

# The Fundamental Nature of Time

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## Abstract

Heinrich Hertz and Albert Einstein were experimental *and* theoretical geniuses. Hertz demonstrated the existence of radio waves. Einstein [with deHaas] experimentally linked magnetism and angular momentum. These two ingenious physicists tackled Maxwell's equations but diverged in their interpretations of reality. Einstein bases his classic paper on the Maxwell-Hertz equations. We report a post-humous meeting of these geniuses discussing '*What is fundamental?*'

The ghosts of Heinrich Hertz and Albert Einstein walk into a tavern. The tavern keeper, a hearty fellow, immediately recognizes them, leads them to a quiet corner, and serves complimentary beer. They observe the walls in their corner are covered with technical papers. On the wall behind Hertz is his 1890 paper <sup>1</sup>:

*"On the fundamental equations of electromagnetics for bodies in motion",*

while behind Einstein is his 1905 paper <sup>2</sup>:

*"On the electrodynamics of moving bodies".*

The tavern keeper explains. One of my regulars, Oliver Heaviside, frequently drops in to discuss physics. He analyzed gravito-magnetism in that 1893 paper <sup>3</sup> on the far wall. But Einstein, your  $E = mc^2$  completely changes Heaviside's finding that the gravito-magnetic field is negligibly weak. The field interacts with mass, so, having energy, these fields have mass and hence nonlinearly interact with themselves.

AE: The nonlinearity of gravity is compatible with my later work. Did you wish to discuss Heaviside?

TK: No. I hope we can discuss the proposition that: *all light propagates in local gravity*. Photons have energy, hence mass, and bend in gravitational fields, effectively diffracting the light. *Light propagating in local gravity* constitutes a preferred reference frame, contrary to your conclusions, Professor.

HH: Why that is most interesting! You clearly state, Einstein, that there is no preferred frame: *"the same laws of electrodynamics and optics will be valid for all frames of reference."* But light propagating in local gravity defines the preferred frame in which the speed of light is constant. Frames moving with velocity  $\vec{v}$  in a local gravity field will see a displaced speed of light,  $c \pm v$ .

AE: Quite so. My basic premise is the essential symmetry between all space-time frames; the *lesson of Copernicus*, one might say. But light propagating in local gravity would seem to break this symmetry.

HH: You also state that *"unsuccessful attempts to discover any motion of the earth relatively to the "light medium" suggest ... no properties corresponding to the idea of absolute rest."* If not 'absolute' rest, *local gravity as ether* implies at least *local or relative rest*. That is a preferred frame, is it not?

AE: Why yes it is. *Any local preference would demolish the symmetry between all space-time frames.* That symmetry is the source of much confusion in special relativity. What picture do you have in mind?

HH: My dear Einstein, when bodies act upon one another at a distance, we can form various conceptions of the nature of this action. We may regard it as direct action-at-a-distance, springing across space, or we may regard it as the consequence of action which is propagated from point to point *in a local medium*. So *"the interior of all bodies, including the free ether, can experience disturbances [that produce changes of state.] These changes of state necessitate an expenditure of energy; their presence represents a stock of energy."*

TK: And if one views stress as a disturbance propagating through ether, we should also note <sup>14</sup>:

*“At each point in a continuous media, whether it be solid or fluid, we need six numbers, each representing a component of force per unit area, to define the local stress completely.”*

This is consistent with Hertz’s 3 electric ‘forces’  $\vec{E} = (X, Y, Z)$  and 3 magnetic forces  $\vec{B} = (L, M, N)$ .

HH: True. In my paper, the energy density of the stressed ether is  $(\epsilon \vec{E} \cdot \vec{E} + \mu \vec{B} \cdot \vec{B})/8\pi$ .

AE: But ‘stressed ether’ seems to imply a velocity of ether flow relative to the earth’s frame, not seen.

TK: Yes. But if local gravity *is* the medium of propagation, and the equipment is never moved from the lab, then the velocity of the lab frame with respect to this local ether is always  $\vec{v} = 0$ , compatible with all results! So they did not *disprove* local ether; only that a universal isotropic homogeneous ether is invalid. For this reason we perceive the Heaviside-Hertz *electro-* and *gravito-magnetic* equations to be:

$$\begin{aligned}
 \vec{\nabla} \cdot \vec{B} &= 0 & (\vec{B} &= \vec{\nabla} \times \vec{A}) & \vec{\nabla} \cdot \vec{C} &= 0 & (\vec{C} &= \vec{\nabla} \times \vec{v}) \\
 \vec{\nabla} \times \vec{B} &= \mu_0 \rho_q \vec{v} + \frac{1}{c} \left( \frac{\partial \vec{E}}{\partial t} + \vec{v} \cdot \vec{\nabla} \vec{E} \right) & \vec{\nabla} \times \vec{C} &= -\frac{4\pi g}{c^2} \rho_m \vec{v} + \frac{1}{c^2} \left( \frac{\partial \vec{G}}{\partial t} + \vec{v} \cdot \vec{\nabla} \vec{G} \right) \\
 \vec{\nabla} \cdot \vec{E} &= \rho_q / \epsilon_0 & \vec{\nabla} \cdot \vec{G} &= -4\pi g \rho_m & \\
 \vec{\nabla} \times \vec{E} &= -\left( \frac{\partial}{\partial t} + \vec{v} \cdot \vec{\nabla} \right) \vec{B} & \vec{\nabla} \times \vec{G} &= -\left( \frac{\partial}{\partial t} + \vec{v} \cdot \vec{\nabla} \right) \vec{C}
 \end{aligned} \tag{1}$$

