ALPHA: Applying a Light Touch?

Abstract: **The particle aspects of light are accommodated so well by the photon model that alternative models are rarely considered. Interval-time coordinates provide a Euclidean lens, through which light quanta are seen to exchange by direct, physical contact. The ALPHA collaboration at CERN is uniquely positioned to experimentally distinguish between the models.**

Atomic Bomb

Planck solved problems understanding black body radiation by postulating quantized light emission. Shortly after, Einstein famously explained the photoelectric effect by modeling those quanta as particles, now universally accepted as “photons”. This is understandable because the model works astoundingly well. However, among Einstein’s other profound works of 1905 was his explanation of Brownian motion, which irrevocably legitimized the atomic theory of matter in physics. Could light have been accidentally caught in a rush to atomism?

Photons were part of a much broader “atomic” explosion. Among others, coins were the atoms of trade in economics, cells the atoms of life, germs the atoms of contagion, genes the atoms of inheritance and binary digits (bits) were emerging as the atoms of information theory. So, atoms of light must have seemed only fitting.

It is the purpose of this paper, not to deny the quantized orbital transitions but to advise on the plausibility of a simpler model, which obviates the photon. It also identifies a definitive test of the model, readily available in an ongoing experiment.

4D Reality

The useful revelations of Relativity are almost beyond counting and certainly not yet fully realized. But in recognizing four dimensions (4D) of potential *separation*, spacetime must also provide the reverse, 4D of paths toward *contact*. This far exceeds those familiar to Newton, who would have recognized only 3D of spatial contact available at any given moment.

To illustrate the difference, consider a “ball” as that region enclosed by a “sphere”, and a sphere the collection of points equidistant from an arbitrary “center” point. A dimensional progression then affords clarity (Fig. 1).

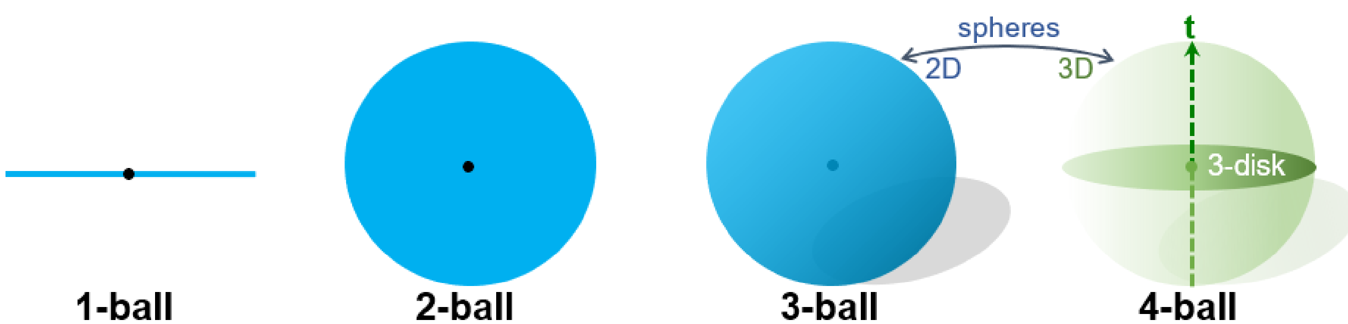


Fig. 1 Radial contact pathways increase geometrically (paths = $2\infty^{(n-1)}$) with dimension (n).

A line segment is a 1D ball (1-ball), having two radial paths leading to contact with its center. A disk is a 2-ball, enclosed by a circle and having an infinite number of radial contact paths. For each of those, an ordinary ball (3-ball) has infinitely more radii. It follows that for each radial path in that 3-ball, a 4-ball entails an infinitely greater number of contact paths than that. Thus, for each radius upon which classical 3D contact can be made at a given time (when $\Delta t = 0$), an overwhelming number of contact paths must be available in the 4D of Relativity (when $\Delta t \neq 0$).

This geometric requirement raises an obvious question, where are all these extra contacts in 4D and why don’t we see them?

Getting Coordinated

Ironically, the answer is we quite literally do "see" the additional contacts in 4D, as they include light! This realization is obscured by a longstanding problem with coordinate choice. Because human survival depended on things like hitting a moving animal with a spear, our brains are hardwired for space and time. So, it's no surprise that spacetime coordinates were developed and embraced. But trying to view reality with spacetime is like guessing someone's actual size from their image in a funhouse mirror.

