# Energy-time dynamics vs space-time symmetry

Abstract

Special relativity is non-intuitive, leading to logical contradictions. For over a century there has been no alternative theory capable of explaining the many relativity experiments, especially time-dilation experiments. Unlike quantum mechanics, relativity is interpreted only in terms of space-time symmetry. Here we derive and discuss an alternative theory, *Energy-time dynamics*, that explains relativistic experiments and does not yield the logical contradictions of relativity.

Einstein [2] based his theory of *special relativity* on 'space-time symmetry', in which every moving object possesses its own space and time (represented by a 4D coordinate system projected onto the object) and the speed of light is the same in all such space-times. The *symmetry* is based on assuming "no space-time is preferred", in which case the equations of physics should be *covariant*, i.e., the same in every space-time. Einstein derived the Lorentz transformation to ensure the Maxwell-Hertz equations were covariant.

In texts,[7,16,17,18,19,34] relativity replaced our intuition of absolute time with *the relativity of simultaneity*; a step so drastic that most probably assume that the existence of multiple time frames has been experimentally or logically proved, but that is not so. What *has* been logically argued are Einstein's two principles:

- The *laws of physics* are the same in *all inertial reference frames.*
- The *speed of light* is the same *in all inertial reference frames.*

But the principles do not mention 'multiple time frames'. So how do these arise? They are hidden in the definition of inertial reference frame! Per Rindler: [7]

> *"An inertial frame is one in which spatial relations, as determined by rigid scales at rest in the frame, are Euclidian* ***and in which there exists a universal time****…*[such that Newton's laws of inertia hold.]"

In other words, rather than argue about the *nature* of universal time, it is simply *assumed* that universal time does not exist, and the consequences of this (hidden) assumption lead to paradoxes and non-intuitive physics. Einstein's gedanken experiments yielded such paradoxes as:

- My clock runs slower than yours *and* your clock runs slower than mine
- The 'twin's paradox' (one brother comes back from a trip younger than his twin)
- The 40 foot pole in the 20 foot garage
- Symmetrical length contraction

Yet Lucas and Hodgson [34] remark:

> *"It* [is] *very difficult to accept that time, and so simultaneity, should not be something absolute, and many thinkers have rejected the special theory on the grounds of being contrary to common sense."*

By *defining* inertial reference frames as *each having its own universal time*, Einstein sneaks an *unphysical assumption* into <u>every</u> argument formulated in terms of two such reference frames. The Lorentz energy factor $\gamma$ can be derived in <u>one</u> inertial frame [3] proving that $\gamma$ does <u>not</u> require two inertial frames when derived from radar measurements based on the Galilean transformation. Unlike Einstein's derivations based on two time dimensions, <u>one</u> inertial frame possesses *one universal time dimension*, $t' = t$ . A Doppler transformation with *apparent* length contraction results from *radar-based measurements* in <u>one</u> frame [12] and the difference between Galilean and Lorentz treatments takes the form of an *energy-factor*.

Einstein's 1905 derivation of the Lorentz transformation group initiated many such derivations; Lucas and Hodgson review a number of such. For physicists conditioned to multiple space-times, even a radar approach is based on *two* frames. For example, Whitrow and Milne *"…developed an elegant and thought-provoking derivation of the Lorentz transformation from the radar rule…"* by invoking measurements based on *two* radars in uniform relative motion. Other assumptions are required, including that electromagnetic radiation be received and *understood*, thus providing a means of *communication* between observers in different inertial reference frames. Yet *"The communication argument gives us a derivation which is not a water-tight mathematical proof, but a schema of argument which has many holes in it…"*. In the derivation, "*lines of simultaneity*" are invoked and tick marks are drawn on various lines, such that

> *"The argument thus given is geometrical…".*

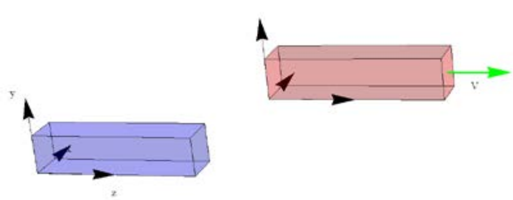
Special relativity is essentially a *geometric* theory based on transforming between *two* 4-dimensional geometries using the Lorentz transformation group based on *space-time symmetry*. Einstein constructed his theory in terms of two abstract *space-times*, represented by four-vectors $(t, x, y, z)$ and $(t', x', y', z')$; despite that the Galilean transformation $\vec{x} = \vec{v}t$ had sufficed for centuries.[49] Einstein specified $t' \neq t$ to be two <u>different</u> time dimensions, running at different clock rates, thus projecting the *Lorentz transformation group structure* onto the physical universe. Physicists came (some kicking and screaming) to accept the relativistic worldview, which is inseparable from the Lorentz transformation.

## Theories of physics and interpretations of theories

There are always *theories of physics* and *interpretations of theories*. For example, there exists a general *theory* of quantum mechanics, but there many *interpretations* of quantum mechanics.[6] From this perspective one might ask how many interpretations of special relativity exist. The surprising answer is only one: the *space-time symmetry* interpretation. Our goal is to provide an alternative interpretation of relativistic particle dynamics, an *energy-time* interpretation in which $\gamma$ applies to mass: $m = \gamma m_0$.

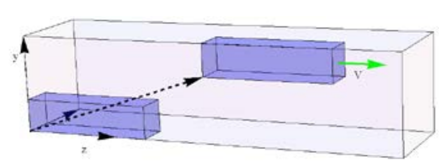
Einstein imagined worlds such that *every* moving object carries its own time dimension, implying *relativity of simultaneity* and paradoxes exhibited by gedanken experiments based on *space-time symmetry*; the *energy-time interpretation* is a *universal-time reality* with physically real clock mechanisms.

**Separate space-time worlds**



Separate times in each frame
plus perfect clocks operating

**Unified energy-time world**



Universal time, but clocks run
differently according to motion

Space-time as constructed by Einstein, *with multiple universal times* and 4D geometries, $\{x, y, z, t\}$ and $\{x', y', z', t'\}$, has length contraction and time dilation from the Lorentz symmetry group, whereas if universal space and time exist, the Lorentz group cannot have these actions. But this begs the question:

> *Why would a moving clock run faster or slower than the stationary clock?*

Einstein could conceive of no reason for this so he based his entire theory on *perfect* clocks that told correct time in whatever time-frame they are *attached to*, and he proceeded to attach a unique universal time to <u>every</u> moving body of interest, beginning with the ground station and the moving object. In our energy-time framework Einstein's separate worlds are replaced by a unified world of ground station and moving object, an asymmetric worldview without space-time symmetry. A moving object at $\vec{r} = (x, y, z)$ in the ground frame, will have the object's origin $\vec{r}' = (0,0,0)$. The time dimension ($t' \equiv t$) is universal and experienced by all, but *measurements of time* are thermodynamic in origin, as the vibration cycle is a measure of the energy of the system. A counter that counts local vibrations is a <u>clock</u>.

## Symmetry and '*the relativity of everything*'

Escaping the '*relativity of everything'* mindset is not a simple matter. A century of repetition of Einstein's principles and his corresponding special theory of reality has worn really deep paths in physicist's brains. Can a physicist *unlearn* the geometric-prescribed symmetry of space-time? Much of twentieth century physics focused on the "geometricization" of physics, exemplified by (but not limited to) *gravity as geometry* as in general relativity. It is not known what percentage of physicists believes that *physics is geometry*, but it is appropriate to consider a point made by Lucas and Hodgson: [34.234]

> *"Scale-indifference plays an important part in the differentiating the parts played by geometry and physics… Geometry… put*[s] *as few constraints as possible upon the way we refer to and characterize positions and figures in space, while leaving to physics the task of not just describing, but of exploring why phenomena are as they actually are." "If this difference of role is accepted* (…) ***geometry needs to be subject to more symmetries than physics****."*

Independently of Lucas and Hodgson, mathematician Zimmer postulated that

> "*the more dimensions a geometric space has, the more symmetries it can have*."

Brown, Salazar and Fisher (BSF) proved Zimmer's conjecture true, by showing that "*below a certain dimension, the special symmetries cannot be found.*[21]

"*At a granular level… symmetry is really about moving points. To transform a space by symmetry means to take each point in the space and move it to some other point in the space* $\{x \to x', t \to t'\}$," etc. In terms of a grid, "*you're allowed to twist the grid, or stretch it in some places and contract it in others, so the transformed grid no longer overlays perfectly on the starting grid*." Galilean transformations do <u>not</u> twist or contract; Lorentz transformations contract length and dilate time. Galilean systems are 4D with $\{x, y, z, t\}$ forming the grid; Lorentz requires more than 4D: $\{x, y, z, t, ...t'\}$. The BSF proof:

> *"…tells you there is something very fundamental about how* [spaces] *are put together that reflect whether they can have these actions."*

If physical reality is based on universal time and space (3D+1) then Lorentz symmetry cannot exist!

In the following we will derive relativistic physics without the Lorentz symmetry, and see how far we can get. Finally, we will discuss the reason that Lorentz is central to physics today.

## Energy-time conjugation versus Space-time symmetry

Einstein's *geometric space-time worlds* require Lorentz symmetry group, but our physical world does not! So the interested physicist asks: "*How does one distinguish 'geometry' from 'physics'?*"

- *Geometry does not have mass terms;* $\{x, y, z, t\}$ *suffices.*
- *Physics has mass terms:* $\{x, y, z, t\}$ *does not suffice –*

The mass is *inertial* mass, which *resists acceleration*, including the acceleration of any restoring force! In the following, we ignore Einstein's geometry and focus on the *energy-momentum physics of relativity*:

$$m = \gamma m_0, \quad p = m\vec{v}, \quad E = mc^2.$$

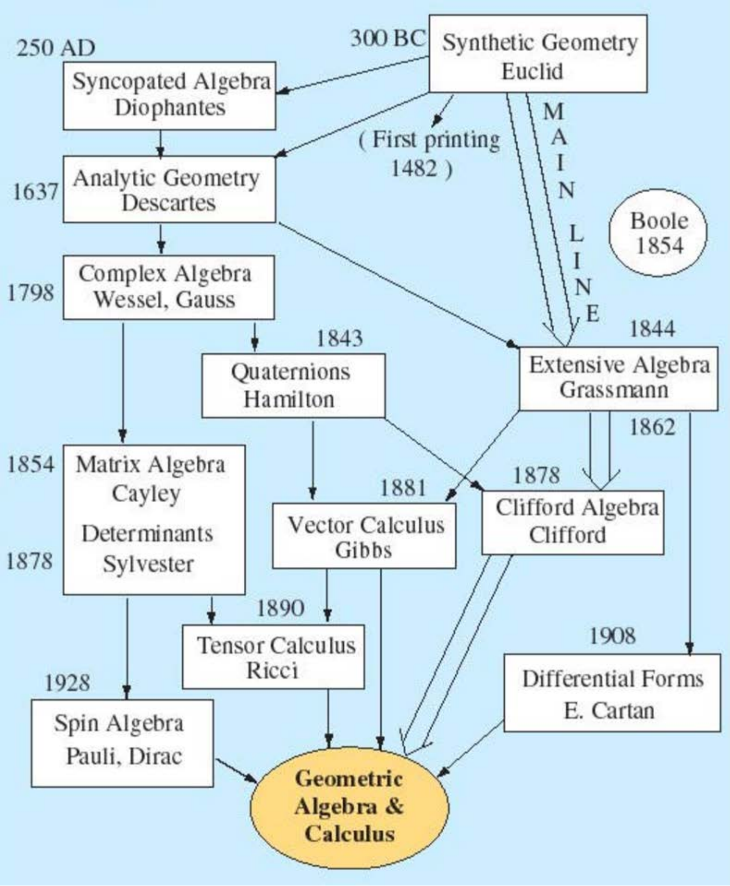
Einstein's basic assumption, never argued or proved, is that the time dimension in each space-time world is universal in that world. This demolishes the intuitive understanding of time as *absolute* – universal time as universal simultaneity – *it is now at every point in our spatial universe*. In place of intuitive time we get the *relativity of simultaneity* implicit in multiple times.

