

Velocity Time Dilation and Spacetime Frame Dragging

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Abstract

This paper explores the ramifications of non-particulate vacuum energy as the medium in which electromagnetic and gravitational waves propagate. This has been explored in the past and rejected based on experimental data, but recent discoveries have added credence to the possibility that the experiment's conclusions could have been inaccurate. The Michelson-Morley Experiment found a null result ruling out the possibility of Earth traveling through a light-propagating medium. However, with Inflation Theory posing that spacetime flowed out faster than light could travel, then we have to consider that spacetime can flow. With the evidence that the Gravity B probe provided about frame dragging, there is the possibility that spacetime is dragged with the Earth. This then allows us to explore how a spacetime medium can affect velocity time dilation and the ramifications of how a dynamic spacetime medium may behave.

Keywords: Michelson-Morley, Velocity Time Dilation, Reference Frames, Speed of Light, Lorentz Invariance.

Introduction:

This paper is a part of a collection. The previous paper, *Quantum Fluctuations as the Substrate of Spacetime*, posited that the universe is built from a Fundamental Energy Field (FEF) from which stable patterns, analogous to Chladni figures¹ or phase transitions, emerge as matter reaches specific energy thresholds ($E = mc^2$).² The previous paper explored gravitational time dilation^{3,4} which will not be integrated here. It looked at how non-particulate vacuum energy³ would contribute to the stress-energy tensor,^{3,4} therefore being a candidate for Dark Matter³ as well as exploring the possible conditions for the Big Bang³ / Big Bounce⁵ from the FEF perspective. It looked at how gravitational time dilation over the entire universe would be an ever changing system affecting the rate of cause and effect differently everywhere and everywhen. The previous paper also established a key conceptual tool, the Stable Frame of Reference (SFR), defined by *Heat Death*⁵ conditions and the CMB.³ The important part of the previous paper is that it touched on the idea that there is no such thing as Lorentz Invariance³ due to any changes detected being a result of spacetime no longer acting as a flat manifold at rest, meaning the different results are from two separate frames of reference and need Lorentz transformations to adjust the readings to appear flat again. This will be explored in more detail in this paper, as well as re-examining relativistic phenomena with invariant proper lengths. This work derives a novel pure velocity time dilation factor,

$$\gamma_v = \frac{(\gamma_\perp^2 + 2\gamma_\perp)}{3}$$

where γ_v represents the total time dilation under purely the effects of velocity and

$$\gamma_\perp = \frac{1}{\sqrt{1 - (v/c)^2}}$$

where γ_{\perp} is the standard Lorentz factor,⁶ representing the time dilation calculated for a perpendicular reading. You can think of γ_v as the average velocity time dilation due to the cosmic coordinates of the distance which waves have to propagate in all 3 axes, and γ_{\perp} as the perpendicular velocity dilation along null geodesics. Gravitational time dilation, and velocity induced time dilation γ_{ξ} (which acts like gravitational time dilation) will be added to create a unified time dilation equation in a separate paper titled *A Unified Model for Gravitational and Velocity Time Dilation*. This γ_v is proposed to arise from an averaging of how intrinsic two-way Cause-and-Effect Events (CEEs) are kinematically affected along different spatial axes relative to motion. A significant prediction of this framework, which rejects intrinsic meter length contraction, is that an observer moving relative to the SFR will measure the speed of light c anisotropically using invariant rods. This could be thought of as the propagation amount being stretched to more or fewer meters, while the physical meters remain the same. At this stage, the effects of frame dragging have not been included into this equation since that math is complex.

Einstein was driven by the paradox: “If I pursue a beam of light with the velocity c (velocity of light in a vacuum), I should observe such a beam of light as an electromagnetic field at rest though spatially oscillating. There seems to be no such thing, however, neither on the basis of experience nor according to Maxwell's equations.”⁷ This led him to develop special relativity. This paper accepts both. Since if matter were to reach the speed of light, then the cause and effect transfer of information would never transfer in a forward direction, therefore the laws of physics would stop since the cause could no longer trigger the effect. This does not mean the laws of physics break. They are merely paused, since the moment the matter slows, then the cause can eventually trigger the effect. It may take trillions of years if the percentage of c is high enough, but the process is again in motion. A simple way to put it is that the processes in your brain will be slowed just as much as the light traveling between two mirrors so you will witness the speed of light as the value of c . However, there are nuances that need to be explored.

In standard physics, all observation is relative; there is no privileged *outside* viewpoint.⁶ This can lead to interpretations that, while mathematically consistent within a given local frame, may not always align with a straightforward understanding of physical reality from a more encompassing viewpoint. For instance, the length contraction predicted for a relativistic spaceship^{3,8,9} doesn't imply that the vast distances between stars physically shrink for stationary observers. This paper, therefore, explores a conceptual model that uses the SFR: an unchanging, absolute observational standpoint, notionally existing outside our universe. This SFR is analogous to the master clock and immutable coordinate grid of a supercomputer simulating a universe, providing a fixed benchmark. From this SFR perspective, this work re-examines velocity time dilation and the possibility of spacetime volumes moving relative to the SFR. The goal is to present an alternative cosmological framework that remains logically consistent with observed physics yet offers fresh insights. In what follows, the work outlines the key concepts of this hypothesis and concludes by discussing potential avenues to test or distinguish this view from standard cosmology.

For the purpose of this discussion, this paper will focus on actual clock rate differences, termed *Instant Observed Time*, as opposed to dealing with the complexities of light-signal travel time (*Light Observed Time*). This is discussed later in: Light Observed Time versus Instant Observed Time (Actual Clock Rates).

The Stable Frame of Reference (SFR)

This paper hypothesizes the existence of a Stable Frame of Reference (SFR): a conceptual, absolute viewpoint external to any particular universe, from which cosmic phenomena can be observed and measured with invariant standards of time and distance. For conceptual consistency, the SFR is specifically defined as corresponding to the conditions of the universe's hypothetical Heat Death, the state of maximum entropy and minimum possible energy field density.^{1,5} While the Heat Death SFR is a theoretical ideal, the Cosmic Microwave Background (CMB) provides a practical, observable proxy for a cosmic rest frame to a certain approximation.ⁱⁱ¹⁰ This state represents the theoretical baseline where time is considered to flow at its fastest possible intrinsic rate. Earth experiences minimal time dilation relative to this SFR (as its velocity relative to the CMB is non-relativistic, $\approx 0.12\%c$), but this baseline remains essential for theoretical accuracy. This is confirmed by using the Lorentz time dilation formula⁶ for our velocity ($\approx 370\text{km/s}$) relative to the CMB¹⁰ and the Gravitational red-shift (Schwarzschild) time-dilation formula for gravity.^{4,11,12} This assumes a static spacetime model. However, until we know if the spacetime we are in is flowing relative to the CMB and how much so (for instance, with FEF entrainment), we won't get definitive velocity time dilation results.