"… 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."[1]

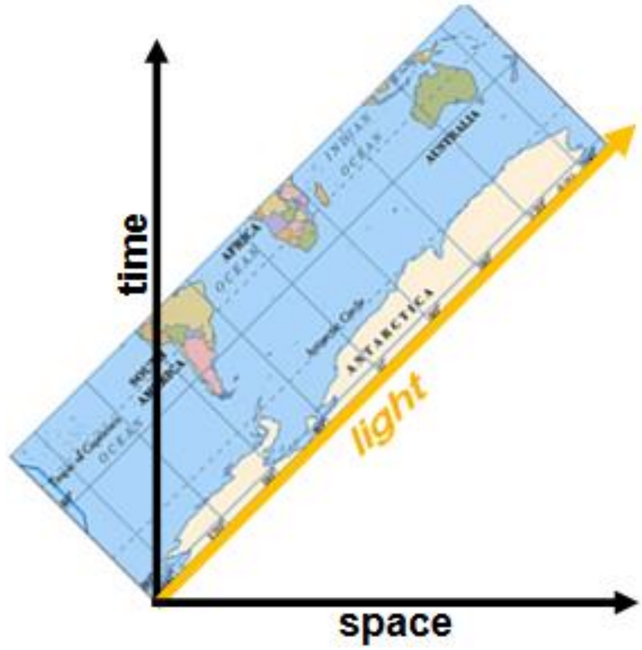


Fig. 2 Reality is difficult to interpret from distorted maps. Left: A curved mirror distorts a person's size. [2] Right: A Mercator projection makes a *single* geographic point (the south pole) seem as long as the equator. Similarly, Minkowski spacetime makes a lightlike interval of *zero* magnitude seem indefinitely long.

Any mismatch between the geometry of a region and the geometry of its map means distortion. Thus, less distortion indicates a better structural match. Is there a better way to map our continuum?

One approach is based on its limits. Special Relativity postulates universal speed limit c. Valued as one in natural units, it is the slope of a light ray in spacetime, corresponding to full time dilation. In other words, aging stops at speed c. Conversely, in any given reference frame, aging is maximal at rest.

"A photon arriving in our eye from a distant star will not have aged, despite having (from our perspective) spent years in its passage."[3]

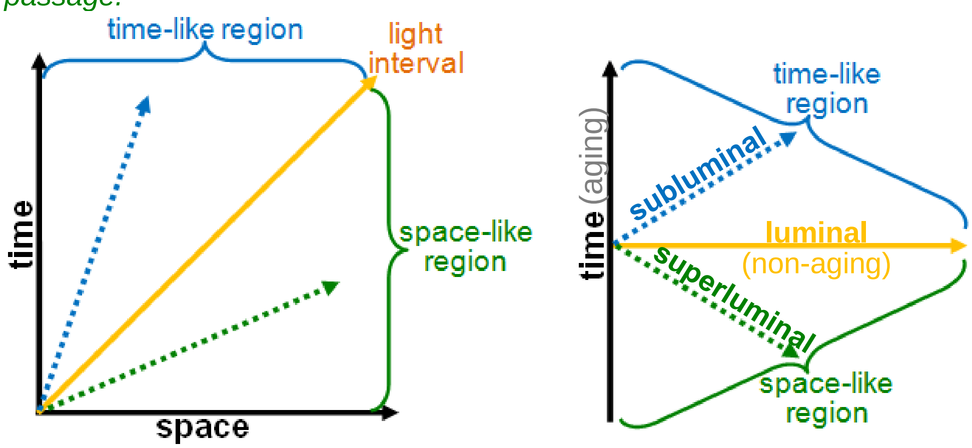


Fig. 3 Corresponding regions mapped on spacetime (left) and with non-aging light perpendicular to the vertical coordinate (right). Relativity prohibits superluminal speeds as they would be retro-temporal.

Thus, one coordinate might correspond to maximum aging at minimum speed and the others with minimum aging at maximum speed (Fig. 3). Light would thus be geometrically independent of aging. But where would space be in such coordinates? Since both aging masses and non-aging light travel to the same future, such a simultaneity would bridge the coordinates. Adapting the balloon analogy of the expanding cosmos, the surface is a spatial 3-sphere and time becomes a 4-field, emanating from the Big Bang event (Fig. 4). The radius of such a simultaneity relates to its cosmic age.