*How does one break such ingrained habits of thinking?*

One way to break ingrained habits of thought is to *change the language*. We do so by switching to *geometric algebra*. While it is possible to begin with the Lorentz transformation, derived in terms of *two* space-times, and show that the critical factor, $\gamma$, can be derived in *one space-time* [3] it's preferable to forego the Lorentz transformation entirely, and to derive the relevant factor in standalone fashion. To do this we introduce Hestenes' *Geometric Algebra*, which incorporates all mathematics used by most physicists (see figure).

Hestenes' *New Foundations for Classical Mechanics* (2nd ed.) [5.615] states in *'Relativistic Particle Dynamics'*:

> *"The entire physical content of the relativity theory has been incorporated into our concept of space-time. It is fully expressed by the Lorentz transformation between inertial systems and the invariant interval between events.* ***No dynamical assumptions are involved****."*




Curious physicists automatically wonder: *if relativistic space-time physics is derivable with no dynamical assumptions*, then can relativistic dynamics be derived without space-time assumptions? We proceed to show that it can and we discuss the consequences.

## Geometric-Algebra applied to relativity

Many physicists consider Hestenes' *geometric algebra* to be *the* most powerful tool for physics. Every physicist spends a major portion of his career expressing physics using algebra and drawing geometric diagrams that correspond in some way to the algebra; nevertheless, the algebraic and the geometric formulations are separate, being related only in the mind of the physicist. Circa 1965 Hestenes, based on Clifford algebra, formulated *geometric algebra* wherein every term has both an *algebraic* and a *geometric* meaning. Geometric algebra can be formulated in an arbitrary number of dimensions, though physicists are primarily interested in $N = 2,3,4$. In *geometric algebra* different kinds of entities can be added together or multiplied together; when equations containing such multi-vectors are evaluated, like terms are grouped accordingly. In two dimensions this is akin to the familiar grouping of *reals* and *imaginaries*.

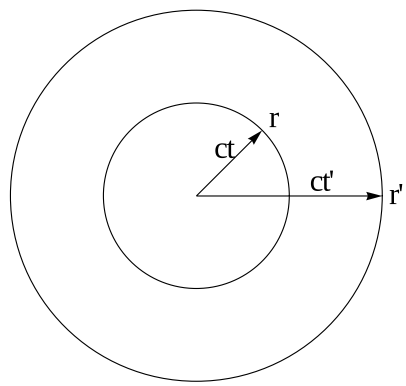
The key entity in geometric algebra, where $\vec{u}$ and $\vec{v}$ are vectors, is the geometric product,[14]

$$\vec{u}\vec{v} = \vec{u} \cdot \vec{v} + \vec{u} \wedge \vec{v}$$

where $\vec{u} \cdot \vec{v}$ is the scalar dot product and $\vec{u} \wedge \vec{v}$ is the *bivector* formed by rotating $\vec{u}$ into $\vec{v}$ thus *producing a directed area.*

## The fundamental law of light propagation

The distance $ct$ that light travels in time $t$ in direction $\vec{r} = (x, y, z)$ from the origin is such that $(ct)^2 = r^2$ or $c^2 (dt)^2 = dr^2$ when $dt = t - 0$, $d\vec{r} = \vec{r} - \vec{0}$. This is true for any point on the expanding light sphere, so $c^2 (dt')^2 = dr'^2$, where $t$ and $t'$ are simply different *values* of time, not different time *dimensions*, as in Einstein's special relativity. We assume there is only one time dimension; the value of time is related to the distance the photon travels at the speed of light, $c$. A geometric diagram relating to the above algebra is shown here:

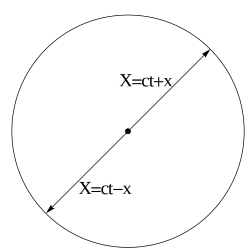



One can derive the difference between the Galilean and Lorentz transformations in one inertial reference frame by invoking the inverse Lorentz property[10], $L^{-1}(v) = L(-v)$, but the Lorentz transformation implies consequences if taken as representative of space-time structure. Having seen that it is possible to derive Lorentz $\gamma$ in one inertial frame, we now focus on deriving the energy-time $\gamma$ factor using a 3D+1 structure with no reference to Lorentz. Physically $\vec{x}$ is any position $|\vec{x}| = ct$ while the conjugate is the inversion $|-\vec{x}| = ct$. Since this applies in all directions, the relation describes a growing light sphere. We begin with the geometric algebraic position four-vector

$$X = ct + \vec{x}$$

where $X$ is an object consisting of current time and location $\vec{x}$ in space. It is quite natural to form an inverse position conjugate four-vector

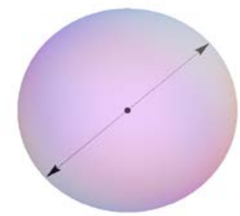
$$\tilde{X} = ct - \vec{x}.$$



Two additive inverse position relations are given: $\frac{X+\tilde{X}}{2}=ct$, $\frac{X-\tilde{X}}{2}=\vec{x}$ while the product $X\tilde{X}$ has the interesting property of *invariance*:

$$X\tilde{X}=c^2t^2-\vec{x}^2=0$$

We project this structure onto two photons, with a common origin but opposite directions traveling at $c$. Hestenes intended to represent special relativistic space-time by $X=ct+\vec{x}$ over all $t$ and $\vec{x}$, but we consider $X$ to represent a photon at $|\vec{x}|=ct$ at time $t$. The conjugate photon $\tilde{X}=ct-\vec{x}$ travels from our origin at $t=0$ to $\vec{x}$ at time $t$. Inversion through the origin conserves momentum: $\vec{p}+\tilde{\vec{p}}=0$. Instead of Einstein's multiple space-time worlds linked via Lorentz transformations, the $X\tilde{X}$ product effectively represents *back-to-back photons* in arbitrary direction $\vec{x}$. The set of all such photon pairs covers an expanding light sphere, represent a *real physical universe*. If $c\Delta t=\pm\Delta\vec{x}$ is interpreted to mean that to reach position $\pm\Delta\vec{x}$ from the origin, light must travel for a period of time $\Delta t$, then position four-vector $\Delta X=c\Delta t+\Delta\vec{x}$ and its conjugate (inverse in origin) $\Delta\tilde{X}=c\Delta t-\Delta\vec{x}$ satisfy



$$(\Delta X)(\Delta\tilde{X})=c^2(\Delta t)^2-(\Delta\vec{x})^2=0\,.$$

This generally holds for space-time points in the space-time enclosed by an expanding sphere of light. Therefore the existence of an alternative coordinate system $X'=ct'+\vec{x}'$ will satisfy

$$(\Delta X')(\Delta\tilde{X}')=c^2(\Delta t')^2-(\Delta\vec{x}')^2=0$$

The key relation these invariants lead to is

$$(\Delta X)(\Delta\tilde{X})=(\Delta X')(\Delta\tilde{X}')$$

An expanding light sphere passing through every spatial point in the universe satisfies $(ct)^2-(\vec{x})^2$ invariance and essentially defines the dynamics of photons, but we wish to consider massive particles that travel with velocity $\vec{v}$. We ask whether any invariance holds when we change $x=ct$ to $\vec{x}=\vec{v}t$:

$$ds^2=c^2(\Delta t)^2-(\Delta\vec{x})^2=c^2(\Delta t')^2-(\Delta\vec{x}')^2=ds'^2$$

$$(ct-vt)(ct+vt)=t^2(c^2-v^2)=ds^2 \;\Rightarrow\; \frac{d(ds^2)}{dt}\to 2t(c^2-v^2)\neq 0$$ is <u>not</u> invariant

But if $\frac{d}{dt}(ds^2)\neq 0$ can we show that $\frac{d}{dt}\left[(c^2-v^2)t^2-(c^2-v'^2)t'^2\right]=0$ ?

In the unified energy-time picture the particle is at location $\vec{x}=\vec{v}t$ in the ground station, while the particle is at $\vec{x}'=(0,0,0)$ in terms of the coordinate system projected onto the particle. But what is $t'$? Before answering this we discuss the nature of real clocks.

## Theory of inertial time clocks

Our innate experience of time is that it's always now wherever one is – our experience of *time is independent of location*. In reality time *is* independent of location in space – it is now throughout the universe at this time. *Absolute time is universal simultaneity,* yet this understanding was demolished a century ago. Also in reality:

> *all real physical clocks have mass*. [3] Only Einstein's imagined "perfect clocks" are weightless.

They are weightless because they lack mass. Relativity is based on *perfect clocks* scattered throughout two different space-time worlds with *all* clocks (after being properly synchronized) telling *perfect* time in their world, which has *its own time*. But special relativity is geometric, based on the Lorentz transformation between two four-dimensional space-time worlds. There is no mass involved in the Lorentz transformation. It is a transformation between two 4D geometries in relative motion, nothing more. Becker, [15] in an FQXi article, discusses the impossibility of building a perfect clock from a quantum mechanical perspective. Renner and del Rio claim that:

> "*the more complicated the system, the more precise the clock…* [but] *no matter how massive or elaborate it is, a quantum clock cannot be arbitrarily precise.*"

So Einstein's *perfect clock* is a fantasy. There is no material that 'measures time'. There is no *time transducer* other than a counter; it is oscillations of real physical systems that clocks count to "tell time". Even the muon has a clock; how else could it know when to disintegrate at rest? Traditionally considered an elementary particle, its decay products suggest a more complex structure. Recall Lucas and Hodgson: [34]

> *"Geometry needs to be subject to more symmetries than physics."*

The key symmetry Einstein imposed is *space-time symmetry*, equivalent to *no preferred frame*. It is why

> *Your clock runs slower than mine,*
> *while mine runs slower than yours.*

## Proper time $\tau$ and clocks

In Einstein's *space-time symmetry theory*, based on multiple time dimensions, $\tau$ is the rate at which 'time flows' in the moving system. It flows more slowly with velocity. Einstein's multiple worlds invoke multiple time dimensions, measured by 'perfect clocks'.

In *energy-time theory*, based on one universally simultaneous absolute time, there are no perfect clocks. We experience the flow of time but our experience of the rate of time flow is subjective and changes with circumstances, so we desire reliable measurements of time and none of these are 'perfect'. All clocks count *ticks* or basic cycle periods. *Local energy changes the frequency of the clock system.*

What *do* clocks as *real moving devices* measure? Habit says clocks measure time, so we ask *how*, and in every case we find that a system exists that oscillates periodically, and the mechanism is constructed to keep a running count of cycles as the best measure of time we can physically obtain. Even in 1600 it was known that pendulum clocks at different geographical locations varied. Indeed, whether *wound spring*, *tuning fork*, or *local crystal oscillator*, all clock mechanisms are subject to local conditions. For example, a quartz-crystal-micro-balance measures adsorbed mass because *its frequency changes* when molecules are adsorbed. But its frequency also changes when the temperature of the piezoelectric crystal changes, so we use temperature-controlled quartz-crystal-micro-balances. All clocks able to measure relativistic time changes are atomic clocks, based on characteristic emission lines such as rubidium$^{87}$ and cesium$^{133}$. But even atom-atom scattering shifts the frequency of atomic clocks.[13]

In other words *there are no perfect clocks* — all are subject to local energy conditions. Einstein entirely ignored this reality; positing 'perfect clocks' and a method to synchronize perfect clocks, and **imagining** that clocks measure *different time dimensions*. A more sober approach would be to ask how clocks are affected by local energy, such that a clock at rest in a universal time dimension might read differently than another clock moving in the *same time dimension* with different energy $\sim mv^2$. This *clock differ-rence* is of quite different nature than assuming that the non-local moving clock is measuring a *different time dimension!* By definition, a clock moving with velocity $\vec{v}$ with respect to our rest frame possesses energy $\sim mv^2$ with respect to clocks at rest in our frame and this may well affect the 'cycle counting' that we interpret as 'measuring time'.