The introduction of an SFR is not intended to invalidate the Principle of Relativity within the domain of local measurements, but rather to serve as a conceptual, absolute benchmark for comparing physical states across different relativistic environments. The CMB rest frame already provides a cosmologically preferred frame against which peculiar velocities are measured. The SFR is a theoretical idealization of this concept, defined by fundamental physical conditions (maximum entropy). This work explores the hypothesis that the observed relativistic effects, such as time dilation (and potentially length contraction), can be derived as physical consequences of an object's interaction with an underlying energy field, as viewed from this benchmark frame. This approach does not seek to replace the mathematical framework of SR, but to investigate a deeper physical reality that could give rise to it, asking what an FEF spacetime does, rather than simply what its geometric properties are.

Within our universe, Einstein's relativity accurately describes physics from the perspective of observers co-moving with their local environment. It tells us there is no empirically detectable absolute frame of rest outside of local frames of reference.^{3,6} However, from the hypothesized SFR's external vantage, the inherent variability of clocks and measurement standards within the universe becomes apparent. The rate at which any local clock ticks is subject to its total time dilation (Γ), which depends on the local energy field density (analogous to gravity) and the clock's velocity relative to that field. As the universe evolves, or as a clock moves through different environments (like Earth's varying velocity through the solar system and around the galaxy, and gravitational potential within the galaxy),¹³ its clock rate relative to the SFR baseline fluctuates. Without a stable, external clock for comparison, precisely determining the *true* speed of objects or the absolute rate of cosmic evolution becomes challenging, as our internal measuring instruments (rulers due to velocity length contraction, and clocks) are themselves subject to these varying conditions.^{3,8,9}

The SFR provides an unchanging benchmark, an imagined objective backdrop with a fixed meter-stick and a clock ticking at the universe's fastest possible rate. It serves as a consistent standard against which to compare different states of our universe's evolution or even different hypothetical universes. Utilizing the SFR allows us to pose unique questions about cosmic processes and potentially reveal subtle effects or alternative interpretations that are not evident from within any single, relative inertial frame. It offers an absolute yardstick to analyze the constant evolution of time rates across the universe's history and different regions.

This paper focuses exclusively on the velocity aspects of the SFR. Gravitational time dilation is not included in this paper.

The Michelson-Morley Experiment and the Concept of Field Entrainment

A significant historical challenge to any theory positing a preferred frame of reference, such as the SFR proposed herein and positing spacetime as a medium which waves propagate through, is the null result of the Michelson-Morley experiment (MME).^{9,14,15} The MME, utilizing an interferometer, aimed to detect Earth's motion through the hypothesized luminiferous ether (aether) by measuring differences in the round-trip speed of light along perpendicular arms. If Earth moved through a static ether, rotation of the apparatus was expected to produce a shift in interference fringes due to varying effective path lengths for light. The consistent failure to observe such a shift was a cornerstone for the development of Special Relativity (SR), which resolved the issue by postulating the constancy of the speed of light in all inertial frames and deriving length contraction.^{6,9} It should be noted that the MME paper states, "It is obvious from what has gone before that it would be hopeless to attempt to solve the question of the motion of the solar system by observations of optical phenomena at the surface of the Earth. But it is not impossible that at even moderate distances above the level of the sea, at the top of an isolated mountain peak, for instance, the relative motion might be perceptible in an apparatus like that used in these experiments."¹⁵ This implies they may have also considered the effect to be increased to noticeable levels with altitude. However, the $1/r^3$ reduction in frame dragging makes a mountain-top detection highly unlikely.

This paper's hypothesis doesn't say that SR is wrong. It's a part of the overall understanding, and from a different perspective. A more complete picture incorporating current observed phenomena like frame dragging (also known as the Lense-Thirring effect)^{3,15-19} and Casimir effect,²⁰⁻²⁷ can lead to a more complete understanding of all the effects that lead to SR being so accurate and why. Fundamentally, at low relativistic speeds, there is no change to the established physics; however, that may not hold true for high relativistic speeds. Factoring in frame dragging is addressed later.

This paper proposes an alternative interpretation consistent with an SFR, drawing upon the established, though distinct, phenomenon of frame dragging. Frame dragging demonstrates that massive, rotating bodies can *drag* spacetime (or the FEF) along with them. This effect is distance-dependent, strongest near the massive body ($1/r^3$ fall-off of frame-dragging).^{18,19} This hypothesis is that a similar, though not identical, phenomenon of field entrainment or co-movement occurs due to an object's linear velocity through the fundamental energy field, particularly at non-relativistic speeds. It is proposed that for an object like Earth, moving at its relatively low cosmic velocity through the FEF, the field in its immediate vicinity (e.g., at Earth's surface) is substantially, perhaps almost completely, entrained or dragged along with the planet.

Fundamentally, an atom traversing a specific cubic meter of spacetime should interact with that cubic meter the same way regardless of whether its trajectory is straight or negligibly curved. The prominence of rotational frame dragging (Lense-Thirring) is likely due to the cumulative effect, where a rotating mass acts upon the same volume of spacetime repeatedly, winding it into a vortex. In contrast, linear entrainment is transient meaning the mass passes through a volume and moves on before a massive current can be established. However, the entrainment bubble around the mass itself (the field gravitationally bound to the matter), should remain dragged in both scenarios but at different amounts. Additionally, if you crush all the mass of the Earth except for 1 continental plate, into a black hole and stop it rotating, then the orbiting continental plate should still drag spacetime, however at a way smaller rate, proportional to its mass relative to the mass of Earth. This black hole with a continent orbiting is analogous to the sun with Earth orbiting.

Conceptually, this implies Earth could be in a natural "Warp Bubble," where the planet is inside a volume of spacetime that orbits the Sun with us. Imagine a ball of tightly scrunched-up fly screen wire traveling in a 1-meter diameter circle within a room of still air, at one revolution per hour. There would be slightly increased air pressure at the front (discussed later), but the drag means the air within the ball practically moves with it rather than passing unhindered straight through.

If the MME apparatus is thus situated within a bubble of this co-moving energy field, it would experience no significant *ether wind* relative to its own motion. Consequently, it would naturally yield a null result. The *ether wind* it seeks to measure is effectively stationary with respect to the laboratory due to this local entrainment.

This concept of velocity-induced field entrainment, particularly its efficiency at different velocities and its potential to locally modify field density (thus creating a form of velocity-dependent time dilation which acts like gravitational time dilation γ_ξ), is complex.

