 TeV. As the relativistic formulas fail, the only way to compute real kinetic energy is again going back to the classical Newtonian formula of $\frac{1}{2}mv^2$;it would then result in a figure of 470 MeV, the reported figure overstating energy by a factor of 15,000.

We have shown that the widespread belief of special relativity being a well verified and tested theory to be false. There is no incontrovertible empirical nor experimental evidence supporting special relativity; nor has Newtonian mechanics been incontrovertibly repudiated. The early Kaufmann-Bucherer-Neumann experiments were not evidence of the failure of invariant mass of Newtonian mechanics, but rather a contradiction between Newton's force law with the Lorentz force law at relativistic speed conditions. The proper conclusion is that the experiments show the failure of the Lorentz force law.

A simple experiment has been proposed that could indisputably decide on which of the two mechanics to be correct - by just doing a direct measurement of the speed of electrons ejected in natural beta-decay. There may not be any relativistic mechanics; we may have to fall back on using only classical Newtonian mechanics.

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