While absolute time is experienced by each of us, subjective time is quite variable in the rate at which it flows. Our instinctual understanding of absolute time is as universal simultaneity: it is the same time everywhere in the universe: *It is right NOW!* But *time flows* and we measure the flow locally using clocks that count cycles in oscillating energetic dynamic systems. The vibration is *thermodynamic in nature*, i.e., *energy-based*. And the characteristic frequency is conjugate to time period $\Delta t$, where $\nu$ = frequency of cycles and $N$ = count of cycles:

$$\nu = N/\Delta t \qquad\qquad h\nu = Nh/\Delta t = E$$

Before discussing the nature of clocks we asked the question: what is $t'$? The symbol $t' = \tau$ represents the clock reading of the *moving* clock. The velocity of the moving object is $\vec{v}$ with respect to the ground station, but the observer is at rest ($\vec{v}' = 0$) in the moving frame, so our invariance relation becomes:

$$\frac{d}{dt}\left[(c^2 - v^2)t^2 - (c^2 - v'^2)\tau^2\right] = 0 \quad \Rightarrow \quad \frac{d}{dt}[(c^2 - v^2)t^2] = \frac{d}{dt}[(c^2)\tau^2].$$

We consider a point in space-time as observed from the different coordinate frames where we assume that the clock in the moving frame (with velocity $\vec{v}$) measures time $\tau = t/\gamma$ while the ground clock measures time $t$. The clock time is measured at rate $\tau$ in the moving frame, so the invariance equation is the time derivative of $(c^2 - v^2)t^2 = (c^2)\tau^2$ re-expressed in terms of ground time $t$ via $\tau = t/\gamma$:

$$2t(c^2 - v^2) = (c^2)2\tau\frac{d\tau}{dt} \quad \Rightarrow \quad \left(1 - \frac{v^2}{c^2}\right) = \frac{\tau}{t}\frac{d\tau}{dt} \quad \Rightarrow \quad \frac{1}{\gamma}\frac{d\tau}{dt} \quad \Rightarrow \quad \frac{1}{\gamma^2}$$

immediately leading to the *condition* that must be satisfied if moving clocks are to be calibrated:

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}. \qquad (1)$$

## The Relativity of Inertia

The velocity $\vec{v}$ of the moving system with respect to the ground frame relates to both momentum $\sim m\vec{v}$ and kinetic energy $\sim m\vec{v}\cdot\vec{v}$ where $\gamma = (1 - v^2/c^2)^{-1/2}$ describes systems which have been accelerated from ground rest to velocity $\vec{v}$ at time $t$. The Galilean transform $x' = x - vt$ then describes the change in position with time, while $m = \gamma m_0$ describes the change in mass-energy of the system as a result of being accelerated to velocity $\vec{v}$ from rest. The time derivative of the transformation is:

$$\frac{dx'}{dt} = \frac{d\vec{x}}{dt} - \vec{v} = 0$$

since $dx'/dt = \vec{v}' \equiv 0$ from the perspective of the primed system. *There is no* $\gamma$ *associated with velocity*; $\gamma$ is associated with an increase in mass-energy: $m = \gamma m_0$.

*The* $\gamma$ *factor does* <u>*not*</u> *directly affect velocity when the four-vector relations use* $m = \gamma m_0$

Relativistic mass is *inertial mass* in motion; the inertia increases with velocity according to energy-factor

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}} = \left(1 - \frac{m_0 v^2}{m_0 c^2}\right)^{-1/2}$$

*As inertia increases, it becomes harder to accelerate the object*, i.e. force a change in the velocity where $\gamma m_0$ is the relativistic mass: $m = \gamma m_0$. To accentuate this point AP French [16.25] states:

> *"…big nuclear machines might appropriately be called 'ponderators' rather than accelerators, for to an excellent approximation they do just add mass to the particles injected into them, with no significant increase in the speed as such."*

Increasing velocity from 0.99995c to 0.999995c does not *accelerate* much; it gains in ponderable mass.

Clock mechanisms share one thing in common – they operate based on elasticity and inertia:

> *When the system is displaced from its equilibrium position, the elasticity provides a restoring force such that the system tries to return to equilibrium. The inertia property causes the system to overshoot equilibrium.* […] *The natural frequency of the oscillator is related to the elastic and inertial properties by*

$$\omega_0 \approx \sqrt{\frac{elasticity}{inertia}} \tag{2}$$

Einstein's *perfect* clocks were *massless*. They were imagined inventions that could be placed anywhere in an inertial reference frame and assumed to accurately measure the time in that reference frame. But massless perfect clocks do not exist. *All* real clocks are based on counting mechanical cycles of oscillators, all of which operate based on elasticity and inertia, with a frequency (count) $\omega_0$. For simplicity we consider the oscillating mass on spring governed by restoring force $-kx$ where $k$ is the elasticity and $x$ is the displacement from the equilibrium displacement, $x = 0$: $F = ma = -kx$. If we let $m = \gamma m_0$ and $a = \ddot{x}$ and $\omega_0 = \sqrt{k/m_0}$ = frequency of clock at rest, then

$$\ddot{x} + (k/\gamma m_0)x = 0 \quad \Rightarrow \quad \ddot{x} + \frac{\omega_0^2}{\gamma} x \quad \Rightarrow \quad \ddot{x} + \omega^2 x = 0$$

and when clock mass $m_0$ moves with velocity $\vec{v}$, $\quad \omega^2 = \frac{\omega_0^2}{\gamma} = \sqrt{1 - \frac{v^2}{c^2}}\ \omega_0^2.$

Thus $\omega < \omega_0$ and the frequency of oscillation is lower, hence the count of oscillator cycles is lower, hence **the moving clock runs slower**. Unlike Einstein's imagined massless 'perfect' clocks, all *real* physical oscillating clocks have rest frequency $\omega_0$ and oscillate more slowly when inertial mass increases.

In *atomic clocks* the inertial aspect is far more complex but in *every* case the fundamental frequency is inversely proportional to inertia. Relativistic particle physics is interpreted according to the *energy-time conjugation interpretation*, if $\tau$ is the period and $\omega_0\tau = 1$ then $\tau = \sqrt{f(m = \gamma m_0)/elasticity}$ and hence **clocks run more slowly as inertia increases**, i.e., per $\gamma$, independent of the clock mechanism.

Accelerating a system to velocity $\vec{v}$ from rest requires energy $m_0 \vec{v} \cdot \vec{v}/2$. This inertial mass increase, represented by $\gamma$, invariably slows the system, so the moving clock will always run more slowly than the ground station. No space-time symmetry here. The key relations of energy-time physics are

$$\frac{dt}{d\tau} = \gamma , \qquad m = \gamma m_0 , \qquad \vec{p} = m\vec{v} , \qquad E = mc^2 . \tag{3}$$

The gamma factor $\gamma$ in the *energy-time theory* is a scalar function relating time to its conjugate, energy. The *Galilean* transformation of the particle is represented by the position four-vector and the velocity four-vector and is linked to the energy state of the system in uniform motion relative to a ground state. Believing that Fizeau [35] had *proved* the law of velocity addition, Lucas and Hodgson state: [34.191]

> "*We then have to choose between defining the mass as m and the velocity as $\gamma v$, or the mass as $\gamma m$ and the velocity as $v$. It is repugnant to have the mass depending on velocity, whereas we know that the velocities behave in a non-Newtonian way…*"

*Repugnant!* On this basis they choose $\gamma v$ (Lorentz-velocity) instead of $\gamma m$ (relativistic mass). However, if we choose $\gamma m$ as the relevant association of rest mass plus kinetic energy, then *velocity* is Galilean. The energy-time physics relations ($m = \gamma m_0$, $\vec{p} = m\vec{v}$, $E = mc^2$) yield *Galilean transformation* with *relativistic mass*, as Lucas and Hodgson note:

> *"…if we insist on retaining Newtonian dynamics, and the Newtonian definition of velocity and acceleration, then we can still obtain relativistically correct results if we pay the price of allowing the mass to depend on the velocity."*

This is a *major* relativistic admission worth repeating:

> ***We obtain relativistically correct results based on relativistic mass and Galilean velocity!***

For some reason the implications of this fact have been ignored for a century.

## Geometry or Physics?

Einstein's derivation is *geometric* in nature, not *physical.* The geometric approach to inertial frames in relative motion is based on *projecting* 4D-coordinate systems onto objects, and treats the frames as physical objects instead of mathematical structures having no physical reality. Yet [34]

> "*Instead of differentiating between geometry and physics,* [Einstein] *sought to identify them…*"

A century of *geometricization* left physics comfortable with this approach, but there are consequences:

> *When one's framework is geometric, one asks questions about 'worm-holes' in space-time.*

> *When one's framework is physical, one asks questions about the topology of stable energy flows.*

Relativistic mass is inertial mass in motion and *the inertia increases with velocity* per the $\gamma$ factor. In the universal time dimension $t$ we measure time by counting cycles of physical systems; *there is no other way to measure time*. But oscillating physical systems are thermodynamic in nature; some particles oscillate faster and some slower as determined by local energy conditions. Our base clock in the stationary system is arbitrarily defined as measuring *real* time. The need to impart energy to a moving clock system will alter the local energy condition of the moving system, such that the time period $dt$ measured on the ground clock counts $d\tau$ cycles on the moving clock. Of paramount importance is the energy relation $E = h\nu$ which in our formulation yields $\Delta t = N\hbar/E$ . Since $E/h$ has units of $1/t$ , $N$ is a pure count related to units of action $E\Delta t$ in Planck units *h*. The clock surrogate, the count $N$ , is *action-based* and thus *energy-based* in Planck units. We represent the invariant interval by the equation

$$(\Delta X)(\Delta\tilde{X}) \quad = \quad c^2(\Delta t)^2 - (\Delta\vec{x})^2$$

in the laboratory-static system, while the moving particle satisfies

$$(\Delta X')(\Delta\tilde{X}') \quad = \quad c^2(\Delta\tau)^2 - (\Delta\vec{x}')^2 . \tag{4}$$

In the lab system the position of the moving particle is $\vec{r} = (x, y, z)$ and the local frequency count or time is based on the energy cycles of the static system at the origin. In the moving particle system, the position of the moving particle is $\vec{r}' = (0,0,0)$ and the local frequency count or time $\Delta\tau$ that matches $\Delta t$ is based on the energy of the system at the location of the particle. We assume the stationary clock cycles differ from the cycles of the moving particle, hence $d\tau \neq dt$ . Since $\Delta X$ is a 4-vector, we proceed to define a 4-velocity.