- At low velocities (like Earth's), this work posits that this entrainment is highly efficient, providing a mechanism for the MME null result within an SFR framework without requiring intrinsic length contraction of the apparatus itself. The primary time dilation experienced by Earth due to its motion in this scenario might then be attributed to the subtle effects of this entrainment process on the local field density (the bunching of field energy as it passes through the mass, creating a higher pressure due to the mass's frame-dragging effects). A slightly higher front pressure would induce more gravitational time dilation as an Induced Gravitational Dilation (γ_ξ , discussed more later), than a lower rear pressure, however this difference would be negligible.
- For objects moving at significant relativistic velocities (v approaching c) relative to the large-scale FEF, it is hypothesized that this entrainment effect becomes progressively inefficient (the field energy passes through the mass before the mass can sufficiently drag the field energy up to its own velocity). The object would then be traversing a field that is largely *not* co-moving with it.
- The mass of the object should also be considered. A satellite, for example, will have next to no drag compared to the mass of the Earth. However, to escape Earth's own entrainment bubble (which falls off as $1/r^3$), the experiment should be conducted in Medium Earth Orbit (approx. 20,000 km) or higher, where the entrainment effect drops to less than 2%, rather than Low Earth Orbit (ISS) where the effect remains dominant ($\approx 80\%$). In this sense, spacetime flow may be detected if a satellite in deep space were to be stationary relative to the CMB yet experience velocity effects due to flowing spacetime.

This paper will focus on the scenario where an object's velocity v is relative to this ambient, largely unentrained, SFR field. This represents the high v limit or situations where local field entrainment by the object itself is negligible compared to other effects.

A more comprehensive model incorporating the physics of velocity-dependent field entrainment and its impact on local field density ($\gamma_\xi(v)$) is a crucial area for future research and will be discussed further in that context. For the following formulas, γ_ξ will not be included in the equations, but it will be included in a subsequent paper where

The Nature of Spacetime: A Fundamental Energy Field

The previous paper reinterprets spacetime as a dynamic, universal energy field rather than a passive geometric structure. It suggests that spacetime emerges from the combined effects of all matter, particles, and vacuum energy.^{20,28} It's like a vast ocean filled with interacting energy waves. Occasionally, these fluctuations align to create powerful local concentrations of energy, manifesting through $E=mc^2$,^{2,3,23} as particle-antiparticle pairs within the quantum foam.²⁸ Although the average vacuum energy appears small on a cosmic scale,^{14,20,22,29} the model proposes that locally, spacetime is highly energetic and continuously active at the quantum level.

For the purpose of this paper, we will view this non-particulate vacuum energy as the medium in which waves travel through before condensing into a freak wave particle when the wave function collapses. We are not suggesting that the wave energy moves faster than the speed of light to collapse into a single point, but taking a theoretical stance that the more you focus the wave energy into a detectable path, the more you build that energy into a single particle point.

As with Einstein's thought experiment of chasing light at the same speed, seeing a wave as stationary but oscillating in spacetime, this paper imagines non-particulate vacuum energy as the medium that light propagates through. For discussing velocity time dilation, this paper will assume the medium to be flat and constant.

1. Field Structure and Propagation:

Constant Propagation Rate through Field *Quantity*: A central tenet is that Cause-and-Effect Events (CEEs), traverse a fixed *quantity* or *amount* of this field energy per unit of SFR time. Again, not intrinsically distinct entities, but an easier way to visualise. This intrinsic propagation rate through the FEF itself is constant from the SFR perspective, regardless of how compressed or rarified that field energy might be over a given SFR-measured distance. The speed of light propagates through the field medium at c , but the propagation distance may not equal physical meters relative to the observer.

2. Velocity Effects as an Extension of Field Interaction:

The concept of traversing a *quantity* of field energy per SFR-second also extends to objects moving with velocity v through the field. It should be noted that frame dragging may mean that the field energy is co-moving at the same rate as objects at low velocities. However, for this exploration, frame dragging is taken out of the equation.

Analogy of Aircraft in Air: An aircraft at full throttle achieves a slower ground speed through dense sea-level air compared to thin high-altitude air, as the jet can only traverse through so many air atoms and molecules per second.

Similarly, if an atom moves at velocity v through the FEF, an internal CEE attempting to propagate a certain proper distance L_0 (within the atom in its direction of motion), must effectively traverse not only the field energy associated with L_0 but also the additional FEF the atom sweeps through due to its velocity v during that CEE's propagation time.

This means that from the SFR perspective, both high field density and high velocity (relative to the field) contribute to slowing down the rate of internal CEE processes within an object. This leads to time dilation from both causes. Photons themselves, as CEEs, are subject to the field density, but their *local measurement as c* is preserved because the observer's own causal processes (and thus their clock) are effectively equally affected by the total effective field interaction (density plus velocity effects).

This framework blurs the line between *space expanding* (like Dark Flow)^{30,31} and *objects changing* (like chemical reactions); both are viewed as manifestations of evolving field conditions. The quantitative factor describing the static field density effect (equivalent to gravitational time dilation) and how it combines with velocity effects (γ_v) to yield a total time dilation (Γ), will be developed in a subsequent paper.

Time Dilation: Standard Effects and the SFR Perspective

The previous paper argues that treating all frames of reference as equally correct creates logical contradictions when comparing time measurements. For instance, due to velocity, GPS satellite clocks slow down by about 7 microseconds per day (though weaker gravity speeds them up by 45 microseconds, masking the effect).^{16,32} Although the satellite won't notice its clock running faster, upon reunion, the satellite's clock is demonstrably faster. The ISS is the reverse due to higher velocity and higher gravity proximity, so it runs demonstrably slower. In the Hafele-Keating experiment, atomic clocks on aircraft showed measurable time loss due to velocity.¹³ It is therefore unreasonable to claim that both are equally "correct" or that the universe itself changes because of the satellite's motion. In knowing one is experiencing velocity and gravitation changes, one can infer that their clock is actually running slow or fast, even if it appears perfectly normal. An SFR would allow the actual changes to be plotted through time accurately, rather than using one clock that's changing all the time to record changes in another clock that's also constantly changing. Granted, an Earth clock is stable almost to the point of negligible changes, however, the changes are real and worth considering for the sake of accuracy.

Velocity Time Dilation

This model proposes an understanding of time dilation, stemming from the influence of an object's velocity (v) through that field, as observed from the SFR. The core hypothesis is that the fundamental *clock rate* of an object or physical process, and thus its total velocity time dilation (γ_v), is determined by an average of how intrinsic two-way Cause-and-Effect Event (CEE) propagations are kinematically affected along different spatial dimensions relative to its motion.

