'c' for Yourself! (Why a speed limit?)

Abstract: **The Euclidean lens of interval-time coordinates reveals *explanations for*, rather than mere *descriptions of* finite, universal, constant and invariant speed limit *c*.**

$c = c'$

Consistent with Maxwell's ingenious derivation, Einstein formulated Special Relativity by postulating an absolute speed limit **–** independent of relative motion between emitter and absorber. Maxwell's feat relied on *measured* electric (ε_0) and magnetic (μ_0) constants, now both related to the fine structure constant (α).[1] His result is thus, tantamount to measuring ***c*** directly as opposed to explaining it.

Equally unsatisfying is the common reference to relativistic mass-energy or time dilation to justify the speed limit. Truly, mass-energy grows unbounded and clocks of all types slow toward a stop in frames seen to be asymptotically approaching lightspeed (in vacuo). But, this invokes circular reasoning as such relativistic consequences derive from an originally postulated ***c***.

Blurred View

Among the first to appreciate Einstein's new theory, Minkowski provided spacetime diagrams. However, the cost of their familiar appearance was a factor of √-1 on appropriate coordinates. This was later remedied by replacing the Pythagorean *sum* with a *difference* in the interval equations, indicating an unintuitive, non-Euclidean geometry.

"…it is not really possible to think of space-time as a real, ordinary geometry because of that minus sign."[2]

The coordinates of inertial frames in relative motion collapse toward the lightlike interval (Fig. 1), thus denying light a rest frame. With natural units, this occurs for slope 1/***c*** = 1, common to all inertial frames but giving *no hint* as to why.

"Why is the speed of light the same in all reference frames? I don't know the answer to that question, and I don't even know how to approach it. … the speed of light is unexplained."[3]

A globe offers an undistorted map of earth's surface because of the *structural match* between the map and the physical region it represents. By contrast, spacetime is highly distorted.

"… the best we can do for figures in Minkowski space is to map them onto Euclidean space, as did Mercator with his flat map of the curved surface of the earth. Such maps necessarily distort metric relations and one has to compensate for this distortion."[4]

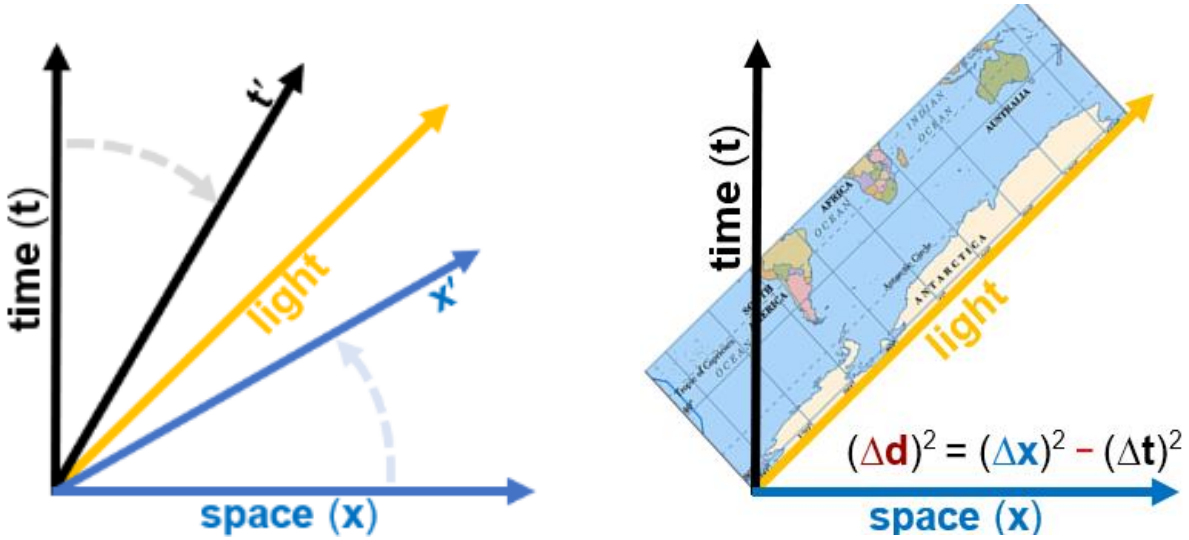

Fig. 1 Left: Moving coordinates (′) collapse toward speed ***c***. Right: A Mercator projection makes a *single* geographic point (the south pole) seem as long as the equator. Similarly, a 2D slice of spacetime makes a lightlike interval of *zero* magnitude (when $\Delta\mathbf{t} = \Delta\mathbf{x}$)[5] seem indefinitely long. A minus sign in the interval formula indicates non-Euclidean geometry. Its map distortion may obscure explanations for limit ***c***.