We began with an invariant physical relation defined by photon behavior $c^2(dt)^2 = (dr)^2$, now we assume that our definition of 4-vector $\Delta X = c\Delta t - \Delta\vec{x}$ and 4-vector product $(\Delta X)(\Delta\tilde{X}) = (\Delta X')(\Delta\tilde{X}')$ are not photon dependent, but describe invariant intervals. Thus since $\Delta\vec{x}' = 0$ we obtain in the limit:

$$(\Delta X')(\Delta\tilde{X}') \quad = \quad c^2(\Delta\tau)^2 \quad = \quad (\Delta X)(\Delta\tilde{X}) . \tag{5}$$

So we divide both sides of this equation by $\Delta\tau$ twice, yielding

$$\left(\frac{\Delta X}{\Delta\tau}\right)\left(\frac{\Delta\tilde{X}}{\Delta\tau}\right) = c^2$$

If $\Delta\tau \to d\tau$ then four-velocity $V$ is the entity $(dX/d\tau)$ with conjugate $\tilde{V} = d\tilde{X}/d\tau$ and we obtain

$$V\tilde{V} = \left(\frac{dX}{d\tau}\right)\left(\frac{d\tilde{X}}{d\tau}\right) = c^2 \qquad (6)$$

Hestenes: [5]

*"Unlike 3-velocities, the 4-velocity has a constant magnitude independent of the particle history."*

Recall that $X(t) = ct + \vec{x}(t)$, $\tilde{X}(t) = ct - \vec{x}(t)$, so

$$\frac{dX}{dt} = c + \frac{d\vec{x}}{dt} = c + \vec{v}\,.$$

If 'particle time' $\tau$ is used and $X(\tau) = ct(\tau) + \vec{x}(\tau)$ then

$$\frac{dX}{d\tau} = \frac{dt}{d\tau}\left(c + \frac{d\vec{x}}{dt}\right) = \gamma(c + \vec{v})\,.$$

In the above derivation we denote $dt/d\tau$ by $\gamma$ where $\gamma = dt/d\tau$ is undefined. Based on $\frac{dX}{dt} = c + \frac{d\vec{x}}{dt}$ then $\frac{d\tilde{X}}{dt} = c - \frac{d\vec{x}}{dt}$ and when $\tilde{X}(\tau) = ct(\tau) - \vec{x}(\tau)$ we obtain $\frac{d\tilde{X}}{d\tau} = \gamma(c - \vec{v})$, so from eqn (6) above we have

$$\gamma(c+\vec{v})\gamma(c-\vec{v}) = c^2 \quad \Rightarrow \quad \gamma^2(c^2 - v^2) = c^2 \quad \Rightarrow \quad \gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}\,.$$

We have once again defined the *energy-time* factor $\gamma$ (considered undefined when we began this derivation) and we see from the above that

$$\gamma = \frac{dt}{d\tau} = \left(1 - \frac{v^2}{c^2}\right)^{-1/2} \qquad (7)$$

where $dt$ is the time interval on our laboratory (static) clock while $d\tau$ is the time interval on the particle's clock, which *counts local cycles of the dynamic system in motion* as a function of energy! We have thus, in a universal time frame, derived the condition that must be satisfied in order to relate moving clocks to static clocks. We have done so without the concept of multiple time dimensions, length contraction, or space-time symmetry. We choose to define the mass as $\gamma m$ and the velocity as $v$, instead of the mass $m$ and velocity $\gamma v$. Relativistic thermodynamic clock-time varies as a function of inertial mass.

## From Geometry to Energy-time Physics

From the above geometry in terms of the four-velocity $V$ of a particle *we can define a four-momentum in analogy with the definition of momentum in Newtonian mechanics by introducing mass* $m$. After associating the $\gamma$ factor with mass, the $\vec{v}$ is with respect to $t$ so $mV = (m/\gamma)\,dX/dt = m_0\,dX/dt$:

$$P = mV = \frac{E}{c} + \vec{p} \qquad \text{from} \qquad \frac{dX}{d\tau} = V = \gamma(c+\vec{v}), \quad mV = \gamma m_0 c + \gamma m_0 \vec{v} \qquad (8)$$

The geometric algebra definition combines a scalar term and a vector term, however the units of physical momentum $(ml/t)$ are preserved. It is a simple matter to then define conjugate momentum $\tilde{P} = \frac{E}{c} - \vec{p}$ such that $P\tilde{P} = \frac{E^2}{c^2} - \vec{p}^{\,2}$ while previous relations show that

$$P\tilde{P} = mVm\tilde{V} = m^2 V\tilde{V} = m^2c^2,$$

hence

$$\frac{E^2}{c^2} - \vec{p}^{\,2} = m^2c^2. \qquad (9)$$

This dynamical energy-momentum relation is ***the essence of relativistic particle dynamics***. The rest mass energy is found by setting $\vec{p} = 0 \Rightarrow E = mc^2$. The energy expression $E(\vec{p}) = (m^2c^4 + c^2\vec{p}^{\,2})^{1/2}$ implies the classical relativistic Hamiltonian:

$$H(\vec{p}) = E(\vec{p}) = (m^2c^4 + c^2\vec{p}^{\,2})^{1/2}. \qquad (10)$$

This *relativistic free particle Hamiltonian* has been derived *without* a Lorentz transformation, in a single inertial frame with universal time. No space-time symmetry applies. This classical relativistic Hamiltonian will be the basis for relativistic quantum Hamiltonian according to the *Correspondence Principle*. We now review the operator formalism leading to quantum mechanics.

## Operator correspondence and four-vector relations

Physicists long focused on Fourier theory, the wave equation, and plane wave solutions formulated as

$$\psi(\vec{r},t) = \psi_0 \exp(i\hbar^{-1}(\vec{p}\cdot\vec{r} - Et)), \qquad (11)$$

and in particular the spatial and time derivatives of $\psi(\vec{r},t)$:

$$\vec{\nabla}\psi = i\hbar^{-1}\vec{p}\,\psi \quad \text{and} \quad \partial_t \psi = i\hbar^{-1}E\psi$$

These relations suggest the identification of momentum and energy operators

$$\hat{p} = -i\hbar\vec{\nabla} \qquad \text{and} \qquad \hat{E} = i\hbar\frac{\partial}{\partial t} \qquad (12)$$

which support the eigenvalue equations:

$$\hat{p}\,\psi = \vec{p}\,\psi \qquad \text{and} \qquad \hat{E}\psi = E\psi. \qquad (13)$$

A question of relevance for *operator-based physics* is how to connect the *time translation operator* to the *spatial translation operator*. In 1890 Heinrich Hertz, [1] discoverer of radio waves, assumed that waves propagate in a medium (the 'ether') which may itself be moving with velocity $\vec{v}$ and thus time derivative $d/dt$ must address this motion of the medium. Hertz interpreted Faraday's experiments as implying the convective derivative [1,3,14]

$$\frac{d}{dt} = \frac{\partial}{\partial t} + \vec{v} \cdot \vec{\nabla}, \tag{14}$$

in the Maxwell-Hertz equations on which Einstein based his 1905 relativity paper.[2] Unfortunately Einstein chose the static equations rather than Hertz's [Ch.14] *equations for electrodynamics in moving systems* that are Galilean invariant ( $t' = t \equiv$ universal simultaneity). Based on the simpler static systems Einstein believed that the Lorentz transformation was required to preserve covariance of the equations. Circa 1918, Emmy Noether derived Noether's Lagrangian theorem for time translation using $L = T - V$

$$\frac{dL}{dt} = \frac{\partial L}{\partial t} + \sum_\alpha \left[ \frac{\partial L}{\partial q_\alpha} \dot{q}_\alpha + \frac{\partial L}{\partial \dot{q}_\alpha} \ddot{q}_\alpha \right] \qquad [T = \text{kinetic, } V = \text{potential energy}] \tag{15}$$

If generalized coordinates $q_\alpha = x_\alpha$ and $\ddot{q}_\alpha = 0$ then $\sum_\alpha \dot{x}_\alpha = \vec{v}$ and $\sum_\alpha \frac{\partial}{\partial x_\alpha} = \vec{\nabla}$, such that Noether's theorem ("*a central organizing principle for all of physics*.") [37] yields the operator expression:

$$\left[ \frac{d}{dt} = \frac{\partial}{\partial t} + \vec{v} \cdot \vec{\nabla} \right] L \tag{16}$$

*essentially defines the convective derivative for energy flow.*

The importance of the convective derivative in Noether's Lagrangian theorem suggests that we may wish to convert the terms to operator expressions:

$$\frac{\partial}{\partial t} = \frac{\hat{E}}{-i\hbar}, \qquad \vec{v} = \frac{\vec{p}}{m}, \qquad \vec{\nabla} = \frac{\hat{p}}{-i\hbar}$$

in which case the convective derivative can be re-expressed: $\left[ \frac{d}{dt} = -\frac{\hat{E}}{i\hbar} - \frac{\hat{p}\hat{p}}{i\hbar m} \right] (L = T - V)$. For a free particle potential $V = 0$ and kinetic energy $T$ is constant, hence $dT/dt = 0$.

$$0 = \left[ -\frac{\hat{E}}{i\hbar} - \frac{\hat{p}\hat{p}}{i\hbar m} \right] T \quad \Rightarrow \quad -\hat{E} - \frac{\hat{p}^2}{m} = 0 \tag{17}$$

The operators are replaced by their operator equivalents to obtain: $i\hbar \frac{\partial}{\partial t} = -\frac{\hbar^2}{m} \nabla^2$. If we operate on the general wave function $\psi$ for a free particle ( $dT/dt = 0$ ) we obtain

$$i\hbar \frac{\partial \psi(\vec{r}, t)}{\partial t} = \frac{-\hbar^2}{2m} \nabla^2 \psi(\vec{r}, t) \tag{18}$$

*Thus the operator equivalent of the convective derivative for stable flow in a medium is Schrödinger's non-relativistic equation for the free particle!*

But Dirac,[41] in his 1930 chapter XI on *'Relativistic Theory of the Electron'*, states on the first page that: "*the theory cannot display the symmetry between space and time required by relativity*", as Schrödinger's non-relativistic free particle equation is *linear in time* and *quadratic in space*.

$$i\hbar\frac{\partial}{\partial t} = \frac{-\hbar^2}{2m}\nabla^2 \tag{19}$$

/ \
Linear time Quadratic space

Dirac tried to fix this 'defect' by forcing the space operator, $\hat{p} = -i\hbar\vec{\nabla}$, to be linear instead of quadratic:

$$i\hbar\frac{\partial}{\partial t} = c\vec{\alpha}\cdot\hat{p} \quad +\beta mc^2 \tag{20}$$

/ \
Linear time Linear space

where $\alpha$ is the 4 x 4 matrix. Dirac 'linearized' the momentum term and ***invented*** the Dirac Hamiltonian:

$$H_D(\vec{p}) = c\vec{\alpha}\cdot\vec{p} + \beta mc^2 \tag{21}$$

Of this equation Feynman [42.57] said

*"Dirac discovered the correct laws for relativity quantum mechanics simply by guessing the equation."*

Dirac admits that the genesis of his equation was the fact that Schrödinger's quantum "*theory cannot display the symmetry between space and time required by relativity*." He does *not* discuss the symmetry structure that had recently been projected onto physics by Pauli, and another soon to be by Heisenberg. Heisenberg would apply the concept of iso-spin symmetry to flip the neutron into the proton and vice versa. Pauli applied the $\hat{\sigma}$ matrix algebra to represent electron spin. Dirac added *iso-spin-like* symmetry via $\beta$ applied to rest energy and Pauli-like spin to the momentum term:

$$\beta = \begin{pmatrix} 1 & \\ & -1 \end{pmatrix} \qquad \sim \text{iso-spin} \;\Rightarrow\; \pm mc^2$$

$$\vec{\sigma} = \{\sigma_x, \sigma_y, \sigma_z\} \qquad SU(2) \text{ symmetry – half-integral spin}$$

Dirac effectively built these symmetry operators into his equation even before the equation was written down, by functionally defining

$$[\vec{\alpha} = \beta\,[\,\vec{\sigma}\,[\,\vec{p}\,]]]\,\psi \tag{22}$$

In actuality, $\beta$ multiplies a scalar portion of the geometric algebra multivector, but the symbolism of the above represents conceptually the symmetry structure Dirac is projecting onto physical reality.

The $\beta$ matrix 'doubled' the $\vec{\sigma}$ matrices, and the $\vec{\sigma}$ matrices 'doubled' the wave function $\vec{\sigma}\psi \Rightarrow \begin{pmatrix}\psi_1\\ \psi_2\end{pmatrix}$.