The formal correspondence<sup>5</sup> between these equations allows substitution of mass for charge, and of Newton’s gravitational constant  $g$  for  $\epsilon_0$  and  $\mu_0$  in Maxwell’s relation  $c = 1/\sqrt{\epsilon_0 \mu_0}$  yielding:

$$c = \frac{1}{\sqrt{\epsilon_0 \mu_0}} \Rightarrow [\epsilon(g) \mu(g)]^{-1/2} = \left[ \left( \frac{-1}{4\pi g} \right)_\epsilon \left( \frac{-4\pi g}{c^2} \right)_\mu \right]^{-1/2} = (c^{-2})^{-1/2} = c \tag{2}$$

This might appear a tautology, but  $\vec{E}, \vec{B}, \vec{G}, \vec{C}$  fields are *real* phenomena and  $\epsilon_0, \mu_0$ , and  $g$  are *real* physical parameters. If mass density  $\rho_m$  is exchanged for charge density  $\rho_q$ , and field correspondences applied, we find complete equivalence of these formal field equations, so deriving the speed of light from the gravito-magnetic equivalent of  $c = 1/\sqrt{\epsilon_0 \mu_0}$  is significant. Only months ago colliding neutron stars<sup>6</sup> were seen, *in both light and gravity waves*, showing that gravity *and* light propagate at  $c$  so  $g = f(\epsilon\mu)$ .

*“Einstein’s axioms logically eliminated the ether concept in physics.”<sup>7</sup>*

If light propagates in gravity, the ether concept has not been eliminated from physics, conflicting with axioms that claim to eliminate the ether. Physicists can project mathematical structure onto reality and can come to believe that the corresponding physical structure is reality, as summarized<sup>7</sup> by Rindler:

*“Each inertial frame now has the properties with which the ether frame had been credited.”*

The hypothesis of the constant speed of light ‘tied to’ each inertial frame is non-intuitive, yet supports the conception of multiple inertial coordinate frames as *real* space-time entities. But as Maudlin<sup>8</sup> observes:

*“...even if we can describe a mathematical structure that everywhere looks locally like a possible spacetime structure, it does not follow that the whole object corresponds to a physical possibility.”*

HH: Yes, and Einstein, I would question your treatment of Lorentz invariance — dependent upon a step you have never justified – the creation of multiple 'real worlds' that you effect by adding a 4D-coordinate system to objects moving in the *unprimed* 4D-coordinate system of the real world. As Rindler notes:

*"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.]"*

Yet there is no direct proof of the existence of multiple 'universal times', each attached to a moving object or object at rest. You state that the Maxwell-Hertz equations hold in the moving frame and the rest frame for time dimension  $\tau$  and  $t$  respectively and that all permutations *must express exactly the same thing*:

$$\frac{1}{c} \frac{\partial E_x}{\partial t} = \frac{\partial B_y}{\partial z} - \frac{\partial B_z}{\partial y} \Leftrightarrow \frac{1}{c} \frac{\partial E'_x}{\partial \tau} = \frac{\partial B'_y}{\partial \eta} - \frac{\partial B'_z}{\partial \xi} \quad (3)$$

but there is no proof that  $\partial E'_x / \partial \tau$  even has physical meaning. The  $\tau$  is a time dimension that you only *postulate* to exist. If it does not physically exist, then this relation is a mathematical equivalence only!

AE: Oh, but my dear fellow, you ignore the numerous proofs of time dilation!

TK: But recall that Voigt in 1887 predicted the Michelson Morley null results without prior knowledge of the experiment... he set himself the project of finding the Doppler effect that would make a wave solution to *Maxwell's equations have the same form for both a stationary observer as for a moving observer*, just as you have done above. His was based on elastic waves in the ether<sup>25</sup>, yours on two 'universal times'.

HH: And I shall be happy to return to time dilation Prof Einstein, but your paper says that one need not "assign a velocity-vector to a point of empty space in which electromagnetic processes take place", contradicting my assumption that "at every point a single definite velocity can be assigned to the medium which fills space." Your theory is based on my Maxwell-Hertz equations:

$$\frac{1}{c} \frac{\partial E_x}{\partial t} = \frac{\partial B_z}{\partial y} - \frac{\partial B_y}{\partial z} \quad \text{and} \quad \frac{1}{c} \frac{\partial B_x}{\partial t} = \frac{\partial E_z}{\partial y} - \frac{\partial E_y}{\partial z} \quad \text{and permutations,} \quad (4)$$

but these equations are from my *first* paper developing the theory of electromagnetics for **bodies at rest**.

AE: Why, that is true! Which equations would you prefer that I use, Professor Hertz?

HH: Why my dear fellow, I would prefer that you use equations<sup>24</sup> from my paper<sup>1</sup> on **bodies in motion**:

$$\frac{1}{c} \left[ \frac{d\vec{B}}{dt} + (\vec{v} \cdot \vec{\nabla}) \vec{B} \right] = -\vec{\nabla} \times \vec{E} \quad \text{and} \quad \frac{1}{c} \left[ \frac{d\vec{E}}{dt} + (\vec{v} \cdot \vec{\nabla}) \vec{E} \right] = -\vec{\nabla} \times \vec{B} + \frac{4\pi}{c} \rho \vec{v}. \quad (5)$$

AE: Well I ignored those equations because I interpreted velocity  $\vec{v}$  to be the velocity of the ether flow relative to the inertial frame. However the truly crucial point is that Maxwell's equations are *not* invariant under Galilean transformation, and therefore require the Lorentz transform that I derive herein.