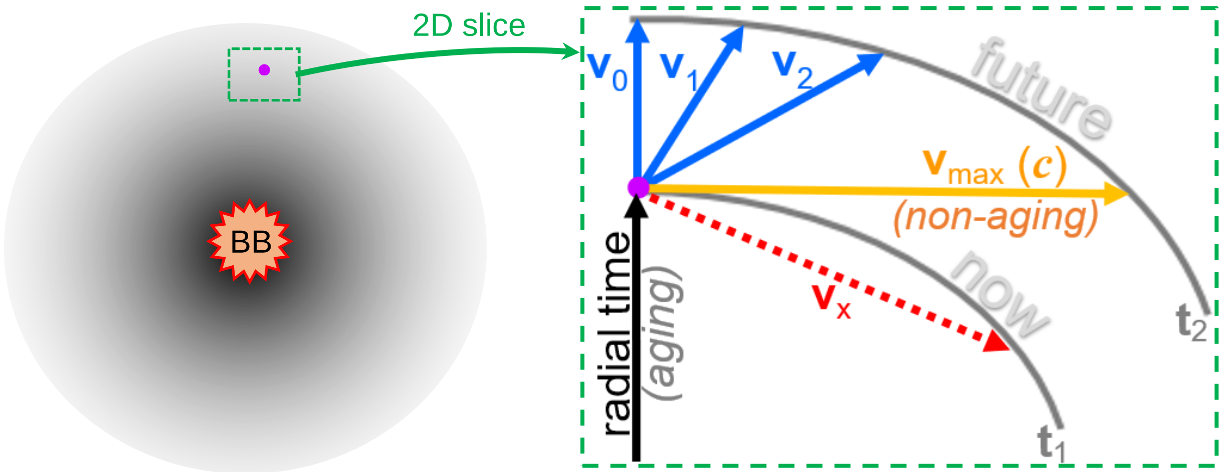


Fig. 4 Left: A 4D temporal field about a central, Big Bang event (BB) is enclosed at any radius by a spatial 3-sphere representing a simultaneity at rest with respect to the BB and cosmic background. Right: From any other event in this curved-space, radial-time model, independent (aging & non-aging) paths to the future may serve as coordinates. V_x is prohibited as it violates the unidirectionality of time.

Allowing time to be *fundamentally* unidirectional, speed limit ***c*** is *universal* because it arises from the underlying structure of the universe, *tangent to space* in every direction at every location. However, a qualitative rationale does not legitimize new geometric coordinates; mathematical justification does…

Contact Sport

Pythagoras's Theorem applies uniquely to Euclidean geometry. The interval formula: $\Delta \mathbf{d}^2 = \Delta \mathbf{x}^2 - \Delta \mathbf{t}^2$ accommodates this by rearranging to: $\Delta \mathbf{x}^2 = \Delta \mathbf{d}^2 + \Delta \mathbf{t}^2$, which implies interval-time coordinates. While light is at rest (interval rest) in such a frame, it retains its direction as a "null vector" perpendicular to time.

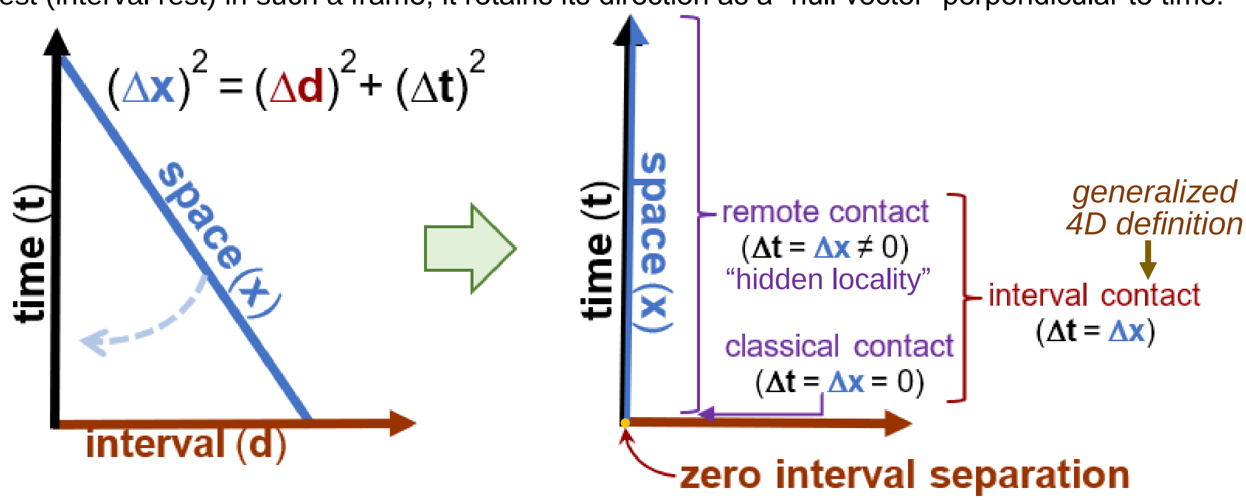


Fig. 5 Left: As magnitude $\Delta \mathbf{x}$ approaches that of $\Delta \mathbf{t}$, interval $\Delta \mathbf{d}$ shrinks. Right: In the lightlike limit ($\Delta \mathbf{x} = \Delta \mathbf{t}$), direct interval contact ($\Delta \mathbf{d} = 0$) occurs, *bypassing* space (shown locally flat) and time of *any* extent.