In Dirac's notation

$$\vec{\sigma}_\pm\,|\pm\rangle = \pm\,|\pm\rangle \qquad \text{where} \quad |\pm\rangle = \begin{pmatrix}+\\-\end{pmatrix} = \begin{pmatrix}+\\0\end{pmatrix} + \begin{pmatrix}0\\-\end{pmatrix}. \tag{23}$$

Thus, essentially: $\beta\vec{\sigma}\psi \quad \Rightarrow \quad \begin{pmatrix} \begin{pmatrix} \psi_1 \\ \psi_2 \end{pmatrix} \\ \begin{pmatrix} \psi_3 \\ \psi_4 \end{pmatrix} \end{pmatrix}$.

Hence $\vec{\alpha}$ is a vector of $4\times 4$ matrices: $\vec{\alpha} = \{\alpha_x, \alpha_y, \alpha_z\}_{4\times 4}$. The structural term $\vec{\alpha}$ was new to physics, so Dirac decided to force his new equation to be compatible with the classical relativistic particle physics Hamiltonian $H(\vec{p}) = E(\vec{p}) = (m^2c^4 + c^2\vec{p}^{\,2})^{1/2}$ by forcing the relation between this classical and his *un-corresponding* Hamiltonian via:

$$|H_D(\vec{p})|^2 = |H(\vec{p})|^2 \quad \Rightarrow \qquad (c\vec{\alpha}\cdot\vec{p} + \beta mc^2)^2 = (mc^2)^2 + |c\vec{p}|^2. \tag{24}$$

Dirac knowingly or unknowingly chose a representation in which $\vec{\alpha}$ is based on Pauli's spin operator $\vec{\sigma}$. Following the Schrödinger operator representation of momentum $\hat{p} \to -i\hbar\vec{\nabla}$ he generalizes to four-operator $\hat{p}_\mu = -i\hbar\partial/\partial x^\mu$ which includes the new operator $-i\hbar\partial/\partial x^0$ corresponding to physical energy. In this formalism he notes that the classical Hamiltonian (derived above for energy-time physics) is

$$E(\vec{p}) = (m^2c^4 + c^2\vec{p}^{\,2})^{1/2} \quad \Rightarrow \quad \{p_0 - (m^2c^2 + p_1^2 + p_2^2 + p_3^2)^{1/2}\}\psi = 0 \tag{25}$$

based on the $\hat{p}_\mu$ operator defined above. Having stated the necessity of imposing space-time symmetry on relativistic quantum mechanics, Dirac looks for an equation "roughly equivalent" to (10) that is linear in $p_0, p_1, p_2, p_3$ and he proposes

$$\{p_0 - \alpha_1 p_1 - \alpha_2 p_2 - \alpha_3 p_3 - \beta\}\psi = 0 \tag{26}$$

where the $\alpha's$ and $\beta$ are independent of the $p's$ and the $x's$. We rewrite and multiply on the left by $\{p_0 + \vec{\alpha}\cdot\vec{p} + \beta\}$ to obtain $[p_0^2 - (c\vec{\alpha}\cdot\vec{p} + \beta mc^2)^2]\psi = 0$. When the equivalence is forced: $(c\vec{\alpha}\cdot\vec{p} + \beta mc^2)^2 = (mc^2)^2 + |c\vec{p}|^2$ it is seen that $\beta^2 = 1$ and $(\alpha_x)^2 = (\alpha_y)^2 = (\alpha_z)^2 = (\beta)^2 = 1$ and $\alpha_x, \alpha_y, \alpha_z$ and $\beta$ all mutually anti-commute. Dirac does not admit to starting his derivation with the intent to impose Pauli's sigma matrix on the relativistic equation, but that is what he ends up with: [43.326]

$$\vec{\alpha} = \begin{pmatrix} 0 & \vec{\sigma} \\ \vec{\sigma} & 0 \end{pmatrix} \quad \vec{\alpha} = \left\{ \alpha_x = \begin{pmatrix} 0 & \sigma_x \\ \sigma_x & 0 \end{pmatrix}, \quad \alpha_y = \begin{pmatrix} 0 & \sigma_y \\ \sigma_y & 0 \end{pmatrix}, \quad \alpha_z = \begin{pmatrix} 0 & \sigma_z \\ \sigma_z & 0 \end{pmatrix} \right\}, \quad \beta = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

Thus, in addition to generalized quantum mechanical operator $\hat{p}_\mu = -i\hbar\partial/\partial x^\mu$, Dirac created a matrix operator ostensibly representing two spins and projected this mathematical structure onto the quantum mechanical operator:

Dirac's insistence on *Lorentz covariance* and *space-time symmetry* led to his equation for the free particle

$$\hat{H}_D(\vec{p}) = -c\vec{\alpha}\cdot\vec{p} - \beta mc^2$$

versus our derivation of the relativistic particle physics Hamiltonian $H(\vec{p}) = (m^2c^4 + c^2\vec{p}^{\,2})^{1/2}$, with the *Correspondence Principle*-derived operator equation

$$\hat{H}(\vec{p}) = (m^2c^4 + c^2\hbar^2\vec{\nabla}^2)^{1/2} . \tag{27}$$

What could go wrong?

In the 19th century the projection of coordinate systems onto physical reality had been so successful that physicists easily believed that coordinate systems were an *aspect* of physical reality. In the decades prior to Dirac, physicists had been faced with *Planck's constant*, Heisenberg's *uncertainty principle*, Einstein's *relativity of simultaneity*, and *curved space-time* gravitation, and Schrödinger's operators $\hat{p} \to -i\hbar\vec{\nabla}$ and $\hat{E} \to i\hbar\partial/\partial t$, as well as Pauli's $\hat{\sigma}$ spin operator. So physicists were impressed and amazed that Dirac's $\vec{\alpha}$ *"predicted"* spin-1/2 electrons and a 'negative energy' anti-particle. The *negative energy* interpretation has fallen out of favor and the Dirac equation does not really predict *spin* 1/2 but at best predicts *helicity*.[24] We derived the classical Hamiltonian $H(\vec{p}) = (m^2c^4 + c^2\vec{p}^2)^{1/2}$ such that $H(\vec{p}=0)$ yields $E = mc^2$. The difference in $H(\vec{p})$ and $H(0)$ is

$$H(\vec{p}) - H(0) = (m^2c^4 + c^2p^2)^{1/2} - (m^2c^4)^{1/2}$$

$$= mc^2\left(1 + \frac{c^2p^2}{m^2c^4}\right)^{1/2} - mc^2 \quad \cong \quad mc^2\left(1 + \frac{p^2}{2m^2c^2}\right) - mc^2 \quad = \frac{p^2}{2m} \quad = \text{kinetic energy}$$

The Dirac equivalent $H_D(\vec{p}) - H(0) = (c\vec{\alpha}\cdot\vec{p} + \beta mc^2) - (\beta mc^2) \quad = c\vec{\alpha}\cdot\vec{p}$

Compare the *Corresponding Hamiltonian* to the *Dirac Hamiltonian* extracted momentum terms:

$$\frac{\vec{p}\cdot\vec{p}}{2m} \quad \sim \quad \vec{\alpha}\cdot\vec{p}\,c$$

The constant $\vec{\alpha}$ is independent of $\vec{p}$ so $$\vec{p}\cdot\vec{p} \quad \sim \quad 2\vec{\alpha}\cdot\vec{p}\,mc \tag{28}$$

Ignoring the constant $2\alpha$ we see the essential structure: $$\vec{p}\cdot\vec{p} \quad \sim \quad \vec{p}\,mc \tag{29}$$

$$(m\vec{v})(m\vec{v}) \sim (m\vec{v})(mc) \tag{30}$$

Dirac *linearized* Schrodinger's quadratic velocity dependence by *forcing one velocity variable to be the constant speed of light*, $c$. Units of energy are preserved since velocity is replaced by the speed of light, but it would be surprising if physical predictions of his theory make sense. For example, a key term,

$$c\begin{pmatrix} 0 & -i\hbar\hat{\sigma}_i\vec{\nabla}_i \\ -i\hbar\hat{\sigma}_i\vec{\nabla}_i & 0 \end{pmatrix}\psi ,$$

based on $\psi_{4\times1}$ and $\hat{\sigma}_{2\times2}$ represents two pairs of coupled wave function equations. The four wave functions are coupled through energy and do *not* yield eigenvalues, therefore Dirac's relativistic electron equation is **not** an eigenvalue equation.[24] This is typically handled by a Foldy-Wouthuysen transformation, effectively shrinking $\psi_3$ and $\psi_4$ to zero while integrating over $\psi_1$ and $\psi_2$. This not only reduces the 4-vector wave function to a 2-vector, but also replaces the *point particle* of quantum mechanics by a particle defined over a 3D region of space. Similarly, while Dirac is often interpreted as describing two particles with 'spin', the non-eigenvalue equation supports only *helicity*, which is a *handedness* (left or right) associated with the momentum $\vec{p}$. Instead of *spin* the Hamiltonian $\hat{H}(\vec{p}) = -c\vec{\alpha}\cdot\vec{p} - \beta mc^2$ commutes with Hermitian helicity operator [24] $s(\vec{p})$:

$$s(\vec{p}) = \frac{\vec{\Sigma}\cdot\vec{p}}{|\vec{p}|} \qquad \text{where} \quad \Sigma = \begin{bmatrix} \hat{\sigma} & 0 \\ 0 & \hat{\sigma} \end{bmatrix}. \tag{31}$$

These *structural* issues do not much bother believers in quantum field theory derived from Dirac's equation. But there are also *physical* predictions. Kauffmann [8] uses Heisenberg's equation of motion $\dot{\vec{x}} = [\vec{x}, \hat{H}]$ to take the time derivative of position $\vec{r}$ based on Dirac's Hamiltonian $H_D$:

$$\dot{\vec{r}} = \left(\frac{-i}{\hbar}\right)\left[\vec{r}, \hat{H}_D(\vec{p})\right] = \left(\frac{-i}{\hbar}\right)\left[\vec{r}, c\vec{\alpha}\cdot\vec{p} + \beta mc^2\right] \tag{32}$$

Since $\beta mc^2$ commutes with $\vec{r}$ the contribution is zero, hence

$$[\vec{r}, c\vec{\alpha}\cdot\vec{p}]\psi = \vec{r}c\vec{\alpha}\cdot\vec{p}\psi - c\vec{\alpha}\cdot\vec{p}\vec{r}\psi .$$

When operator $\hat{p} \sim \vec{\nabla}$ is used, $\hat{p}$ operates on everything to its right:

$$c\vec{\alpha}\cdot\hat{p}(\vec{r}\psi) = c\vec{\alpha}\cdot(\vec{\nabla}\vec{r})\psi + \vec{r}c\vec{\alpha}\cdot(\vec{\nabla}\psi)$$

The last term cancels the first in the equation above and $(\vec{\alpha}\cdot\vec{\nabla})\vec{r} = (\alpha_1, \alpha_2, \alpha_3) = \vec{\alpha}$ leaving

$$\dot{\vec{r}} = [\vec{r}, c\vec{\alpha}\cdot\hat{p}] = c\vec{\alpha} \tag{33}$$

If we define the particle speed $v = |\dot{\vec{r}}| = |\vec{v}| = \sqrt{\vec{v}\cdot\vec{v}}$ then

$$v = |\dot{\vec{r}}| = c\sqrt{\vec{\alpha}\cdot\vec{\alpha}} = c\sqrt{3} \tag{34}$$

In other words Dirac's *space-time symmetric Hamiltonian* describes a free particle whose speed is $\sim 1.7$ times the speed of light. No text books point out this relativistically impossible consequence of Dirac's relativistic Hamiltonian that violates the *Correspondence Principle* in order to enforce *space-time symmetry* and *Lorenz covariance* on quantum mechanics. Taking the next time derivative of position shows that *the acceleration of a particle at rest is astronomically great:* $\ddot{\vec{r}} = 2\sqrt{3}mc^3/\hbar \sim 10^{28} g$

Is it surprising that replacing $p^2 = \vec{p}\cdot\vec{p}$ with $\vec{\alpha}\cdot\vec{p}$ alters the relation between velocity and momentum? Dirac noted: "*the* $x_1$*-component of the velocity is* $\dot{x}_1 = [x_1, H] = c\alpha_1$." Having specified $\alpha_1 = 1$ he states:

> *"This result is rather surprising, as it means an altogether different relation between velocity and momentum from what one has in classical mechanics… a measurement of a component of the velocity of the free electron is certain to lead to the result* $+c$*."*

Most textbooks ignore the problem, with exceptions like L.I. Schiff, who states [43.328] that

> *"Thus the eigenvalues of the velocity component are* $\pm c$*."*

When Feynman famously declared that no one understood quantum mechanics, he gave cover to physicists who agree with Feynman that Dirac "*simply guessed*" the equation for the *"correct laws for relativistic quantum mechanics"*. Yet Dirac's Hamiltonian for the free particle produces nonsense: velocity unrelated to momentum, velocity exceeding speed of light, not a valid eigenvalue equation, no spin but helicity, and *averaged spin* over integrated regions under the Foldy-Wouthuysen transformation. Each of these is unphysical in a different way, yet physicists act as if together they somehow make sense!