HH: Oh but that point is mistaken! Maxwell-Hertz equations are invariant under Galilean transformation;

from  $\vec{r}' = \vec{r} - \vec{v}t$  and  $t' = t$  we find:  $\vec{\nabla}' = \vec{\nabla}$ ,  $\frac{\partial}{\partial t'} = \frac{\partial}{\partial t} + \vec{v} \cdot \vec{\nabla}$  (6)

The total time derivative is  $\frac{d}{dt} = \frac{\partial}{\partial t} + \vec{v}_e \cdot \vec{\nabla}$  so applying Galilean law  $\vec{v}'_e = \vec{v}_e - \vec{v}$  where  $\vec{v}_e$  is *ether velocity* measured in the unprimed (rest) frame,  $\vec{v}'_e$  is the same measured in the primed frame, and  $\vec{v}$  is the (constant) velocity of the primed relative to the unprimed ( $v = 0$ ) frame, we find<sup>9</sup>

$$\left(\frac{d}{dt}\right)' = \left(\frac{\partial}{\partial t} + \vec{v}_e \cdot \vec{\nabla}\right)' = \frac{\partial}{\partial t'} + \vec{v}'_e \cdot \vec{\nabla}' = \left(\frac{\partial}{\partial t} + \vec{v} \cdot \vec{\nabla}\right) + (\vec{v}_e - \vec{v}) \cdot \vec{\nabla} = \frac{\partial}{\partial t} + \vec{v}_e \cdot \vec{\nabla} = \frac{d}{dt} \tag{7}$$

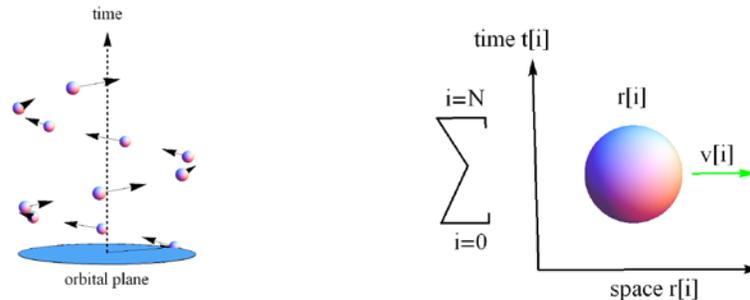
which verifies the first-order Galilean invariance of  $\frac{d}{dt}$ . QED

AE: My dear Prof. Hertz, I never realized that your equations of electrodynamics *are* Galilean invariant. I simply *assumed* that velocity  $\vec{v}$  was identically zero due to the lack of ether.

HH: Well, it is not. But might I ask, dear Sir, just how you came to invoke multiple time dimensions? I conjecture that, in pondering Michelson-Morley(MM)-experiments, you viewed their lab frame at various times in solar orbit, and formalized these as an array of 4D-frames, *each with its own space and time coordinates* and laws of inertia, and each with the speed of light apparently attached to the frame.

AE: Why yes, that approximates my thinking.

TK: Mr. Heaviside suggested you viewed the universe as the sum of these frames, as seen on his napkin:



The MM experiment was performed at different places and times in the Earth's orbit. Einstein viewed this as an array of inertial frames [i], each with a 4D coordinate system attached to the laboratory, specifying a 3D space  $r[i]$  and 1D time  $t[i]$ . But Earth exists in and travels through *one* time dimension, not *one per location!*

Heaviside pointed out that the classical conception of universal time has the earth moving through *one* time and three space dimensions. The mere fact that clocks or seasons 'tell time' along this dimension does not argue for multiple time dimensions, yet that is exactly what you postulated Professor Einstein. Of course when you create these multiple time dimensions, you fracture the classical understanding of *universal time as universal simultaneity* and you then proclaim "*the relativity of simultaneity*".

AE: My word! I hope we can discuss time dilation soon.

HH: We can. But your time dilation and length contraction results are derived, as you say<sup>2</sup>, "*with the help of certain imaginary physical experiments*". Yet, after more than a century<sup>10</sup>, *no physical proof exists of length contraction*. And with respect to your popular railway gedanken experiments you state<sup>11</sup>

*"The laws of transmission of light in vacuo must be the same for the railway car as reference-body as when the rails are the body of reference."*

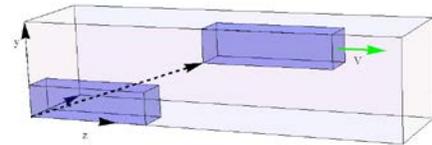
Surely from the perspective of ‘*local gravity as preferred frame*’ this is a false statement. Else the railway car must need to generate a local gravitational field greater than the earth’s field associated with *the rails*.

AE: Oh, yes! If the hypothesis of gravity as local medium of propagation is correct, then my statement is assuredly incorrect. Let us now discuss time dilation, as my theory possesses much experimental support.

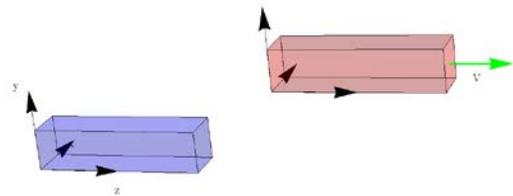
HH: Of course. But may I take a moment to contrast my paper [*on which you base yours*] with your own?

AE: Yes, please do.