"…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."[4]

In 4D, *all contact is interval contact* ($\Delta \mathbf{d} = 0$), with classical contact a minor subset. This is consistent with the Standard model in that particles rarely collide spatially ($\Delta \mathbf{x} = 0$), being prevented by orbitals, the Pauli exclusion principle or insurmountable electrical repulsion. Rare exceptions include annihilation, reverse β decay and neutrino detection. The vast majority of contact is spatially remote, "hidden locality".

It's no coincidence that speed c and a single point of contact are both invariant. From this perspective, c is an *absolute* speed limit because contact is an *absolute* proximity limit. Nothing is closer than contact.

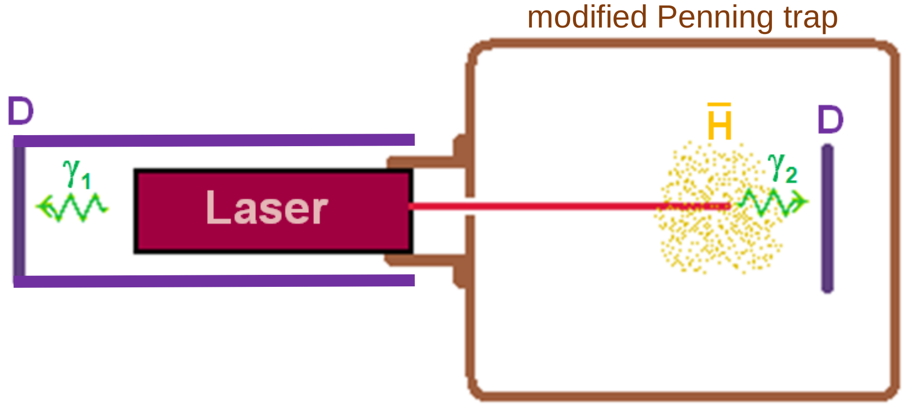
What then becomes of photons? Through the Euclidean lens of interval-time coordinates, light quanta are seen to spend zero time crossing zero interval path. There's no room for, nor need of, a light particle. Einstein could have explained the photoelectric effect just as well by *direct physical contact*. Instead of photons, light transmission via pinhole (particle-interaction wormhole), *bypasses* space and time of any extent (Fig. 5). These would clearly not be gravitationally induced wormholes, instead being akin to the variety envisioned by John Wheeler.

"Wheeler…has novel geometries…One such geometry consists of a space full of wormholes. Such holes are ultra-tiny."[5]

But the photon model has enjoyed over a century of *extraordinary* success so, the experimental evidence required to justify a transition to pinholes must be *at least* as extraordinary.

c-ing is Believing

For more than two decades, the ALPHA collaboration[6] at CERN, in friendly competition with ATRAP[7], has labored to produce, isolate and characterize antihydrogen (anti-H). Having succeeded in matching its inertial[8] and gravitational mass[9] to that of ordinary hydrogen, ALPHA has more recently been pursuing the anti-H spectrum. Ordinary exchange of light quanta between electrons cannot distinguish between an intermediary photon or direct physical contact via pinhole. However, contact between an emitting *electron* and an absorbing *positron* predicts annihilation of both despite being spatially remote!



γ_1 precedes γ_2 by $\Delta\mathbf{t}$ = (spatial separation)/c

Fig. 6 Lightlike interval contact between electron and positron would result in their *remote annihilation*. If gamma detector (D) *inside* the trap is infeasible, it is all the more important to place one around the light emitter *outside* the trap (left).

ALPHA has already published results for the 1S-2S absorption of anti-H[10], verifying the same wavelength as for ordinary hydrogen. However, this results from of two coincident, oppositely-directed light quanta. But since annihilation is strictly quantized 1:1, it would not be expected from *dual* photon absorption. A positron never annihilates with two different *half* electrons.

ALPHA also published findings on the 1S-2P Lyman-α absorption.[11] While this involves the required *single* light quantum, ALPHA reports[12] that thick magnet coils prevent gamma emissions characteristic of positron annihilation ($\approx$ 511 keV) from leaving the trap. Thus, ALPHA should position gamma detectors around the emitting electrons outside the trap. If remote photo-annihilation occurs, the emitting electron would be lost first. Subsequent positron annihilation within the trap, leaves an anti-proton adrift to annihilate with the chamber wall. Those higher energy gamma emissions are recorded by ALPHA vertex detectors. Thus, a strong correlation should exist between emissions (γ_1) from the light source and subsequent proton-antiproton emissions from the trap.