Yet distortionless coordinates are readily available!

Corrective Lens

Rearranging the formula for a spacelike interval[5] ($\Delta\mathbf{d}$) from: $\Delta\mathbf{d}^2 = \Delta\mathbf{x}^2 - \Delta\mathbf{t}^2$ to: $\Delta\mathbf{x}^2 = \Delta\mathbf{d}^2 + \Delta\mathbf{t}^2$ yields a Pythagorean relation, reflecting Euclidean geometry, with **interval-time** coordinates.

Consider further a lightlike interval.

"…the interval AB between two events can vanish even when the separations Δx, Δy, Δz in space and Δt in time between B and A are individually quite large."[6]

"Where light goes from a given point is always separated from it by a zero interval"[7]

"In other words, the spacetime interval between two events on the world line of something moving at the speed of light is zero."[5]

Euclidean coordinates make it obvious that zero interval "separation" is direct, physical **contact** (Fig. 2). Nothing is closer than contact. ***c*** is an *absolute* speed limit because contact is an *absolute* proximity limit!

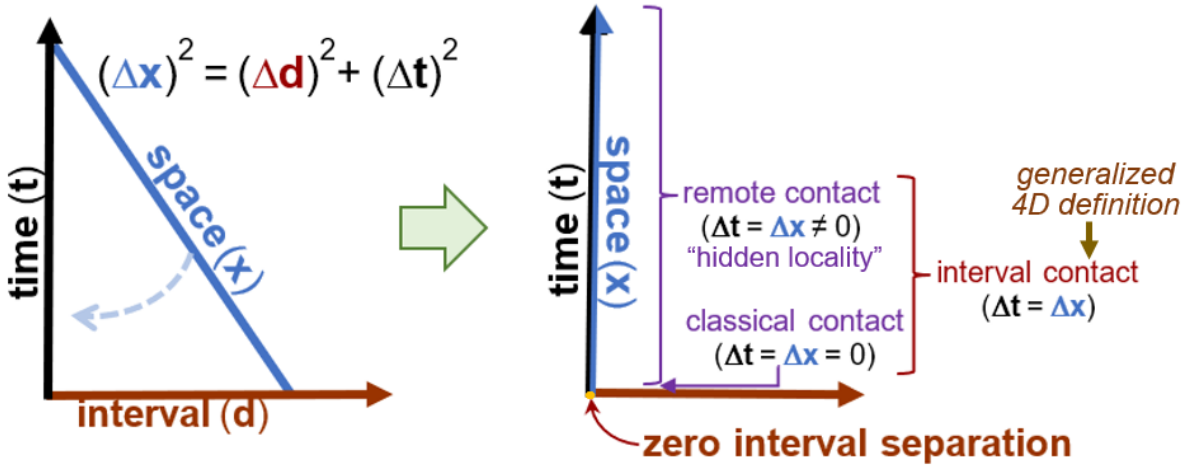

Fig. 2 Left: As magnitude $\Delta\mathbf{x}$ (shown locally flat) approaches that of $\Delta\mathbf{t}$, interval $\Delta\mathbf{d}$ shrinks. Right: In the lightlike limit ($\Delta\mathbf{x} = \Delta\mathbf{t}$), direct *interval contact* ($\Delta\mathbf{d} = 0$) occurs, *bypassing* space and time of *any* extent. Instead of photons, light quanta pass through pinholes (particle-interaction wormholes).

In 4D, all contact is interval contact, which includes *classical* ($\Delta\mathbf{x} = \Delta\mathbf{t} = 0$) and *remote* ($\Delta\mathbf{x} = \Delta\mathbf{t} \neq 0$) types. If "zero interval separation" doesn't mean *physical contact*, physics is at a loss to explain what it does mean. In fact, 4D *must* provide infinitely more radial contact paths than are classically recognized in 3D (Fig. 3).