HH: I view the reality of fields as energy **in** moving bodies, including the ether, while your description is **between** bodies in relative motion. Specifically, I view Faraday's *lines of force* as being conveyed by the ether, consistent with the "convective derivative". The *lines of force* simply represent a symbol for the special conditions of matter, that is, *local stresses in the ether* (which flow with the ether.) This conflicts with your principle that the speed of light is constant in all frames regardless of the speed of the emitter. At right, local ether is represented by *one* frame containing *both* physical entities, including simply disturbances in the ether. The entity at the origin is at rest with respect to local gravity, while the entity at upper right is moving with respect to local gravity.



In an ether-free perspective, you, of necessity, attribute the physical properties of the ether to *each* inertial frame, two of which are shown here. Your astonishing contention that *each frame possesses its own time dimension* and physical laws essentially creates a *real world* each time you define a new inertial frame. This exemplifies the problem of identifying a mathematical projection as real physical structure, yielding the paradoxes and contradictions associated with special relativity theory, for instance...



*‘Your clock runs more slowly than mine,  
while my clock runs more slowly than yours.’*

And yet your proposed length contraction has never been experimentally seen <sup>10</sup> or known to happen.

AE: Perhaps, but time dilation is experimentally proved. For example, consider the muon.

HH: I shall consider the muon in a moment. But your gedanken experiments always postulate two time dimensions, and draw conclusions about the behavior of clocks, assuming *perfect* clocks and defining a method of synchronization, leading to the *relativity of simultaneity* and to *time dilation*.

AE: Quite true. But my dear Professor, how else can one treat these issues?

HH: One can replace *space-time symmetry*, based on your assumption of multiple real worlds, each possessing its own  $\bar{v}$ -dependent time dimension, with **one** real energy-based world of kinetic energy  $\sim v^2$  (and gravitational energy  $\sim mGz$ ). My theory of electrodynamics <sup>1</sup> for bodies in motion is *energy-based*:

*" ... in every self-contained electromagnetic system the amount of energy in question is balanced by the mechanical work which is done by the electric and magnetic ponderomotive forces of the system during the element of time under consideration."*

Since *clocks* represent mechanical work, defining them as “perfect” is a vast oversimplification. Should one radically alter the nature of time and space, as you have done, on the basis of such oversimplification?

AE: I await your elucidation of a better approach.

TK: Well, the phase  $\vec{k} \cdot \vec{r} - \omega t$  of the wave  $\psi = \sin(\vec{k} \cdot \vec{r} - \omega t)$  involves a product of the space and time coordinates  $\vec{r}$  and  $t$  times the wave parameters, the propagation constant  $\vec{k}$  and the frequency  $\omega$ . We can mathematically transform the phase by transforming the space and time  $\vec{r}$  and  $t$  **or** by transforming the propagation constant  $\vec{k}$  and frequency  $\omega$ . Voigt<sup>25</sup> inappropriately chose to represent the Doppler effect as a transformation in the *space and time coordinates* for a stationary observer to those for moving observer, leading to the naïve assumption that *space and time* themselves could somehow change in the moving system, and resulting in ‘length contraction’ and ‘time dilation’. Lorentz later extended this. However the Doppler effect is concerned solely with *wave properties*: the propagation constant  $\vec{k}$ , and the angular frequency  $\omega$ , the phase velocity  $v$  and the velocity of energy propagation  $c$  so the transformation should have been in terms of frequency  $\omega$  and ‘momentum’  $\vec{k}$ . That is, in terms of energy.

Also consider that classical Poisson brackets provide that, for function  $F$ , the time derivative is given by  $dF/dt = \{ F, H \}$  with momentum time derivative  $dp_k/dt = \{ p_k, H \}$ . The Hamiltonian,  $H$ , or energy function, corresponds to change with time, formalized in quantum mechanics as the *energy operator*:

$$\hat{H} \sim \frac{d}{dt} \quad \text{with momentum operator:} \quad \hat{p} \sim \vec{\nabla}. \quad (8)$$

Emmy Noether’s fundamental theorem related conserved quantities in physics to symmetries of the laws of nature: space translation symmetry yields conservation of momentum; rotation symmetry yields conservation of angular momentum; and ***time translation symmetry yields conservation of energy***. In most physically relevant cases, the Hamiltonian is the total energy. When expressed as operators on appropriate functions  $F \rightarrow \psi$  we obtain the basis of quantum mechanics, Schrödinger’s equation:

$$i\hbar \frac{d\psi}{dt} = \hat{H}\psi \quad (9)$$

All of this implies that the difference in *rest frame energy* and the *energy of mass moving* with velocity  $\vec{v}$  is linked to *change with respect to time*:  $d/dt$ .

AE: Yes, as in my photo-electron paper:  $E = h\nu$ ,  $\nu = \text{frequency} = \text{cycles/sec} \sim d(\text{cycles})/dt$ .

TK: Of course change in frequency with gravitational energy was demonstrated by Pound and Rebka and is proved every day in the *global positioning system* (GPS). As we have seen above, the Maxwell-Hertz equations (5) for moving bodies use the total time derivative including the convective derivative. In fact, Noether’s theorem for time translation uses Lagrangian  $L = T - V$  [ $T = \text{kinetic}$ ,  $V = \text{potential-energy}$ ]:

$$\frac{dL}{dt} = \frac{\partial L}{\partial t} + \sum_{\alpha} \left[ \frac{\partial L}{\partial q_{\alpha}} \dot{q}_{\alpha} + \frac{\partial L}{\partial \dot{q}_{\alpha}} \ddot{q}_{\alpha} \right] \quad (10)$$

If the generalized coordinate  $q_{\alpha} = x_{\alpha}$  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 yields the operator expression:

$$\left[ \frac{d}{dt} = \frac{\partial}{\partial t} + \vec{v} \cdot \vec{\nabla} \right] L \quad \text{this is the **definition** of the convective derivative!} \quad (11)$$

Thus Noether’s fundamental physics derived in 1918 was already 'built into' Hertz's electrodynamics of moving bodies in 1890. It is the key to Galilean invariance (where  $t' = t \equiv$  universal simultaneity).