In an atomic clock, the measured *oscillation* is the quantum phase evolution between two internal energy states of the atom, not a physical vibration confined to a single spatial axis. In practice, experimenters define a quantization axis using a static magnetic field (e.g., in lattice clocks, a bias magnetic field sets the axis to align laser polarization for spectroscopy),^{33,34} and measure the transition along that axis for clarity and control. However, this does not mean the underlying quantum information transfer is restricted to that direction. In the absence of external fields, atomic states such as s-orbitals are isotropic, and the quantum evolution is inherently symmetric, with no preferred orientation (ground-state S orbitals are spherically symmetric and have uniform probability distributions).³⁵ Because quantum behavior is fundamentally governed by probability, and probability does not favor one axis over another unless an external force breaks the symmetry, the most physically faithful description is to view the process as occurring equally in all directions, with the single-axis measurement representing just one projection of an underlying, direction-averaged reality. In simpler terms, quantum information does not have a fixed, singular path it follows each time, but instead spreads and interacts in all directions without repeating the same axis over time.

To intuitively grasp how both local field conditions and relative motion impact the flow of time and the propagation of interactions from the SFR perspective, an analogy can be employed based on a 'light clock' concept.⁹ Imagine fundamental processes within an object are akin to a Cause-and-Effect Event (CEE), like a light pulse or a messenger, completing a round trip over a characteristic internal distance. Two primary orientations are considered for such a trip within a conceptual 'train': one parallel to its direction of motion (e.g., from caboose along the track to engine and back) and one perpendicular (e.g., from the train's center on the ground to a sidecar and back).

The 'messengers' in this analogy always exert the same 'effort' and the same number of steps per second (analogous to CEEs having an intrinsic propagation rate through the field medium).

- **Pure Velocity Effect (contributing to γ_v):** Consider the train moving at velocity v (pushed by other runners, on clear tracks). Currently, this is also not including the effects of frame dragging or gravitational fields.
 - The messenger running from the caboose (*alongside the train on the ground*) to the engine must cover an actual distance greater than the train's length because the engine is receding. The return trip to the caboose is shorter as the caboose approaches. The total round-trip time is longer than if the train were stationary.
 - The messenger running from the train's center to the sidecar and back must also cover a longer diagonal path (again, running on the ground alongside) because the train moves forward during their perpendicular journey. This round trip also takes longer than if the train were stationary.

Crucially, as this paper aims to show, the SFR-observed increase in time (and CEE path length) due to velocity v is different for the parallel journey compared to the perpendicular journey. The following model for total pure velocity time dilation (γ_v) will build upon these kinematical effects, proposing that an object's intrinsic clock rate is an average of how such two-way CEEs are affected across all spatial dimensions. An atomic clock^{16,32} has quantum information (CEEs) passing through it in the same way the laser pulses travel. Chemical reactions also rely on this quantum information, CEE speed. A toy model can easily be created to visualize this process in a velocity simulation.ⁱⁱⁱ

Core Concepts and Symbols:

1. Velocity of an Object (v):

- Symbol: v
- Meaning: The velocity of an object relative to the local energy field structure, as measured by an SFR observer. For now, we are assuming flat spacetime and no frame dragging or flow of spacetime.

2. Fundamental CEE Propagation Speed (c):

- Symbol: c
- Meaning: The constant propagation speed of Cause-and-Effect Events (CEEs, including light) in the SFR under minimal field density conditions (flat non-flowing spacetime). This is equivalent to the speed of light, $c \approx 299,792,458$ m/s, measured locally by any observer in their own frame by definition.³⁶

3. Perpendicular Kinematic Velocity Factor (γ_{\perp}):

- Symbol: γ_{\perp} (gamma-perp)
- **Meaning:** A dimensionless factor that arises from analyzing the kinematics of a two-way CEE process (like a light clock) oriented *perpendicular* to the direction of motion v , as observed from the SFR. It accounts for the increased path length of the CEE due to the object's motion relative to the local SFR-observed CEE speed.
- **Formula:**

$$\gamma_{\perp} = \frac{1}{\sqrt{1-(v/c)^2}}$$

Note: This factor is the Special Relativistic Lorentz factor ‘time-stretch factor’,⁹ but here γ_{\perp} is used so we can separate it from the values aligned with the direction of motion.

4. Averaged Pure Velocity Dilation Factor (γ_v):

- **Symbol:** γ_v

Meaning: The overall time dilation component due purely to velocity v . It is derived by averaging the kinematic dilation effects experienced by two-way CEE processes along three orthogonal spatial dimensions within the moving object (one parallel to v , two perpendicular). The parallel effect is γ_{\parallel}^2 and the perpendicular effect is γ_{\perp} .

These individual directional dilation effects (γ_{\perp} and γ_{\parallel}^2 , where γ_{\perp} is the Lorentz-like factor defined above) are derived from standard relativistic kinematic analysis of two-way light paths as viewed from the SFR.⁹ (*Note: This is because of the conclusion that the direction that quantum information travels in an atom is, on average in all directions equally, otherwise, atoms would age differently based on their orientation. This is consistent with standard physics^{33,34}*).

Formula:

$$\gamma_v = \frac{(\gamma_{\perp}^2 + 2\gamma_{\parallel})}{3}$$

Derivation of the Pure Velocity Time Dilation Component (γ_v):

To determine how velocity v (relative to the field it’s traveling through) affects an object's internal clock rate, we consider fundamental two-way CEE processes (analogous to a light clock of proper length L_0) within the object, as observed from the SFR.

It is instructive to consider how this velocity-dependent dilation component is formulated. If one were to calculate a pure velocity dilation factor assuming the relevant speed of light c was always the universal constant (as in an idealized flat spacetime without considering background field density effects), the kinematic analysis of two-way CEE paths would yield factors related to the standard Lorentz factor,

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

3,6,9

However, in this model, we are calculating the total time dilation of a light clock when the velocity is constant, and the total distance is different for perpendicular compared to parallel orientation.

- **Perpendicular Two-Way CEE Process:** For a CEE completing a round trip of $2L_0$ perpendicular to the direction of motion v :
 - The SFR-observed time for this round trip is

$$\Delta t_{\perp} = \left(\frac{2L_0}{c} \right) \cdot \gamma_{\perp}$$

- **Parallel Two-Way CEE Process:** For a CEE completing a round trip of $2L_0$ parallel to the direction of motion v :

- The SFR-observed time is

$$\Delta t_{//} = \left(\frac{2L_0}{c} \right) \cdot \gamma_{\perp}^2$$

- The purely velocity-induced dilation factor for this orientation is γ_{\perp}^2 . The parallel time dilation factor corresponds to the square of the perpendicular factor.

Physical objects are three-dimensional, and their intrinsic *clock* mechanisms (atomic oscillations, chemical reaction rates, biological processes) likely depend on CEEs propagating isotropically in their own rest frame. A directional lock for these processes would imply anisotropic aging or function, which is not observed. Therefore, it's propose that the object's pure velocity-dependent time dilation component, γ_v , is an average of these kinematic effects across three spatial dimensions. Where one with greater effect along the direction of motion z axis (experiencing γ_{\perp}^2) and the lesser effect in the perpendicular directions x and y axis, (experiencing γ_{\perp}).

$$\gamma_v = \frac{(\gamma_{\perp}^2 + \gamma_{\perp} + \gamma_{\perp})}{3} = \frac{(\gamma_{\perp}^2 + 2 \cdot \gamma_{\perp})}{3}$$

Therefore, to model the total time dilation experienced by the atom, it is necessary to average the kinematic effects across all spatial dimensions. The arithmetic mean is proposed as the most direct mathematical representation of this underlying isotropic quantum reality, averaged over the three orthogonal axes of the macroscopic experience. This quantifies the average dilation due to velocity.