Since physicists are more interested in particles interacting with fields, we ask how Dirac's Hamiltonian handles such interactions. From nonrelativistic quantum mechanics physicists were accustomed to adding the four-vector electromagnetic gauge potential $A^{\mu} = (\phi, \vec{A})$ to the momentum

$$\frac{p^2}{2m} \;\Rightarrow\; \frac{1}{2m}\left(\vec{p} - \frac{e}{c}\vec{A}\right)^2 + e\phi \tag{35}$$

so Dirac made the obvious modifications to his relativistic Hamiltonian:

$$c\vec{\alpha}\cdot\vec{p} \;\Rightarrow\; c\vec{\alpha}\cdot\left(\vec{p} - \frac{e}{c}\vec{A}\right) + e\phi . \tag{36}$$

Based on $H_D(\vec{p}) = c\vec{\alpha}\cdot\vec{p} + \beta mc^2$ we obtain the wave function equation

$$(E + c\vec{\alpha}\cdot\vec{p} + \beta mc^2)\psi = 0 \tag{37}$$

and the operator equation

$$(i\hbar\frac{\partial}{\partial t} - i\hbar c\vec{\alpha}\cdot\vec{\nabla} + \beta mc^2)\psi = 0$$

Thus when electromagnetic potentials are included [43.329]

$$(E - e\phi + \vec{\alpha}\cdot(c\vec{p} - e\vec{A}) + \beta mc^2)\psi = 0 .$$

The goal is to produce a form similar to Shiff's eq(42.10) and this is achieved by multiplying on the left by

$$[E - e\phi - \vec{\alpha}\cdot(c\vec{p} - e\vec{A}) - \beta mc^2]$$

to obtain (38)

$$[(E - e\phi)^2 - [\vec{\alpha}\cdot(c\vec{p} - e\vec{A})]^2 - m^2c^4 + (E - e\phi)\vec{\alpha}\cdot(c\vec{p} - e\vec{A}) - \vec{\alpha}\cdot(c\vec{p} - e\vec{A})(E - e\phi)]\psi = 0 .$$

The next step is to expand the second term and we do so using the $\vec{\sigma}$ sub-matrix of $\vec{\alpha}$ and replacing the momentum term $(c\vec{p} - e\vec{A})$ with $\vec{B}$ or $\vec{C}$. These are expanded via [*geometric algebra bivector identity*]:

$$(\vec{\sigma}\cdot\vec{B})(\vec{\sigma}\cdot\vec{C}) = \vec{B}\cdot\vec{C} + i\vec{\sigma}\cdot(\vec{B}\times\vec{C}) \tag{39}$$

and the relation

$$(c\vec{p} - e\vec{A})\times(c\vec{p} - e\vec{A}) = -ce(\vec{A}\times\vec{p} + \vec{p}\times\vec{A}) .$$

The magnetic field $\vec{B}=\vec{\nabla}\times\vec{A}$ therefore using $\vec{p}=-i\hbar\vec{\nabla}$ this expression becomes $-ce(\vec{p}\times\vec{A})=ie\hbar c\vec{B}$. From the above we obtain

$$[\vec{\alpha}\cdot(c\vec{p}-e\vec{A})]^2=(c\vec{p}-e\vec{A})^2-e\hbar c\vec{\sigma}\cdot\vec{B}.$$

The last two operators in the above wave function equation reduce to $ie\hbar c\vec{\alpha}\cdot\vec{E}$ where $\vec{E}$ is the electric field: $\vec{E}=-\frac{1}{c}\frac{\partial\vec{A}}{\partial t}-\vec{\nabla}\phi$.

The resultant wave function equation is

$$[(E-e\phi)^2-(c\vec{p}-e\vec{A})^2-m^2c^4+e\hbar c\vec{\sigma}\cdot\vec{B}+ie\hbar c\vec{\alpha}\cdot\vec{E}]\psi=0 \tag{40}$$

The $\vec{\sigma}\cdot\vec{B}$ term is the Pauli spin term with the correct coefficients for the magnetic moment interacting with the local magnetic field. The $\vec{E}$-field term does not appear in nonrelativistic equations but is *needed to preserve Lorentz invariance*. It arises from the smearing of the Foldy-Wouthysen transformation.

*Dirac then treats the fine structure of the energy levels of hydrogen,* [41.269] finding the formula for the discrete energy levels of the hydrogen spectrum first obtained by Sommerfeld working with Bohr's orbits.

> *How does this make sense? If the Dirac equation for the free particle yields impossible velocity and obvious nonsense, how can the equation be used to treat the fine structure of hydrogen?*

Let us re-examine the last Dirac equation (40) above we see that ***the first three terms are <u>identical</u> to the classical wave equation derived from our relativistic equation (10):***

$$E^2=c^2p^2+m^2c^4.$$

In other words, after imposing space-time symmetry "***as required by special relativity***" and exhibiting "*electron spin*" and "*negative energy anti-particles*" in terms of the free particle wave function, Dirac actually returns [quietly, with no hoopla] to the *quadratic spatial dependence* that "*corresponds to*" our *classical relativistic Hamiltonian*. Recall the bivector identity: $(\vec{\sigma}\cdot\vec{B})(\vec{\sigma}\cdot\vec{C})=\vec{B}\cdot\vec{C}+i\vec{\sigma}\cdot(\vec{B}\times\vec{C})$. In actuality we can rewrite this $(\vec{\sigma}\cdot\vec{B})(\vec{\sigma}\cdot\vec{C})=(\vec{\sigma}\cdot\vec{\sigma})(\vec{B}\cdot\vec{C})+i\vec{\sigma}\cdot(\vec{B}\times\vec{C})$ since $\vec{\sigma}\cdot\vec{\sigma}=1$ and the $\alpha_i^2$ terms are identically one. If we return $\vec{B}\to\vec{p}$ and $\vec{C}\to\vec{p}$ we obtain:

$$(\vec{\sigma}\cdot\vec{p})(\vec{\sigma}\cdot\vec{p})=(\vec{\sigma}\cdot\vec{\sigma})(\vec{p}\cdot\vec{p})+i\vec{\sigma}\cdot(\vec{p}\times\vec{p}) \quad\Rightarrow\quad \vec{p}\cdot\vec{p}.$$

After obtaining nonsense results when forcing the equation to “conform to special relativity”, Dirac quietly switches from the ‘linear’ Hamiltonian, $c\vec{\alpha}\cdot\vec{p}$ back to the quadratic $\vec{p}\cdot\vec{p}$ which, of course *corresponds to the classical relativistic Hamiltonian that we derived*, just as it is supposed to do!

Thus Dirac’s free particle equation (20) based on *space-time symmetry* leads to exquisite nonsense, whereas his interaction formulation (40) corresponds to our *energy-time dynamics* Hamiltonian.

## The Quantum Photon

Our energy-time theory of dynamics has led to quantum Hamiltonian $\hat{H} = (m^2c^4 + |c\vec{p}|^2)^{1/2}$. The fuss for a century has *been how to interpret the square root operator*; the obvious first choice is to square both sides. Schrödinger first took this approach, but the Klein-Gordon equation $(\partial_\mu \partial^\mu - m^2)\psi = 0$ introduces extraneous solutions that gum up the works. For various reasons, Dirac chose a first-order Hamiltonian

$$H_D \psi = (c\vec{\alpha} \cdot \vec{p} + \beta mc^2)\psi \tag{41}$$

with anti-particles and no eigen-solutions, and leading to $v = \sqrt{3}c$. However, Dirac's interaction Hamiltonian restores the quadratic nature of the momentum-energy term (while 'retaining' the structure of $\vec{\alpha}, \beta, \sigma$ etc.). A number of Dirac-type treatments of the photon exist, so we have these to compare to our energy-time theory of the photon. Photon mass is considered to be zero, however the photon field energy density will have a "mass density" equivalent. The continuum nature of the field, and the convective-derivative nature of quantum energy-momentum operators $\hat{p} = -i\hbar\vec{\nabla}$ and $E = i\hbar\partial_t$ almost guarantee that continuity equations associated with mass/energy-density flows will preserve the requisite Born "probability density" rules so thoroughly explored by Kobe, Kiesling, Sebens. [46,47,48] We define the energy density function $\psi = (\vec{E} \cdot \vec{E} + \vec{B} \cdot \vec{B})^{1/2}$ such that

$$\tilde{\psi}\psi = E^2 + B^2 . \tag{42}$$

The zero-mass relativistic photon Hamiltonian, $H = c\sqrt{\hat{p}^2}$ is written

$$i\hbar \frac{\partial \psi}{\partial t} = c\sqrt{(-i\hbar\vec{\nabla})^2}\,\psi$$

We rewrite the time-dependent Hamiltonian, operating on the energy function $\psi$ as

$$\left(i\hbar\partial_t - c\sqrt{(-i\hbar\vec{\nabla})^2}\right)\psi = 0$$

We next define the correlate, $\left(i\hbar\partial_t + c\sqrt{(-i\hbar\vec{\nabla})^2}\right)$ and construct the product

$$\left(i\hbar\partial_t + c\sqrt{(-i\hbar\vec{\nabla})^2}\right)\left(i\hbar\partial_t - c\sqrt{(-i\hbar\vec{\nabla})^2}\right)\psi = 0$$

to obtain

$$-\hbar^2\left[\partial_t^2 - c^2\nabla^2\right]\psi = 0 \tag{43}$$

This second-order (massless Klein-Gordon) wave equation for the scalar energy density, $E^2 + B^2$ supports gradients, but what of the actual fields, $\vec{E}$ and $\vec{B}$? Based on *geometric algebra*, we declare the magnetic field $\vec{B}$ to be a *bivector*, defined in geometric algebra [26.28] as the directed area formed by rotating one vector into another: $\vec{u} \wedge \vec{v} = -i(\vec{u} \times \vec{v})$. The $\vec{u} \times \vec{v}$ is the familiar *vector cross product*, which produces a vector orthogonal to the plane of $\vec{u}$ and $\vec{v}$. The pseudo-vector $i$ is the *duality* operator, which transforms one geometrical algebra entity into another. In this case the vector cross product, $\vec{u}\times\vec{v}$ is transformed by the duality operator $i$ into the bivector $\vec{u}\wedge\vec{v}$. Multiply both sides of equation [ $\vec{u}\wedge\vec{v}=-i(\vec{u}\times\vec{v})$ ] to obtain

$$i(\vec{u}\wedge\vec{v})=-(\vec{u}\times\vec{v})=\vec{v}\times\vec{u}\,. \qquad (44)$$