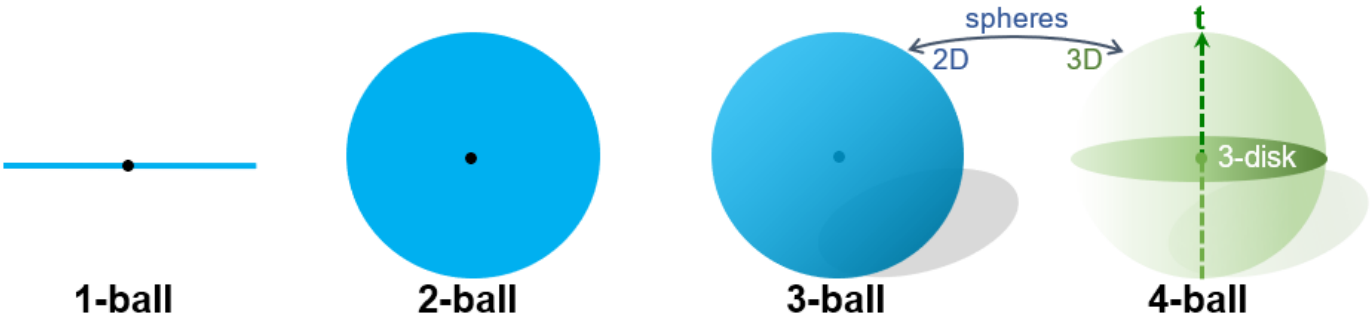

Fig. 3 Contact with the center of an n-ball[8] occurs when radial separation is zero. The number of radial contact paths (p) increases geometrically with dimension (n): $p = 2\infty^{(n-1)}$.

Though bypassing indefinite (but equal) spans of space and time, light makes zero interval displacement. Thus, in terms of *invariant* interval speed ($\Delta\mathbf{d}/\Delta\mathbf{t}$), interval-time coordinates provide light's rest frame. ***c*** is an *absolute* speed limit because nothing is slower than *absolute* rest!

It's no accident that a *single geometric point* and ***c*** are both invariant.

"…to state that the propagation speed of light is invariant is the same as saying that the interval is zero."[7]

What would Einstein think of replacing his energy "quanta" with energy conduits (i.e. pinholes)? Actually, the photoelectric effect is explained even *more elegantly* by direct contact, without photons.

As for the coordinates, recall:

"Indeed, Einstein himself was not sympathetic to this idea when he first encountered it. The idea of space-time was not, in fact, Einstein's…It was …Hermann Minkowski …in 1908"[9]

Einstein would likely have *preferred* interval coordinates which, unlike space, are *invariant*.

"'Relativity' is in fact a thoroughly bad name for the theory: Einstein considered calling it the opposite: 'invariance theory.'"[10]

"Einstein seriously proposed in the early 1920s changing his theory's name from 'relativity theory' to 'invariant theory,' precisely to emphasize that it was the invariant core that represents reality." [11]

Where do interval-time coordinates physically apply? Everywhere! Extrapolate the Big Bang (BB) to a single 4D event, central to the balloon analogy of the expanding cosmos. This implies a *curved-space*, *radial-time* model, with a 4D temporal field emanating out from the BB. Space is the enclosing 3-sphere at any radius (i.e. at any cosmic age).

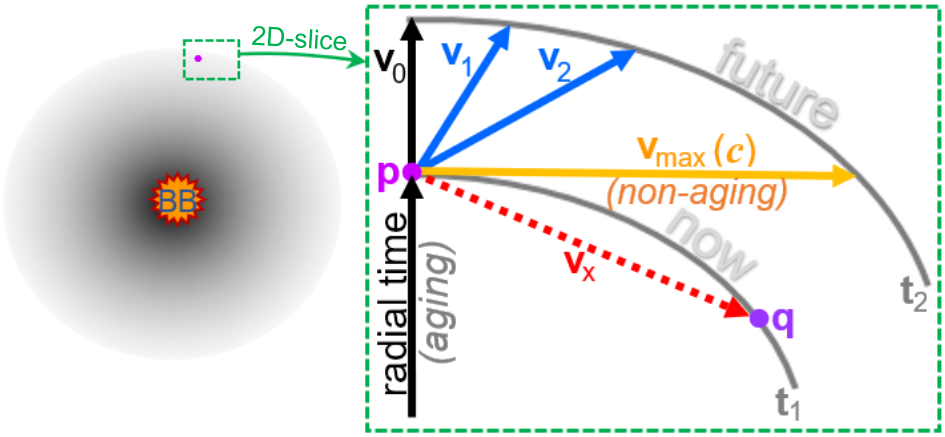

Fig. 4 Left: A temporal 4-field about a central, Big Bang event (BB) is enclosed at any radius by a spatial 3-sphere (a simultaneity) at rest with respect to the BB (and cosmic background). Right: From any event (**p**), interval-time coordinates correspond to $\mathbf{v}_{max}$ and $\mathbf{v}_0$ respectively. Being independent of time, $\mathbf{v}_{max}$ is non-aging. $\mathbf{v}_x$ is non-traversable, as it violates fundamentally *unidirectional* time. (But this *shortest* possible connection between **p** & **q**, may still serve as a simultaneous correlation reference for entangled particles.)