It is important to remember that the field energy itself may be flowing relative to an object that is considered stationary within the SFR's coordinate system (e.g., due to frame dragging or cosmic flows). For the application of this formula, v is understood as the velocity of the object relative to the immediate local structure or flow of the energy field it is traversing. This ensures the principle of relativity is respected for the interaction: moving the object through a stationary field has the same CEE propagation consequences for its internal processes as the object being stationary and the field energy flowing past it at the same relative velocity.

What This Formula Is Good For & Why We Should Use It:

This velocity formula offers a framework to:

1. **Correctly calculate time-dilation in different velocity frames of reference:** An interferometer traveling through space will have different light velocities for each arm with L_0 because the actual cosmological coordinates for the trajectories are different lengths. At velocity, the angles the light takes through space do not resemble the orthogonal geometry of flat spacetime at rest. If you take a single moment in time, at the instant the light leaves the source, it comes out at an angle, not like how flat spacetime at rest behaves. The geodesics are literally different angles compared to at rest. If you use L_0 instead of cosmological coordinates, you are not using the true distance the light has to travel. In order to get L_0 to accurately calculate c , you have to use the Lorentz transformations to convert the results from the actual distance to the perceived distance of L_0 to make the L_0 appear as a flat spacetime manifold. So, for numerous random CEEs at velocity, that have no alignment, all 3 axes will be affected, and you can correctly calculate the average time-dilation of all those CEEs.

2. **Model Limits on Speed and Reaction Rates:** It inherently shows how γ_v imposes a limit on the rate of internal processes. The closer v gets to c , the more pronounced the slowing of chemical reactions, nuclear decay, or any cause-and-effect sequence within the object. This could be particularly relevant for understanding particle stability or reaction pathways under extreme conditions. Especially in regard to nuclear energy output at relativistic speeds or Ion engines etc.
3. **Investigate Frame Dragging Effects:** While not explicitly detailed here, the concept of a background field (gravitational fields) that can be influenced by mass-energy suggests that if this field itself is *dragged* or set into motion by a rotating massive body, the v term in the formula might need to be considered relative to this moving field, potentially offering a new way to model frame dragging's impact on local clocks, an effect predicted by General Relativity and experimentally confirmed.^{3,17,18} Additionally, the potential for an induced field density, created by velocity, may also impact the equation, similar to how gravitational fields contribute. This formula would allow the exploration of such events where velocity alone may yield some results that don't match observations due to frame dragging, entertainment, and gravitational time dilation.

By providing a mechanism that directly links an object's experienced time to its motion and the state of the local energy field, this formula aims to offer a more fundamental perspective on relativistic phenomena.

How this Framework Interacts with Established Equations

This SFR framework and the associated total velocity time dilation factor (γ_v) are not intended to dismiss or replace established physical equations like $E=mc^2$ or $F=ma$ in their local application. Instead, the framework aims to provide a new lens through which to view these equations comparatively across different relativistic environments, particularly when relating them back to the SFR. The goal is to understand how the *rates* of physical processes or the *manifestation* of energy and momentum differ when observed or accounted for from varying frames of reference, each characterized by its own γ_v .

1. Interpretation, Local Invariance, and Comparative Analysis

It is crucial to emphasize that this SFR framework serves as a comparative tool and does not alter the fundamental principles of local physics:

- **Local Physics Unchanged:** For any observer, the laws of physics retain their standard form within their own local (co-moving, free-falling) reference frame.^{3,6,9} For example, an astronaut on a spaceship will use $E=mc^2$ to calculate energy, $F=ma$ for forces, and will measure the speed of light as c^{21} (in most cases, as this is proposed to progressively skew as v gets closer to c), all using their local measurements of mass, length, time, etc. In general, there is no need to introduce γ_v directly into these local formulations for the astronaut's own calculations, as any such universal scaling factor affecting all components of a physical process would effectively be self-canceling for predictions within standard local frames. This is similar to how Newtonian gravity is still used for general NASA calculations instead of GR.³⁷

- **γ_v as a Descriptor of Relative Proper Time Dilation:** The γ_v factor of a moving clock, as observed from a stationary observer (γ_v' where the ' denotes the states in the moving frame), quantifies how much their local proper time is dilated (slowed) compared to time in the SFR. If $\Delta t'$ (say a second in the moving frame) is a time interval on the astronaut's clock, and Δt is the corresponding interval on an SFR clock, then: $\Delta t = \gamma_v' \cdot \Delta t'$. This means that for every one second ($\Delta t' = 1s$) that elapses on the astronaut's clock, the astronaut would observe γ_v' seconds have elapsed on the SFR clock. Consequently, the SFR observer would see the astronaut's clock accumulates fewer total seconds ($\Delta t' = \Delta t / \gamma_v'$) than an SFR clock over the same underlying event or duration.

2. Comparative Analysis, Example: Energy Expenditure Rate

Consider an astronaut on a spaceship (with total velocity time dilation γ_v' relative to SFR) and, for conceptual comparison, a hypothetical mission controller existing within the SFR (where $\gamma_v = 1$). If the astronaut is moving, then $\gamma_v' > 1$ (astronaut's time is dilated/slower than SFR time).

- **Astronaut's Perspective (Local):** The astronaut's life support system consumes energy. We can use $\Delta E'$ for the energy change measured by the astronaut and $\Delta t'$ for an astronaut-second. P' representing the power measured by the astronaut is at a rate of $P' = \Delta E' / \Delta t'$ (Joules per astronaut-second). This is what their instruments measure and what matters for their local resource management.
- **SFR Perspective (Comparative):** If we want to describe this energy consumption rate in terms of SFR seconds (the SFR observer watching the rate for the astronaut but using the SFR clock), we account for the different rates of time flow. The energy $\Delta E'$ is consumed over the astronaut's proper time $\Delta t'$. This same local duration for the astronaut corresponds to the astronaut observing the elapsed SFR-time of $\Delta t = \gamma_v' \cdot \Delta t'$. So, the power consumption as perceived from the SFR, expressed in terms of SFR seconds, would be:

$$P = \frac{\Delta E'}{\Delta t} = \frac{\Delta E'}{(\gamma_v' \cdot \Delta t')}$$

$$P = \left(\frac{1}{\gamma_v'} \right) \cdot \left(\frac{\Delta E'}{\Delta t'} \right) = \frac{P'}{\gamma_v'}$$

This means that if γ_v' is large (e.g., $\gamma_v' = 2$, meaning the astronaut's time is dilated by a factor of 2), the astronaut is consuming their locally measured power P' at what seems to be a normal rate. From the SFR perspective, this same amount of energy $\Delta E'$ is consumed over γ_v' times as many SFR seconds. Thus, the rate of energy consumption per SFR-second (P) appears *lower* by a factor of γ_v' compared to the astronaut's locally measured rate P' . A process happening at a certain rate in a *slow time* environment (high γ_v) appears to happen at a *slower rate* when time is measured by the faster SFR clock-ticks. So an example may be that Earth may read 2 hours of oxygen left by their clocks, but the astronaut looks at his readings and sees it's only 1 hour left.