Thus we can transform the *bivector* into a corresponding *vector* via the same duality operator, bringing new meaning to the '*Weber vector'*,

$$\vec{\psi}=\vec{E}+i\vec{B} \qquad (45)$$

which is chosen and discussed in [46,47,48]. We find that the vector $\vec{E}$ and the vector $i\vec{B}$ are of the same type and can be operated on jointly. If we define $\tilde{\vec{\psi}}=\vec{E}-i\vec{B}$ we find

$$\tilde{\vec{\psi}}\vec{\psi}=E^2+B^2 \qquad = \text{energy density}$$

The energy density (normalized) represents the probability density in the Born interpretation, and other authors analyze this correspondence in detail. Our immediate interest is in replacing Kauffmann's invented Hermitian field operator $B^+$ with $\vec{B}$ such that his *polar-axial conjugation* transforms $\vec{B}$ from an axial transverse vector to a polar transverse vector that mimics $\vec{B}$ itself "*as closely as possible…*": [45]

$$B^+=(-\nabla^2)^{-1/2}\,\vec{\nabla}\times\vec{B}\ , \qquad \text{with Hermitian property } [B^+]^+=B\,. \qquad (46)$$

We let $B^+=\vec{B}$ and factor duality operator $i$ from both sides to obtain $\vec{B}=(-\nabla^2)^{-1/2}\,\vec{\nabla}\times\vec{B}$, which implies that

$$(-\nabla^2)^{-1/2}=(\vec{\nabla}\times)^{-1}$$

and, inverted, we obtain

$$(-\nabla^2)^{1/2}=\vec{\nabla}\times\,. \qquad (47)$$

The Hamiltonian operator that will operate on the $\vec{E}$ and $i\vec{B}$ fields to describe massless photon, $m=0$

$$\hat{H}=(m^2c^4+c^2\hat{p}^2)^{1/2} \underset{m=0}{\Rightarrow} \hbar c\sqrt{(-\vec{\nabla}^2)}$$

It should perhaps not be surprising that the *square-root Hamiltonian, a mystery for a century*, is defined differently for different entities:

$$\hbar c\sqrt{(-\vec{\nabla}^2)}\,\psi_{scalar}=i\hbar\vec{\nabla}\,\psi_{scalar} \qquad (48a)$$

$$\hbar c\sqrt{(-\vec{\nabla}^2)}\,\vec{\psi}_{vector}=i\hbar\vec{\nabla}\times\vec{\psi}_{vector} \qquad (48b)$$

Kauffmann [45] has explored the *Energy-time square root Hamiltonian* $\hat{H}=(m^2c^4+|c\vec{p}|^2)^{1/2}$, including for zero-mass particles, $m=0$, wherein the *Hamiltonian* reduces to: $\hat{H}=hc(-\nabla^2)^{1/2}$.

We formulate the four-vector operator representing a pair of coupled wave equations for the Weber vector

$$H = \begin{vmatrix} 0 & -i\hbar\partial_t \\ \hbar c\vec{\nabla}\times & 0 \end{vmatrix} \tag{49}$$

and the wave-function based on two transverse fields:

$$\vec{\psi} = \begin{pmatrix} \vec{\psi}_+ \\ \vec{\psi}_- \end{pmatrix} \equiv \begin{pmatrix} \vec{E} + i\vec{B} \\ \vec{E} - i\vec{B} \end{pmatrix} \tag{50}$$

such that

$$H\vec{\psi} = \begin{vmatrix} 0 & -i\hbar\partial_t \\ \hbar c\vec{\nabla}\times & 0 \end{vmatrix} \begin{pmatrix} \vec{\psi}_+ \\ \vec{\psi}_- \end{pmatrix} = \begin{pmatrix} -i\hbar\dot{\vec{\psi}}_- \\ \hbar c\vec{\nabla}\times\vec{\psi}_+ \end{pmatrix} \tag{51}$$

Let $tr(H\vec{\psi}) = 0$ to obtain $-i\hbar\dot{\vec{E}} - \hbar\dot{\vec{B}} \equiv \hbar c\vec{\nabla}\times\vec{E} + i\hbar c\vec{\nabla}\times\vec{B}$. (52)

We group real and imaginary terms to obtain

$$\left\{ \begin{aligned} -\dot{\vec{E}} &= c\vec{\nabla}\times\vec{B} \\ \dot{\vec{B}} &= c\vec{\nabla}\times\vec{E} \end{aligned} \right\} \quad \textit{Maxwell's source free equations.} \tag{53}$$

Thus from our relativistic *Energy-time Hamiltonian* we derive the Schrödinger equation for two coupled transverse fields that propagate at the speed of light as massless particles. The corresponding quantum Hamiltonian and massless photon formulation yields *Maxwell's source-free equations*. Observe that the quantum of action vanishes in the Schrödinger equation yielding a classical field theory of the continuum.

When 4D space-time is partitioned into 3D+1; the 3D and the 1D do *not* rotate into each other. The *split* is formulated in terms representing energy and momentum $E, \vec{p}$ which contain relativistic mass $m = \gamma m_0$ associating inertial factor $\gamma$ with each term in the four momentum: { *energy, momentum* }. So 4D gauge physics does *not* require belief in (or even the concept of) multiple time dimensions of special relativity: [20]

> *"The belief that space-time actually described reality has led to numerous misconceptions about the nature of space and time. These are distinct phenomena, and are not fused into some 4D-entity."*

The four-vector formulation of gauge theory is compatible with our energy-time dynamics derivations:

| | | | | |
|---|---|---|---|---|
| $\{E, \vec{p}\}$ | $\{\partial/\partial t, \vec{\nabla}\}$ | $\{\phi_q, \vec{A}\}$ | $\{\phi_m, \vec{v}\}$ | |
| Classical Mechanics | Quantum Mechanics | Electro-Magnetics | Gravito-Magnetics | (54) |
| $E \sim p^2$ | $(\partial/\partial t \sim \nabla^2)$ | $E \sim d\phi_q/dt$ | $G \sim d\phi_m/dt$ | |
| | | $B \sim \nabla\times A$ | $C \sim \nabla\times v$ | |

## Relativity of the four-vector electromagnetic potential $A^{\mu}(x^{\alpha})$

At this point let us ask ourselves, *what can account for "success" of special relativity in electrodynamics if the Maxwell-Hertz equations are actually Galilean invariant?* We assume the following:

1) $m = \gamma m_0$, $\vec{p} = m\vec{v}$, $E = mc^2$,
2) Maxwell-Hertz electrodynamics equations are Galilean invariant.

If this is the case there are two implications:

a) Maxwell-Hertz does not specify mass, so *the $\gamma$-factor should not enter into electrodynamics*.
b) Maxwell-Hertz is Galilean invariant, so *the $\gamma$-factor should not enter into electrodynamics*.

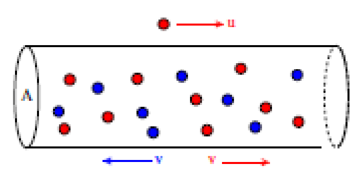
But we know that $\gamma$ very much enters into relativistic electrodynamics. *To what end?* We examine this by analyzing typical treatments of *'Relativity and Electromagnetism'*. Although Einstein claimed that Lorentz transformation is *required* by the Maxwell-Hertz equations, he unfortunately used Hertz's electro-static equations. When Hertz's electro-dynamic equations are used, the Maxwell-Hertz equations *are* Galilean invariant. It is a fact [3] that Maxwell-Hertz equations *are* Galilean invariant, and do not require Lorentz as Einstein claimed. There seems to be no case wherein it makes sense for electrodynamics to be both Galilean and Lorentz invariant. Kauffmann [38] considers the Lorentz case of electrodynamics:

$$F^i = e\gamma(\vec{E} + \frac{\dot{\vec{r}}}{c} \times \vec{B})^i \tag{55}$$

This of course is *the Lorentz force law expressed in 'proper time' via $\gamma$*.

I quote a paper from *the Department of Applied Mathematics and Theoretical Physics* at Cambridge U.:

*"To start, consider a bunch of positive charges +q moving along a line with speed +v and a bunch of negative charges −q moving in the opposite direction with speed −v as shown in the figure. If there is equal density, n, of positive and negative charges then the charge density vanishes while the current is*




$$I = 2nAqv$$

*where A is the cross-sectional area of the wire. Now consider a test particle, also carrying charge q, which is moving parallel to the wire with some speed u. It doesn't feel any electric force because the wire is neutral, but we know it experiences a magnetic force. Here we will show how to find an expression for this force without ever invoking the phenomenon of magnetism.*

*The trick is to move to the rest frame of the test particle. This means we have to boost by speed u. The usual addition formula tells us that the velocities of the positive and negative charges now differ, given by (Lorentz law of velocity addition)*

$$v_{\pm} = \frac{v \mp u}{1 \mp uv/c^2}$$

*But with the boost comes a Lorentz contraction which means that the charge density changes. Moreover, because the velocities of positive and negative charges are now different, this will mean that, viewed from the rest frame of our particle, the wire is no longer neutral. [To see how* *this works ] we'll introduce* $n_0$, *the density of charges when the particles in the wire are at rest. Then the charge density in the original frame is*

$$\rho = qn = \gamma(v) q n_0$$

*In this frame the wire is neutral because the positive and negative charges travel at the same speed, albeit in opposite directions. However, in our new frame, the charge densities are*

$$\rho_{\pm} = q n_{\pm} = q\gamma(v_{\pm}) n_0 = \left(1 \mp \frac{uv}{c^2}\right)\gamma(u)\,\gamma(v)\, q n_0\,.$$

*At this point these values get plugged into the expression for an electric field derived from the charge density and*

*"this [result] precisely agrees with the Lorentz force law…"*

A detailed treatment of ***the same problem*** is in [40.122] who earlier derived $m = \gamma m_0$, and next treats current as $\vec{j} = \gamma \vec{j}_0$. This is not derived, but *claimed* because *length contraction* does not change conserved charge, but *does* change charge density.