We know that  $d/dt \sim \partial/\partial t$  are essentially energy operators, but what is  $\vec{v} \cdot \vec{\nabla}$ ? In quantum mechanics  $\vec{\nabla}$  is proportional to the momentum operator  $\hat{p}$ , hence we would surmise:

$$\vec{v} \cdot \vec{\nabla} \sim \vec{v} \cdot \vec{p} = \vec{v} \cdot m\vec{v} = mv^2 = \text{energy}. \tag{12}$$

That is, the convective derivative represents an energy term associated with the ether velocity that is tightly bound to change with respect to time. It should show up in a Hamiltonian.

HH: So it seems clear that local velocity-related energy-change in **one** inertial frame, *the real world*, should be thoroughly analyzed *before* one takes the radical step of proposing a new time dimension.

AE: Perhaps, but, my *gedanken experiments* lead to *length contraction* and *time dilation*, as proved by muons and atomic clocks. And I clearly formulate my space-time frameworks using *perfect clocks*.

TK: Ah ha! That may be the problem. *What is a perfect clock?* The first clocks derived from pendulums, and even in 1500 it was known that pendulum clocks at different geographical locations varied, since the period being counted is  $\sqrt{l/G}$  where  $l$  is the length and the local gravity  $\vec{G}$  varies due to the oblateness of the earth. 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. Finally, all realistic clocks that are able to measure relativistic time changes are atomic clocks, based on characteristic emission lines such as rubidium<sup>87</sup> and cesium<sup>133</sup>. But even atom-atom scattering shifts the frequency of atomic clocks<sup>13</sup>.

In other words, Einstein, *there are no perfect clocks* — all are subject to local energy conditions. You entirely ignore this reality; positing 'perfect clocks' and a method to synchronize perfect clocks, and then you **imagine** the clocks measuring *different time dimensions*. It would seem that a more sober approach would have been 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 *exact-same-one-and-only time dimension* with different energy  $\sim mv^2$ . This *clock difference* is of quite different nature than assuming that the non-local moving clock is measuring a *different time dimension!* By definition, if the clock is moving with velocity  $\vec{v}$  with respect to our rest frame, it 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’.

HH: Yes, consider the photon energy  $h\nu$  that describes all atomic clocks used to "prove" time dilation:

$$E = h\nu \sim \frac{d}{dt}(\text{cycles}) \quad \text{where } \nu = \frac{c}{\lambda} \text{ (rest) and } \nu = \frac{c-v}{\lambda} \text{ (moving)}. \tag{13}$$

AE: But what about the muon? It lives nine times longer than it would in its rest frame.

HH: It certainly does. But why? Is that a *space-time symmetry* effect? And, if so, does the same logic apply to the neutron, which lives for fifteen minutes as a free particle, but billions of years in the nucleus?

AE: My dear Sir, nucleons in the nucleus are in a vastly different energy environment or ground state.

HH: That is indeed true, and a muon traveling at 0.997 c also exists in a vastly different energy state. My dear Einstein, are you claiming that energy differences affect the neutron, but such do not affect muons?

AE: Hmm... I may have to ponder that point.

TK: Pound-Rebka showed that even a 25 meter gravitational energy shift changes a photon's time period.

**Fundamental reality is based on energy-time conjugation,  $\Delta E \sim 1/\Delta t$ , not on space-time symmetry.**

If we approach with speed  $v$ , a light wave moving in local gravity with speed  $c$ , then we will see light with speed  $c + v$ , contradicting your basic principle. In fact *this very day as we meet*, two new tests of relativity are reported<sup>22,23</sup>. One tests an electromagnetic field holding a superconducting niobium sphere against the gravitational pull of the earth, and finds no compelling evidence for Lorentz violation, but the null results are compatible with 'gravity as ether'. The other uses 48 years worth of *Lunar Ranging* data to conclude that "no Lorentz violations were found". Neither test is based on the existence of two time frames, so in both tests, the 'relativity survives scrutiny' conclusion is meaningless!

The *energy-time interpretation of relativity* is based on a universal time frame in which moving objects have energies proportional to  $v^2$ . Energy-time conjugation means the resonant frequency of the mechanical system will change with energy, hence with velocity. Quantum theory: minimum change  $\Delta E \Delta t \sim \hbar$

*'Clocks' are always implemented as 'cycle counters' so clocks actually measure energy, not time.*

*Clocks responding to local energy-changing conditions read differently according to their velocities.* This does not imply another time dimension in any way. Lorentz transform describes *physics energy relations* in **one** time dimension, the real physical world; it has no significance outside the realm of kinetic energies and gravitomagnetic circulation. Nor does the GPS system exhibit space-time symmetry: a ground station is *always* the fastest clock; it is *not* symmetrical as claimed by Einstein. Minkowski formulation applies to *energy-momentum* with 3 space dimensions such that we can rotate  $x$ ,  $y$ , or  $z$  into two other dimensions; say project  $x$  onto the  $y$ -axis. But with only one time dimension we cannot rotate  $t'$  into  $t$ ; they are the *same* axis. We can adapt Maudlin's logic to 'attaching a time dimension to each inertial frame':