Showing the Way

Interval-time coordinates are a qualitatively and quantitatively justified Euclidean lens, offering a new, clearer perspective. This lens provides our first view of a light path *undistorted*, as a single point of contact in 4D, obviating photons.

"In other words, the spacetime interval between two events on the world line of something moving at the speed of light is zero."[13]

"Where light goes from a given point is always separated from it by a zero interval"[14]

The invariance of interval coordinates makes them, if anything, more "real" than conventional spatial coordinates because they are agreed by all observers. That the universe has a finite, universal and constant speed limit c is explained by both the zero-magnitude proximity limit and the direction (tangent to curved space) of light's 4-vector.

"…to state that the propagation speed of light is invariant is the same as saying that the interval is zero."[14]

The invariance of is also apparent as its vector remains tangent in all reference frames, as increasing speed draws any future simultaneity ever closer (Fig. 7).

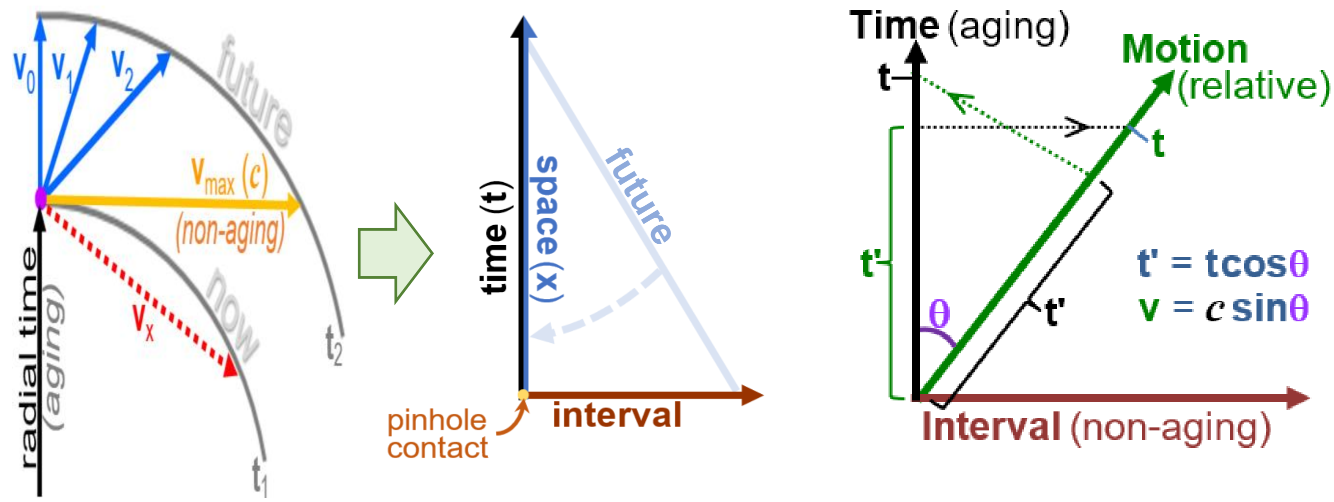


Fig. 7 Left: Compared to Fig. 4, the cosmos shrinks in the direction of motion, but light's path is always tangent to the space of its emitter. Center: At c, pinhole contact with the future. Right: Inertial clocks run mutually slow. With Euclidean coordinates $\cos\theta = \sqrt{(1 - v^2)}$, which simplifies common expressions.

A Euclidean lens has revealed an opportunity for ALPHA to literally *shed light* on the possibility of pinholes. At speed c, emitter and absorber make contact and the predicted photo-annihilation should be experimentally verifiable. *Remote* contact may seem a *remote* possibility, but it is no more preposterous to test it than it was to learn if antihydrogen "falls up" gravitationally.

There remain many other mysteries upon which this lens may be trained for an unprecedented view. We should be as prepared for what we see as Galileo was with his telescope.

1] W. Rindler Special Relativity Special, General and Cosmological ISBN-10: 0198508360, 2001 p.90
2] fun house mirror photo (adapted)
3] Spacetime Interval Wikipedia, 2019
4] R. Feynman Perfectly Reasonable Deviations from the Beaten Track ISBN-10: 9780465023714, 2005 p.432
5] E Taylor, J. Wheeler, Spacetime Physics ASIN: B0000CNCLY,1963 p.37-38
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8] C. Amole, et.al. Nature **483**: 439–443, 2012
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