This comparative use of γ_v does not change $E = mc^2$ for the astronaut. It's about how a *rate* (which involves time in the denominator), established in one frame with its own proper time, is described or accounted for using the time units of another frame (the SFR) that ticks at a different fundamental rate.

3. Relation to Standard Relativistic Transformations:

For this, both the astronaut and Earth are considered as moving, and we will drop the v to distinguish between the two (γ_A' and γ_E' for the Astronaut and Earth, respectively). The framework aims for consistency. For instance, if the astronaut sends a light signal every second of their time ($\Delta t_A' = 1\text{s}$), an observer in a different inertial frame (say, Earth, with its own velocity time dilation factor γ_E' relative to SFR and depending on entrainment levels) would measure the interval between these signals using the standard relativistic Doppler effect and time dilation transformations^{3,9} that depend on their relative velocity (and any gravitational potential differences which are not included for this paper). The γ_v values for the astronaut and Earth (γ_A' and γ_E') each relate their local proper times back to the common SFR baseline:

$$\Delta t_A = \gamma_A' \cdot \Delta t_A'$$

$$\Delta t_E = \gamma_E' \cdot \Delta t_E'$$

The full transformation of observed frequencies or time intervals between Earth and the astronaut would still involve the complexities of their relative motion and positions within the overall FEF, but the γ_v factors provide a consistent way to normalize local proper time experiences to the SFR.

The key is that γ_v isn't a factor directly inserted into local physical laws, like $E = mc^2$, to alter their form for local calculations. Instead, if E represents an amount of energy involved in a process occurring over a local proper time $\Delta t'$, then γ_v (where $\Delta t = \gamma_v' \cdot \Delta t'$) allows for the comparison of process rates or accumulated times across different γ_v inertial frames from the common SFR perspective.

The comparison of rates then follows:

$$R' = \frac{\Delta Q'}{\Delta t'}$$

where R' is the rate in the moving frame, using the moving frame's own local clock.

$$\Delta t = \gamma_v' \cdot \Delta t'$$

where Δt is how many seconds pass in the rest frame during the same time interval $\Delta t'$ in the moving frame (e.g. how many rest-frame seconds go by while the moving frame's 1 second ticks).

$$R = \frac{\Delta Q'}{\Delta t} = \frac{\Delta Q'}{(\gamma_v' \cdot \Delta t')}$$

where R is the rate as seen from the rest frame, looking at the same quantity $\Delta Q'$ used in the moving frame, but measured by the rest-frame clock Δt .

$$R = \left(\frac{1}{\gamma_v'} \right) \cdot \frac{\Delta Q'}{\Delta t'}$$

where R is the rest-frame rate, equal to the moving-frame rate $R' = \Delta Q' / \Delta t'$ reduced by the time dilation factor $1/\gamma_v'$.

This demonstrates how processes in environments with higher time dilation (larger γ_v) appear to proceed at a reduced rate when measured against the unchanging clock of the SFR.

Interpretation of Length, Time, and Local Light Speed Measurement in the SFR Framework

In this model, the total velocity time dilation (γ_v), derived from an average of how two-way Cause-and-Effect Events (CEEs) are affected along three spatial axes due to an object's motion relative to the local field they are in (not including gravitational time dilation), is considered the primary and fundamental relativistic effect in flat spacetime. This γ_v dictates the rate of all internal physical processes and clocks in flat spacetime. A foundational postulate of this framework is that an object's proper length (L_0), its physical dimension as defined in the SFR, remains invariant irrespective of its velocity. Otherwise, if one considers a universe without observers or photons, a particle moving near c would imply the universe is physically compressed relative to that particle. This leads to the paradox of the universe having multiple physical shapes simultaneously, dependent solely on the existence of a moving entity. Or this effect only exists because photons and observers exist, meaning it's not physical at all and just a photon / observer interaction effect. This perspective, prioritizing invariant length and universal time dilation, leads to distinct interpretations and predictions regarding the local measurement of the speed of light, differing from standard Special Relativity's (SR) reliance on intrinsic length contraction (where the observer's local frame of reference is true and observes the other frame of reference's changed lengths).^{3,6,9}

The imperative for a uniformly experienced time dilation (γ_v) stems from considering the three-dimensional nature of matter. Atoms and the chemical or biological processes they constitute involve information transfer (CEEs) occurring in myriad directions. If time dilation were purely a one-dimensional effect locked to the direction of motion, different parts or processes within an object or organism, oriented differently with respect to v , would experience disparate rates of time flow, leading to internal desynchronization or anisotropic aging. This model posits that the pilot's subjective *master clock* and the rate of all fundamental local processes reflect an average of these multi-directional CEE propagation effects.

Special Relativity, with its postulate that all observers measure the speed of light c isotropically in their own frame,⁶ reconciles the differing SFR-observed kinematics of light clocks (parallel vs. perpendicular to motion) by invoking length contraction along the direction of motion^{3,6,9} (the entire 'virtually at rest' universe sees anything moving close to c as physically shorter, and the fast things looking at the universe see the universe as squashed). This paper proposes an alternative: length (L_0) is invariant (outside of negligible tidal forces) in the SFR, and the consequence of the pilot's universal velocity time dilation (γ_v) is that their *measurement* of c using invariant rods becomes anisotropic.¹⁴ This is because L_0 is not the actual path that the light takes and converting the actual path to L_0 creates inconsistencies, akin to treating two separate inertial frames as the same without using Lorentz transformations.

The departure from Special Relativity's postulate of intrinsic length contraction stems from a pursuit of an alternative interpretation that prioritizes time dilation as the primary, directly observed phenomenon^{12,13} and maintains invariant proper lengths within the SFR. While SR's mathematical framework is predictively powerful, concepts like length contraction, invoked to preserve the local isotropy of c for all inertial observers, can present a conceptual dissonance. This model explores the consequences of positing an absolute SFR and invariant lengths, attributing relativistic effects to a *real* γ_v affecting an observer's clock rate.