*"I can say "if Nixon were a ham sandwich..." and thereby produce a representation according to which Nixon was a ham sandwich, but it does not follow that in any sense it is possible for Nixon to have been a ham sandwich."*

Even Rindler, whose name is attached to aspects of special relativity, states about Einstein's postulate:

*"Light propagates the same in all inertial frames... It is not for us to ask how!"*

If it made sense, we could ask how, so Rindler admits that it doesn't make sense. It is simply a 'fudge' to explain the MM-null results; it has no physical reality. That is why space-time symmetry leads to paradox and nonsense and has never been experimentally proved. *Time dilation*, which is experimentally confirmed [muon, GPS, atomic clocks, Pound-Rebka] is subject to an asymmetric *energy-time interpretation* compatible with universal time, i.e., universal simultaneity, which leads to neither paradox nor nonsense; nor to the non-intuitive multiple worlds that Einstein invented to plug the 'ether' hole in electrodynamics. When Hertz derived his theory, atoms were only *assumed* to exist, so Maxwell-Hertz equations are formulated in the continuum, which represents classical gravity. Atomic clocks were half a century away, so **perfect** clocks seemed reasonable at the time. But this doesn't justify Einstein's creation of **new time dimensions** to attach to moving objects, the source of all the non-intuitive nonsense of special relativity. But if  $\vec{v} \neq 0$

$$E = \gamma mc^2 = mc^2 \left[ 1 - \frac{v^2}{c^2} \right]^{-1/2} = mc^2 + \frac{1}{2} mv^2 \dots = \text{particle energy} + \text{energy of motion} \quad (14)$$

The Lorentz transformation is very appropriate for 4D physics:  $\{E, \vec{p}\}$ ,  $\{\rho, \vec{j}\}$ ,  $\{\phi, \vec{A}\}$  but sophisticated use of gauge physics in 4D does **not** require the belief in [or even the concept of] *multiple time dimensions* and corresponding *relativity of simultaneity*. I.e., “*attaching time to an object*” is artificial, not realistic.

*Clocks measure energy, only indirectly related to fundamental time, that is, universal simultaneity.*<sup>20</sup>

*“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.”*

Special relativity texts<sup>7,8,16,17,18,19</sup> use your **two** inertial frames to *derive* the Lorentz transformation from one frame to another, *yet the transformation can be derived in one real world*<sup>12</sup>, with universal time, in terms of two energy states: the ground state ( $v = 0$ ) and the energy of the moving object ( $\sim mv^2$ ). This *one-inertial-frame derivation* is compatible with relativistic particle physics while rejecting non-intuitive space-time symmetry. In other words, it implies *only one time dimension!* This is very significant.

And Einstein, your 1905 rejection of ether was short-lived; in 1916 you wrote<sup>15</sup> to Lorentz: “*This new ether theory ... 'g<sub>μν</sub> = ether' ... would be a function of position determined by material processes*”. Your use of differential manifolds to model space and time apparently never caused you to re-think your ‘*relativity of simultaneity*’, confusing at least three generations of physicists about *the fundamental nature of time*.

AE: Yes, if light propagates through local gravity as ether, then domains of *relative rest* **do** exist and the space-time symmetry based on *no preferred frame* is broken. Also Prof Hertz’s energy-based analysis of *stresses* moving in an energetic background *does* yield Galilean space-time transformation with Lorentz obtained in only one time dimension when energy  $\sim mv^2$  is compared to the ground-state energy  $\vec{v} = 0$ .

TK: Professor Einstein, what I find so strange is that in 1913 you said in a letter<sup>15</sup> to Mach:

*“The... masses generate a field g<sub>μν</sub> (gravitational field) which controls the development of every process, including the **propagation of light rays** and the **behavior of measuring rods and clocks.**”*

Yet in spite of your redefinition of ether as gravity potential or  $g_{\mu\nu}$ , **which propagates light**, you felt no need to modify special relativity — neither ‘no preferred frame’ nor ‘relativity of simultaneity’. We could discuss this further, but it is now closing time at the Tavern — we have not time to describe a proposed experiment to demonstrate that one can measure the absolute [local] velocity from *within* the moving inertial frame, which is forbidden by special relativity. That would seem to be determinative.

AE: Yes, that would be a convincing experiment, certainly worth pursuing.

TK: Your space-time symmetry leads to non-intuitive physics and paradoxes and its predictions have never been experimentally proved while Noether’s *fundamental theorem of conservation of energy as time translation symmetry* yields the convective derivative operator that is **built into** Hertz’s *electrodynamics in moving bodies* [including ether]; that is Galilean invariant, and that formally breaks space-time symmetry and thus restores classical understanding of

***the fundamental nature of time as universal simultaneity.***

As the ghosts leave the Tavern, the keeper calls, “*Perhaps next time we can discuss implications of this fundamental nature of time.*”

— Endnotes —

Physicist’s discussions of special relativity theory (SRT) and Lorentz transforms often go like this: The problem is analyzed from the perspective of one observer at rest and another observer who considers himself to be at rest in a frame that is in motion relative to the first. *Each* frame obeys Einstein's postulates and one thus **always** obtains SRT results; *the math is consistent*, but is based on multiple time dimensions. If the problem is analyzed in only one inertial frame, we obtain different results. In realistic situations,  $v \ll c$ , the difference cannot be measured, *so one is arguing on faith*. The relativistic particle physics transform is interpreted as  $f(\text{energy}) \sim (1 - mv^2/mc^2)^{-1/2}$  and energy-based results actually do agree with SRT, but do not require two time dimensions. Most particle physics occurs at a collision point, where the times are unquestionably the *same time* so *if one assumes SRT, one gets SRT results*, but these cannot be proved experimentally. Thus relativistic particle physics energies *do* agree with SRT, but do *not* require two time dimensions. *Clocks* measure energy by counting cycles; they do not measure separate time dimensions. There is only *one* universal time dimension.