Schwartz [40.123] claims "*there must be a "magnetic field"…*" on the basis that Lorentz invariance implies a vector potential. Of course Maxwell-Hertz equations (*our starting point*) are formulated *in terms of* the magnetic field, but Schwartz pretends that these equations, derived from experiments and preceding special relativity, actually derive from Lorentz. To do so he reverts to electrostatics. From the change in charge density, he assumes a corresponding change in current density, $\vec{j}' = \gamma \vec{j}$ , then generalizes the laws of electrostatics by introducing 4-vector potential $A_\mu$ corresponding to the 4-vector current $j_\mu$ such that

$$\sum_{\nu=1}^{4} \frac{\partial^2 A_\mu}{\partial x_\nu^2} = -4\pi\, j_\mu$$

He then rewrites $\vec{E} = -\vec{\nabla}\phi$ as $-iE_\nu = \dfrac{\partial A_4}{\partial x_\nu} \qquad (\nu = 1,2,3)$

and states that *the three components of electric field are really elements of the second rank tensor in 4D space*. Up to this point Schwartz has 'deduced' the above from Coulomb's law and conservation of charge (*not density!*) under Lorentz transformation, but next he invokes God to deal with the problem of only six independent components when a second rank tensor in 4D implies up to sixteen possible independent components. God solved this problem for Schwartz by choosing the anti-symmetric tensor

$$F_{\mu\nu} = \left(\frac{\partial A_\nu}{\partial x_\mu} - \frac{\partial A_\mu}{\partial x_\nu}\right)$$

which leads, after transformation by Lorentz, to terms of the form

$$F' = -i\gamma(E_x - \beta B_z) \qquad (56)$$

where $\gamma = (1 - v^2/c^2)^{-1/2}$ and $\beta = v/c$ and the component of either $\vec{E}$ or $\vec{B}$ along the direction of relative motion remains unchanged. Of course, in the end, Schwartz ends up with the same result as DAMTP, which is the proper Lorentz force

$$\frac{d\vec{p}}{d\tau} = q\gamma(\vec{E} + \frac{\vec{v}}{c} \times \vec{B}) . \tag{57}$$

After all of the convoluted transformations and appeals to God, *we end up by invoking the same relation between $d\tau$ and $dt$ from the energy-time theory of physics:* $dt/d\tau = \gamma$ which yields

$$\gamma \frac{d\vec{p}}{dt} = q\gamma(\vec{E} + \frac{\vec{v}}{c} \times \vec{B}) \tag{58}$$

*Lo and behold*, **the $\gamma$'s cancel on both sides** and *the relativistic Lorentz force equation* is exactly the same as the non-relativistic force equation,

$$\frac{d\vec{p}}{dt} = q(\vec{E} + \frac{\vec{v}}{c} \times \vec{B}) \tag{59}$$

just as *energy-time theory* predicts: if the $\gamma$ factor is associated only with mass, not velocity, then, since electromagnetics is based on charge, not on mass, there is no reason at all to expect any $\gamma$-factor in electrodynamics. If it did show up it would be incompatible with the fact that *the Maxwell-Hertz electrodynamic equations are Galilean invariant!*

## Applying Relativity to Electrodynamics

We can pretend that multiple time dimensions exist, attached (by the physical speed of light) to any arbitrary velocity of a coordinate system, or we can derive the inertial factor $\gamma$ that applies to mass, $m = \gamma m_0$, but not velocity, based on absolute time and real physical inertial clocks instead of Einstein's imaginary massless 'perfect' clocks. In our physical world, *real clocks have mass and count oscillations*, such that when the oscillating system gains inertial mass $m = \gamma m_0$, the inertia resists the (always present) restoring force and hence 'runs slower'. For those forced by faith to apply Lorentz everywhere, the approach is to

1) Assume the velocity addition law (elsewhere disproved)
2) Assume length contraction (nowhere proved)
3) Deduce changes in charge density (from step 2)
4) Appeal to God for correct anti-symmetry
5) Apply Lorentz transformation symmetry

and, after all these steps, to find out that

***"there is absolutely no change in the basic Lorentz force law of electrodynamics."***

This is the *expected* result from the perspective of energy-time theory.

## Analysis

While engaged in analyzing the way that false premises of special relativity play out in quantum relativistic field theories, one easily loses track of the basic issue. The basic issue is whether physical time is **absolute**, and *simultaneity is universal* (it's the same time everywhere!) or whether multiple times exist and simultaneity is relative. The energy-time interpretation of particle dynamics is compatible with universal time $t' = t$ and with one universe and with dynamic systems whose energy characteristics are conjugate to time. Inclusion of gravity will bring back the reality of absolute space.

Einstein's step away from the natural world occurred as communist challenges to political reality arose. Communism's goal since has been to confuse thinking about reality in terms of absolutes; the **absolute** is associated with religion and attacked ferociously. Reactions to attack on the **absolute** range from *literary deconstruction* to *gender confusion*, and have been near catastrophic for religion, wherein the Absolute is core. Thus the mistakes have not been costless.

*The absolute space and time universe differs from the relational space-time of special relativity.*

We experience space and time, and this experience is the basis of our physical reality, not mathematical constructions that we project onto space and time as we experience them. In fact, space is a construct; we experience a *gravitational field* and project coordinate systems onto the field. The field is essential, and will never go away, but we imagine subtracting the field, and the abstraction remaining is 'space' with a coordinate system. Einstein: "*There is no space absent a field*." So the underlying quality of three-dimensions of movement is abstracted into a 3D "container", *space*, in which the physical world is situated. There is no physical correlate for *space* – it is a property of the field.

When Einstein added *another* 'space and time' to the classical 'space and time' he added "nothing" in reality. But his insane idea that universal time can be replicated and attached to every moving object is the basis of his theory of special relativity, and the space-time symmetry, anchored by light to every moving object, leads to nonsense predictions. Amazing that a century of nonsense is only now being exposed in conclusive fashion, and $v = \sqrt{3}c$ is *conclusive*. Dirac's quantum field theory also leads directly to the '*worst mistake in the history of physics*', the $10^{120}$ factor by which the virtual particle background energy differs from reality (as measured by gravity). In addition, the *Relativistic Quantum Field Theory* derived from Dirac also produces today's proton radius anomaly.

From Newton to 1900, the results obtained from projecting coordinates onto reality were so excellent that physicists truly believed that Nature actually *had* this mathematical structure. Thus when they started projecting *new* structures (Heisenberg's iso-spin, Pauli's SU(2) $\vec{\sigma}$, Einstein's Lorentz symmetry, and later symmetries such as SU(3) and 5d structures), physicists were accustomed to believing the structures actually represent physical reality. But geometry inflicts more symmetry on reality than physics warrants.

Einstein's Lorentzian theory is said to be about *the structure of space-time*. Technically, *space-time* is an abstraction, and does not really have a structure, but *two* space-time coordinate systems in motion impart enough "structure" to space-time for the twentieth century; it is actually "*the theory of two 4D-geometries in uniform relative motion*". The Lorentz group symmetry is **geometric**; it does **not** describe physical reality. There is no mass involved in the transformation, only $\{x, y, z, t\}$. *Mass breaks the "no preferred frame" symmetry* and *applications of $\gamma$ to velocity are in error*; $\gamma$ is applied to mass as the *inertia factor* and calls for a new interpretation of relativistic physics; the *energy-time* interpretation.

## Lorentz over-constrains

Lorentz forces the physics in any inertial frame (including our *one and only universe*) to preserve the symmetry associated with two 4D geometries. Universal time does not support two time dimensions and Lorentz enforces symmetries based on two time dimensions. The Lorentz symmetry group has an inverse $L^{-1}(\vec{v}) = L(-\vec{v})$, hence physics is *reversible* or 'two-way' in nature. In fact, physicists can "prove things" using Lorentz, most of which proofs are *algebraic*, not *numeric*. However, [48]

> "…*a purely algebraic derivation of the relativistic wave equations for a particle is not capable of telling us anything about the object that satisfies those equations, beyond how that object should transform under Poincare transformations.*"

Lorentz imposes a structure allowing theories to transform from one inertial frame to another at will. This is almost too good to be true, so physicists almost worship Lorentz symmetry, and apply it religiously. Yet, if, as energy-time dynamics implies, *universal time is real*, the Lorentz transformation reduces to inertial factor $\gamma = (1 - mv^2/mc^2)^{-1/2}$ and Galilean motion. We proceed to define a relativistic energy:

$$E = (m^2c^4 + |c\vec{p}|^2)^{1/2}, \qquad m = \gamma m_0, \qquad \vec{p} = m\vec{v}.$$

If we restrict inertial factor $\gamma$ to mass, the velocity-addition-laws, length contraction, and the whole kit-and-caboodle of non-Galilean velocity transformation simply goes away. Application of $\gamma$ to relativistic magnetic fields is such that $\gamma$ vanishes in the end (except mass inertia, $m = \gamma m_0$), and is compatible with Phipps' demonstration of Galilean invariance of Maxwell-Hertz theory, which invokes a total time derivative for Faraday's experimental-based law via the convection derivative

$$\frac{d}{dt} = \frac{\partial}{\partial t} + \vec{v} \cdot \vec{\nabla}.$$

Lorentz transformation is a two-way transform between inertial reference frames in mutual uniform relative motion. Possessing the inverse element means that Lorentz symmetry group operators are instantiated by $4 \times 4$-matrices, and, post-Minkowski, post-Dirac's $\vec{\alpha}, \gamma$ the symmetry properties and mathematical proofs backing up the transformation are countless – which is to say that physicists believe solidly in the efficacy of Lorentz invariance as a guarantor of well-ordered behaviors.

Based on *Energy-time dynamics*, the *time-dimension* of the moving object is replaced by the *clock rate* of the moving object, by which is meant the rate at which the moving clock measures universal time. One universe of *universal time*, with local coordinate systems imposed on objects in relative motion, does *not* support two 4D geometries based on two co-moving universes. Space-time symmetry over-constrains reality, but there is virtue in keeping things within known bounds, with universal support architecture and tools and technologies – hence the Lorentz focus of Kobe, Kauffmann, Kiessling, and Sebens.

In short, *Lorentz is a structure imposed on theories of physics*: a reversible 4-dimensional transformation from one inertial reference frame to another four-dimensional inertial reference frame (containing its own universal time) in uniform motion with relative velocity $\pm\vec{v}$. The laws of physics are preserved across these 4D representations, and an orderly development of Noether-Lagrangian-based physics results. For this reason I no longer concern myself with the myriad details of Lorentz covariance, since universal time-based physics occupies a lower dimensionality and, per Lucas and Hodgson

> *"Geometry needs to be subject to more symmetries then physics"*

## Summary and conclusions

In an earlier paper, [3] *Everything's relative, or is it?* we analyzed Einstein's special relativity and explained classic relativity experiments in terms of energy-time dynamics. In this paper, *Energy-time dynamics vs space-time symmetry*, we expressly avoid the Lorentz transformation and accompanying 4D geometries. Having shown that *energy-time theory* successfully explains the classic relativistic experiments, we derived *energy-time*-based theories and compared to *relativity*-based theories.

Our energy-time-derived relativistic-energy-momentum Hamiltonian is used, with Hertz's convective derivative, to derive a quantum relativistic Hamiltonian, $\hat{H}$, for comparison to Dirac's Hamiltonian $\hat{H}_D$. Then using our quantum Hamiltonian to derive a theory of photons, we derive Maxwell's equations.

Energy-time theory is based on *absolute time and space*. We have dealt with time here; gravity invokes space. As seen in *'Everything's relative…'* the gravitational field acts as the ether in which photons propagate; it restores local absolute space, continuously connected to the absolute space of the universe. As a physical theory in *one time and space*, energy-time physics does not require the symmetries that 4-dimensional geometries $\{x, y, z, t\}$ and $\{x', y', z', t'\}$ support, which is to say that *reality is Galilean with inertial dynamics*. The Maxwell-Hertz equations are Galilean invariant, as explained by Phipps. [9]

Although much effort has been toward dismissing the Lorentz transformation with its ridiculous length contraction and multiple time dimensions, non-physical velocity addition laws, and so forth, this structure imposed on theories of physics has consequences for Lorentz-covariant theories, so one hesitates to throw away the scaffolding upon which ornate geometric theories are constructed. The wealth of proven axioms, postulates, principles encompassed by Lorentz covariance has a certain baroque glory; theories derived from Lorentz invariant Lagrangian actions tend to be hardy and well behaved. Belief in the physical reality of the Lorentz structure probably hides the simpler physical reality from sophisticated physicists, who hold fast to Lorentz covariance. Special relativity can be replaced by inertial mass, Galilean motion, and photons propagating in the gravity field. Reality is simpler than Lorentz, but Lorentz is the 'sandbox' in which theories are built; Lorentz covariance is demanded of the action principle used to derive equations of motion.

Did you think that there would be no consequences when we restore absolute time and space? Ironically, while things become simpler and unified, non-intuitive nonsense is strong in many physicists; but some seem to know that it is nonsense, as discussed in several books and articles in the last decade. [6, 22]

It is a Humpty Dumpty problem, whether, after a fall from the grace of *a unified world of absolute time and space*, one can unlearn the split, schizophrenic universe of the "*the relativity of simultaneity*", and come to realize the integrity of what was lost. But it is only a matter of time, as energy-time physics is based on physical reality, while Einsteinian space-time symmetry is based on two 4D geometries.

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