"A photon arriving in our eye from a distant star will not have aged, despite having (from our perspective) spent years in its passage."[5]

Aging occurs maximally at rest (along a timeline) and is avoided altogether at speed $\boldsymbol{c}$, orthogonal to time. Thus, limit $\boldsymbol{c}$ defines a tangent 3-plane at every location on a spatial 3-sphere.

$\boldsymbol{c}$ is ***finite*** because time is fundamentally *unidirectional*, enforcing the tangent limit.

$\boldsymbol{c}$ is ***universal*** because it relates to the underlying structure of the universe.

$\boldsymbol{c}$ is ***constant*** because tangent planes apply to all 3-sphere sizes (i.e. every cosmic age).

$\boldsymbol{c}$ is ***invariant*** because tangent planes persist even as spatial curvature increases in the direction of motion with respect to the cosmos (Fig. 5).

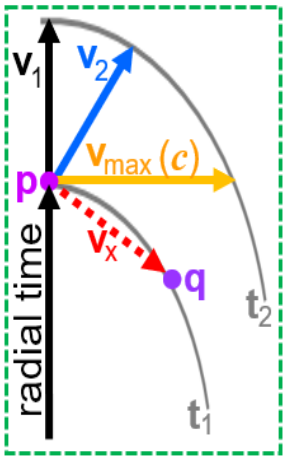

Fig. 5 In the rest frame of $\mathbf{v}_1$, the size of the cosmos is contracted in the direction of motion, yet $\mathbf{v}_{max}$ remains tangent to spatial simultaneity $\mathbf{t}_1$ (all space "now"). Thus, $\boldsymbol{c}$ is invariant.

If speed $\boldsymbol{c}$ is "interval contact", why is $\mathbf{v}_{max}$ shown above with apparent length? For individual light quanta, "speed" $\boldsymbol{c}$ is a null *vector* with zero *magnitude* and a particular tangent *direction*. $\mathbf{v}_{max}$ shows only direction on an interval coordinate (Fig. 4). Zero magnitude is seen for the lightlike requirement ($\Delta\mathbf{x} = \Delta\mathbf{t}$) where the cosmos is maximally contracted (Fig. 2).

Einstein's famous energy equation applies directly to Euclidean, interval-time coordinates.

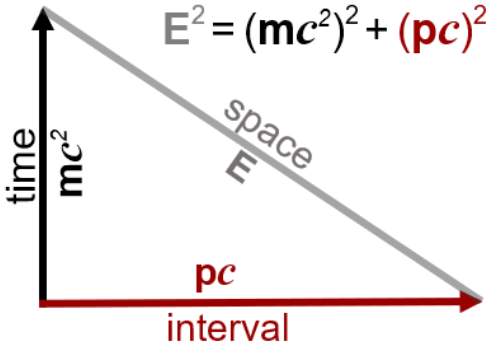

Fig. 6 With components corresponding to rest mass-energy along *time* and momentum on the *interval* coordinates, Einstein's total mass-energy (**E**) is their vector sum.

Can we expect science to reject well-entrenched photons? No! Not without *extraordinary* evidence. Fortunately, this is readily accessible from an ongoing experiment.

For more than two decades, the ALPHA collaboration[12] at CERN has labored to produce, isolate and characterize antihydrogen (anti-H). Having succeeded in matching its inertial[13] and gravitational[14] mass to that of ordinary hydrogen, ALPHA now pursues the anti-H spectrum.[15] Exchange of light quanta between electrons can't distinguish between an intermediary photon or contact via pinhole. However, direct contact between an emitting *electron* and an absorbing *positron* predicts annihilation of both, despite being spatially remote!

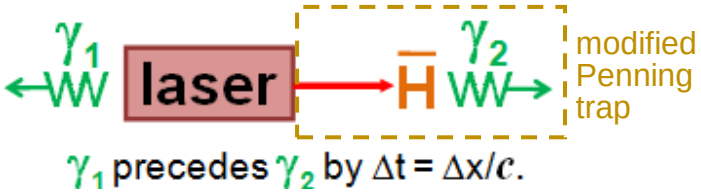

Fig. 7 Pinhole contact between electron and positron may result in their *remote annihilation*. Since a gamma detector *inside* the anti-H trap (right) is infeasible, it is all the more important to place one around the light emitter *outside* the trap (left).

Imagine what Einstein (or any physicist) would think of spooky *annihilation* at a distance! While awaiting further ALPHA results, reach up to the night sky *yourself* and ***touch the stars!***

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