**Hertz’s 1890 equations**  $\vec{v} = (\alpha, \beta, \gamma)$   $\vec{E} = (X, Y, Z)$   $\vec{B} = (L, M, N)$

$$\left( \begin{array}{l} A \left\{ \frac{d\mathfrak{E}}{dt} + \frac{d}{dy}(\beta\mathfrak{E} - \alpha\mathfrak{M}) - \frac{d}{dz}(\alpha\mathfrak{Z} - \gamma\mathfrak{X}) + \alpha \left( \frac{d\mathfrak{X}}{dx} + \frac{d\mathfrak{M}}{dy} + \frac{d\mathfrak{Z}}{dz} \right) \right\} \\ \quad = \frac{dZ}{dy} - \frac{dY}{dz}, \\ A \left\{ \frac{d\mathfrak{M}}{dt} + \frac{d}{dz}(\gamma\mathfrak{M} - \beta\mathfrak{Z}) - \frac{d}{dx}(\beta\mathfrak{E} - \alpha\mathfrak{M}) + \beta \left( \frac{d\mathfrak{E}}{dx} + \frac{d\mathfrak{M}}{dy} + \frac{d\mathfrak{Z}}{dz} \right) \right\} \\ \quad = \frac{dX}{dz} - \frac{dZ}{dx}, \\ A \left\{ \frac{d\mathfrak{Z}}{dt} + \frac{d}{dx}(\alpha\mathfrak{Z} - \gamma\mathfrak{X}) - \frac{d}{dy}(\gamma\mathfrak{M} - \beta\mathfrak{Z}) + \gamma \left( \frac{d\mathfrak{E}}{dx} + \frac{d\mathfrak{M}}{dy} + \frac{d\mathfrak{Z}}{dz} \right) \right\} \\ \quad = \frac{dY}{dx} - \frac{dX}{dy}, \end{array} \right) \left( \begin{array}{l} A \left\{ \frac{d\mathfrak{X}}{dt} + \frac{d}{dy}(\beta\mathfrak{X} - \alpha\mathfrak{L}) - \frac{d}{dz}(\alpha\mathfrak{Z} - \gamma\mathfrak{X}) + \alpha \left( \frac{d\mathfrak{X}}{dx} + \frac{d\mathfrak{M}}{dy} + \frac{d\mathfrak{Z}}{dz} \right) \right\} \\ \quad = \frac{dM}{dz} - \frac{dN}{dy} - 4\pi A\alpha, \\ A \left\{ \frac{d\mathfrak{M}}{dt} + \frac{d}{dz}(\gamma\mathfrak{M} - \beta\mathfrak{Z}) - \frac{d}{dx}(\beta\mathfrak{X} - \alpha\mathfrak{L}) + \beta \left( \frac{d\mathfrak{X}}{dx} + \frac{d\mathfrak{M}}{dy} + \frac{d\mathfrak{Z}}{dz} \right) \right\} \\ \quad = \frac{dN}{dx} - \frac{dL}{dz} - 4\pi A\beta, \\ A \left\{ \frac{d\mathfrak{Z}}{dt} + \frac{d}{dx}(\alpha\mathfrak{Z} - \gamma\mathfrak{X}) - \frac{d}{dy}(\gamma\mathfrak{M} - \beta\mathfrak{Z}) + \gamma \left( \frac{d\mathfrak{X}}{dx} + \frac{d\mathfrak{M}}{dy} + \frac{d\mathfrak{Z}}{dz} \right) \right\} \\ \quad = \frac{dL}{dy} - \frac{dM}{dx} - 4\pi A\gamma. \end{array} \right)$$

I have converted Hertz’s equations into vector notation shown as eqns (5) in the essay. His total time derivative replaces Maxwell’s partial time derivatives<sup>9,20</sup> *Hertz’s electromagnetic field equations are Galilean invariant.*

**Treatments of derivatives in electromagnetic textbooks**

TE Phipps<sup>9</sup> discusses Hertz’s version of Maxwell's equations, in which the *total time derivative replaces the partial time derivative*, in terms of classic E&M treatments, including the following textbooks: **Panofsky and Phillips:**<sup>27</sup>

$$\oint \vec{E} \cdot d\vec{l} = -\frac{d}{dt} \iint \vec{B} \cdot d\vec{S} = -\iint \frac{\partial \vec{B}}{\partial t} \cdot d\vec{S}. \quad \text{The change from } \frac{\partial}{\partial t} \text{ to } \frac{d}{dt} \rightarrow \frac{\partial}{\partial t} + \vec{v}_d \cdot \vec{\nabla} \text{ is implied by Faraday's}$$

experiments in which *Faraday actually changed the shape of circuits*, altering the  $d\vec{l}$  in flux-penetrated space. And **John David Jackson**<sup>28</sup> notes: "*Faraday's law can be put in differential form by use of Stokes theorem, provided the circuit is held fixed in the chosen reference frame...*", but *this contrasts with what Faraday actually did*. **Lorraine and Corson**<sup>29</sup> allow non-inertial motions but require the circuit at all times to move as a rigid whole, *again conflicting with Faraday*. **Wangness**<sup>30</sup> claims to allow shape changes of the Faraday circuit, but Phipps criticizes this. **Ohanian**<sup>31</sup> inverts Panofsky and Phillips by taking the integrated form of Maxwell's equation as the starting point;  $\partial \vec{B} / \partial t$  appears under the integral sign, *then he extracts the partial time derivative as a total time derivative*.