This is not about overturning established equations. This is analogous to relative time dilation. If one chooses the moving clock as the standard, then the stationary clocks must be judged as fast. If one chooses the stationary clock as the standard, then the moving clock must be judged as slow. In the relationship $c = d/t$, if c (speed of light) is held constant, d (distance, length) and t (time) must vary. Conversely, if d is held constant, c and t must adjust. Changing the constrained variable shifts the perspective but preserves the mathematical equivalence of the system.

This perspective re-frames classic examples. The extended atmospheric path traversed by high-speed muons is explained by the muon's profound γ_v , which allows it to *live longer* in SFR time to cover the invariant atmospheric depth, rather than the atmosphere contracting in the muon's frame.³⁸ Similarly, a pilot experiencing only 1 second for a ~ 4.37 light-year (SFR distance) journey to Alpha Centauri is understood as their clock being extremely dilated, not the intervening space physically shrinking.

It is crucial to distinguish between an object's physical dimensions and its visual appearance. Relativistic effects like the Terrell-Penrose rotation shows that fast-moving objects appear visually distorted due to light-travel time effects, but this does not necessitate an intrinsic physical contraction.³⁹ This model proposes a clear distinction between such light-based observational effects and the underlying physical reality.

This perspective shares philosophical ground with neo-Lorentzian interpretations,⁴⁰ which also posits a fundamental reality (a preferred frame, like the SFR, with absolute time and lengths) of which local measurements in moving frames are γ_v -affected manifestations. While SR dispenses with a preferred frame by making the relativity of space and time fundamental, this paper investigates the outcomes of reintroducing one as a conceptual anchor.

Consider a light clock experiment on a spaceship of proper length L_0 . From the SFR perspective, a two-way light pulse parallel to motion v takes a total SFR time

$$\Delta t_{\parallel} = \left(\frac{2L_0}{c} \right) \cdot \gamma_{\perp}$$

while a perpendicular pulse takes

$$\Delta t_{\perp} = \left(\frac{2L_0}{c} \right) \cdot \gamma_{\perp}$$

where

$$\gamma_{\perp} = \frac{1}{\sqrt{1 - (v/c)^2}}$$

3,6,9

The pilot's clock, however, is dilated by the fundamental

$$\gamma_v = \frac{(\gamma_{\perp}^2 + 2\gamma_{\perp})}{3}$$

Therefore, the pilot measures:

- For the perpendicular clock:

$$\Delta t'_{\perp} = \frac{\Delta t_{\perp}}{\gamma_v}$$

The speed measured is

$$c'_{\perp} = \frac{2L_0}{\Delta t'_{\perp}} = c \cdot \frac{(\gamma_{\perp} + 2)}{3}$$

- For the parallel clock:

$$\Delta t'_{\parallel} = \frac{\Delta t_{\parallel}}{\gamma_v}$$

The speed measured is

$$c'_{\parallel} = \frac{2L_0}{\Delta t'_{\parallel}} = c \cdot \frac{\left(1 + \frac{2}{\gamma_{\perp}}\right)}{3}$$

These predicted measured speeds are generally not equal to c and differ from each other if $v > 0$ (for $v = 0, \gamma_{\perp} = 1$, and both yield c). Specifically, $c'_{\perp} > c$ and $c'_{\parallel} < c$ when $v > 0$. This anisotropy in the locally measured speed of light, using invariant rods, is a key prediction distinguishing this model from SR. It should be noted that this is only the case if the spacetime is not dragged with the object, where v is relative to the spacetime it's in.

This interpretation avoids concepts like the universe *squashing* to accommodate a traveler's local perception of c . For instance, a journey of 4 light-years (SFR distance rounded down to 4 years) to Alpha Centauri experienced by a pilot in 1 pilot-second is understood not as the distance contracting to 1 light-second, but as the pilot's 1 second being equivalent to 4 SFR-years due to extreme γ_v . It is more probable that the traveler's clock has profoundly slowed relative to the SFR baseline than for SFR-defined cosmic distances to physically deform.²

Experimental Signatures:

The distinct predictions of this framework, particularly regarding anisotropic local light speed measurement and invariant proper lengths, suggest concrete experimental tests. These tests are to discern if length contraction is a consequence of light's behavior under velocity (such as the aberration of light, the headlight effect,^{9,15} and Doppler shifting of light from *external* sources^{6,10,12,16,32,36}), is purely the velocity's effect on light, or if the effects are purely physical, or a combination of both. Several experimental protocols could distinguish between these two interpretations.

For example, LIGO detects gravitational waves by measuring changes in the proper distance between suspended mirrors, which are hung to allow them to shift with the time-like spacetime geodesics,⁴¹ This stands in contrast to the facility's physical structure, which relies on atomic forces to maintain a rigid physical length (resisting the tidal stress). Since the light follows the change in the null geodesic,⁴² while the rigid structure resists it, this implies that spatial metric changes do not inherently force physical length contraction on rigid matter (since gravity is many orders of magnitude weaker than the atomic-scale forces). However, definitive proof distinguishing these mechanisms is arguably absent in the general scientific community (scientists still talk about physical length contraction). Therefore, the proposed experiment includes a dedicated satellite mission (or a land-based version capable of high-velocity acceleration), designed to probe these effects.

Satellite (or land-based device) Design: A land based version would have a vacuum tube that could propel the device at significant speeds along a frictionless track to induce relativistic effects compared to an Earth mounted observer. However, this would be incredibly difficult and therefore, a satellite is potentially more viable. The satellite would be equipped with a central sensor array capable of detecting light from multiple directions and initiating laser pulses. It would also feature 6 extended, rigid arms of precisely known proper length L_0 along three orthogonal axes. These arms would house light emitters at their ends and mirrors designed to reflect a portion of incident light back to the central sensor and another portion towards Earth-based observatories. Multiple synchronized clocks would be distributed for precise event timing. Pulses of light could be sourced from the center, or from the ends of the arms.

- **Light-Based Measurements and SFR Kinematics:**

- **Ground-Based (SFR) Verification of L_0 :** Earth stations, acting as an approximate SFR, could verify the satellite's invariant physical dimensions L_0 while in orbit using triangulation and precise timing of light signals from the satellite's arm-ends. Careful calibration for light propagation effects through Earth's atmosphere and gravitational field might be necessary. In the same way GPS satellites accumulate noticeable errors over a full day^{16,32}, millions of readings for the length contraction experiment would cumulatively show the effects. Alternatively, it could emulate the Michelson-Morley experiment measurements.¹⁵
- **Satellite's Internal c measured Tests:** The satellite's central sensor, its clock governed by γ_v , would record round-trip times for light pulses along each arm. This model predicts the satellite would deduce $c'_{\parallel} \neq c'_{\perp}$ (as per the previously derived formulas:

$$c \cdot \frac{(\gamma_{\perp} + 2)}{3}$$

for perpendicular and

$$c \cdot \frac{\left(1 + \frac{2}{\gamma_{\perp}}\right)}{3}$$

for parallel).