**Smythe**<sup>32</sup> is also criticized, and **Purcell**<sup>33</sup> describes Faraday's observations by  $\vec{\nabla} \times \vec{E} = -(1/c) d\vec{B}/dt$  but then he says "*Recognizing that  $\vec{B}$  may depend on position as well as time we shall write  $\partial \vec{B} / \partial t$  in place of  $d\vec{B} / dt$ . We have then these two entirely equivalent statements of the law of induction.*" [ but this is true only if  $v = 0$ . ]

**All of the texts recognize that Maxwell’s  $\partial / \partial t$  is a departure from Faraday’s fundamental  $d / dt$ .**

### Einstein: the Ether is absolutely necessary

Einstein<sup>11</sup> assumes that *the gravitational field pervades all space*, saying "There exists no space 'empty of field'." In 1922 he said: "[In] the general theory of relativity, **space without ether is unthinkable; [as] there would be no propagation of light...**" and<sup>15</sup> "We will not be able to do without the ether in theoretical physics; a continuum which is equipped with physical properties." **Ether, physical space, and field** became synonymous. So Einstein "imagines a space filling medium; the electromagnetic fields ... are its states." This is Hertz's electrostatics.

### Rindler: "Einstein's axioms logically eliminate the ether concept in physics."

One might hope, when Einstein decided that ' $g_{\mu\nu} = ether$ ' and identified the ether with the field filling space, that he would re-visit his axioms, particularly "the speed of light is constant in all frames", and re-think the act of creating multiple time dimensions. Such was not the case, and his two incompatible theories are still taught and believed.

### Volovik: Condensed Matter Ether analogy

For Einstein, even empty space has physical qualities, characterized mathematically by the ( $g_{\mu\nu}$ ) gravitational potential. Others view the ether as *quantum fields*; in *The Universe in a Helium Droplet*<sup>21</sup> the 'quantum vacuum' is the ether; the approach is based on condensed matter physics. These fields, including gravity, represent collective motion of this vacuum, considered a perfect fluid. The speed of light  $c$  is not a fundamental constant, but a material parameter. The fields are *local disturbances* in Hertz's sense. In this *superfluid* one can find the preferred reference frame, where  $v = 0$ , which determines the invariant characteristic of the liquid. The total system, fluid plus quasi-particles is Galilean invariant. A normal liquid is described by two variables: mass density  $\rho$  and the velocity  $\vec{v}$ .

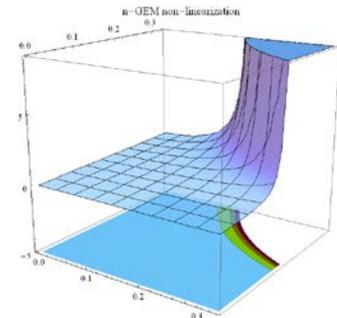
The velocity  $\vec{v}$  is not curl free;  $\vec{\nabla} \times \vec{v} \neq 0$ . "The only completely local theory of hydrodynamics is presented by the Hamiltonian formalism", using Poisson brackets  $\partial_t \rho = \{H, \rho\}$ ,  $\partial_t \vec{v} = \{H, \vec{v}\}$ . Hydrodynamics variables do not form pairs of canonically conjugate variables, so there is no well-defined Lagrangian. The Hamiltonian is the energy of the liquid expressed in terms of hydrodynamic variables:

$$H = \int d^3x ((\rho v^2 / 2) + \varepsilon(\rho))$$

Thus the Hamiltonian equation yields *continuity* and *Euler* equations:

$$\frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot (\rho \vec{v}) = 0, \quad \left( \frac{\partial}{\partial t} + \vec{v} \cdot \vec{\nabla} \right) \vec{v} + \vec{\nabla} \frac{\partial \varepsilon}{\partial \rho} = 0.$$

So whether *gravitational potential*,  $g_{\mu\nu}$ , or *quantum vacuum*, modern physics sees an ether. *The difference is that 'quantum vacuum energy' is off by  $10^{123}$ .* Note also that the Schrödinger and the corresponding Liouville-von Neumann equation are covariant under the action of the Galilean group.<sup>26</sup>



### The Non-linear Self-interaction of the Gravitational Field

The gravitational field is non-linearly self-interactive — Heaviside drew this iterative self-interacting behavior on a napkin. The steepness of circulation growth exceeds exponential<sup>4</sup> and must be limited by available energy causing the growth of the gravitomagnetic circulation. This self-limiting behavior is unique and has not been factored into physics as of this writing. However, beginning with Einstein and continuing today, local gravity as the medium of light propagation, i.e., *ether*, is increasingly recognized as significant, in that it voids claims of *constant speed c in all frames*. And this voids Einstein's creation of multiple time dimensions leading to the 'relativity of simultaneity'. The effect of this belated recognition of 'ether' is the restoration of physical intuition and

*understanding of the fundamental nature of time as universal simultaneity.*

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