- **One-Way Signal Analysis:** Analysis of one-way signal arrival times from synchronized emitters at the arm-ends to the central sensor would further test for anisotropic light speed inference or apparent desynchronization of simultaneity within the satellite's frame relative to the SFR. While it is understood that synchronization of clocks and one-way signal analysis is a debated topic,⁴³ the proposed experiment suggests an adequate physical test away from dragged spacetime would yield more accurate results.^{vi}
- **Verification with Earth:** Signals from the satellite's mirrors, reflected to Earth upon internal light pulse impact, would allow Earth observers to reconstruct and verify the SFR-observed kinematics of light propagation (Δt_{\parallel} and Δt_{\perp}) relative to the moving satellite.

- The benefits of this are the exact measurements of L_0 before it's launched, and the guarantee of relativistic speeds through spacetime to give concrete results. The downside is that the extreme precision needed may be below that of the noise to the point where a clean signal may be too difficult to obtain.

Lunar Laser Ranging (LLR)⁴⁴ - a directional null test: A possible directional null test using Lunar Laser Ranging (LLR) could compare return times when the Earth/Moon laser path is oriented differently with respect to Earth's orbital velocity. Near midnight at a full Moon, the beam is roughly perpendicular to Earth's orbital motion, while around 6 am at first quarter it is roughly parallel. By analysing thousands of measurements over many years, one could form two long-term datasets and examine whether any persistent difference appears between these two orientations.

The aim is not to test for a change in the local speed of light (light propagation speed through spacetime), but to check whether the interpreted Earth/Moon path length (relative to each other) is directly proportional to a broader cosmological coordinate, since over time, the actual cosmological distance the light travels (due to the moon reflector and the detector moving a certain distance in the ≈ 1.28 and ≈ 2.56 seconds respectively), should differ slightly between the parallel and perpendicular directions.

However, this experiment faces major limitations. Modern LLR analyses typically define the Earth/Moon distance using light-time itself, so a directional test risks circularity. If the distance scale is set by $d=ct/2$ (distance, speed of light, time), then comparing those same times for anisotropy may guarantee a null result. It's not measuring the actual distance. It's measuring the light path, which can bend and warp depending on circumstances. It is analogous to using a steel ruler to measure a gap throughout the day and night. If the ruler expands with heat, the gap will appear to shrink and expand. Then, if you use the shrinking and expanding gap to measure if the synchronized ruler is changing or not, the changing gap will imply the ruler is perfectly accurate. The circular logic hides the reality that the gap never changed, but the ruler gave inaccurate readings due to thermal expansion.

Independent knowledge of the Earth/Moon distance would be required (which may differ from the light-time distance), but geometric methods lack the precision needed, and dynamical models may not be separable from the light-time assumptions at millimeter sensitivity. Additional systematics (atmospheric delay, tidal forces, gravitational perturbations, temperature fluctuations, etc.) would also alter the round-trip times and have to be accounted for.

This experiment is distinct from previous LLR Lorentz tests because it isolates a direct geometric comparison between two specific beam orientations rather than searching for Standard-Model Extension-type (SME) tensor signatures (six linearly-independent Lorentz-violation parameters in the pure-gravity sector of the SME).⁴⁵ Even if prior analyses found no Lorentz violation, this narrower directional test has not been explicitly performed and provides an independent null check.

Unlike the Michelson-Morley experiment, which was performed at the Earth's surface where field entrainment is hypothesized to be maximal (effectively shielding the apparatus), the LLR test spans the distance to the Moon (≈ 60 Earth radii). As frame-dragging effects typically scale with $1/r^3$, the space between the Earth and Moon likely resides well outside the two entrainment bubbles, making the beam sensitive to velocity effects that surface-based experiments cannot detect.

This possible experiment may not be viable in practice, but if it is, a long-term directional comparison of LLR return times could provide a distinct constraint on any orientation-dependent discrepancy in the interpreted Earth/Moon photon path length. When using the physical distance between Earth and the Moon (separate from the actual distance through spacetime), we could get different values of c depending on the angle relative to the direction of orbital motion.

Probing Physical Length Invariance (Non-Light-Based Tests):

To distinguish between apparent effects due to light measurement and potential intrinsic physical changes in length, non-light-based tests are crucial:

- **MEMS Devices:** High-precision Micro-Electro-Mechanical Systems⁴⁶ could be designed to detect minute changes in physical dimensions along different axes due to velocity. Comparing these physical measurements with light-based length inferences would be key; however, the electromagnetic aspects of this form of measuring length may be affected by the propagation speed of light.
- **Instantaneous Physical Collisions / Contact Tests:** A conceptual experiment could involve two components set to make contact simultaneously when the satellite is at rest. When one of the rods is moving at sufficient speeds, if true physical length contraction occurs, the contact point timing would change. While practically challenging, this illustrates the principle of testing physical dimension directly.

Further precision techniques, possibly involving quantum phenomena sensitive to physical dimensions like the Rayleigh limit of charged droplets, might also be explored.⁴⁷

Frame Dragging: Conducting these experiments both with and against Earth's frame-dragging effect,^{3,17} could help quantify this phenomenon's impact on v (the satellite's velocity relative to the local field) and thus on the measured γ_v . Additionally, at satellite altitude, this could detect the velocity around the sun since Earth's frame dragging may not be as prominent at those altitudes. Orbits around the Lagrange L2 point might definitively remove the frame-dragging issues entirely, but the distance would probably make readings impossible.

Such multifaceted experiments would directly probe the nature of time dilation and the consequences of assuming invariant proper lengths in an SFR. The resulting data, whether confirming anisotropic c or revealing true physical length contraction, would provide crucial insights, potentially leading to more accurate predictions for objects in extreme relativistic environments. This predicted anisotropy in the "locally" measured speed of light, arising from invariant proper lengths and a universal time dilation γ_v , highlights a key divergence from Special Relativity's framework, which ensures local isotropy of c via length contraction. However, it should be noted that if light has to travel a path that isn't equivalent of a locally flat spacetime manifold, then Lorentz transformations are needed to convert the values to an equivalent flat spacetime manifold, which would convert the values to a constant c . Meaning the moment you have velocity through spacetime, the perpendicular measurements are a different frame of reference from the parallel measurements and therefore, no longer local.

The differences between these experiments highlight a crucial point between light-based observed phenomena (e.g., light-based measured length) and the physical dimensions (e.g., confirmed by contact or non-optical measurement), and should reveal any key differences. To further clarify how these fundamental rate differences relate to what observers visually perceive of distant moving clocks, we must understand the impact of light propagation itself.

Confusion due to lack of definitions: *Light Observed Time versus Instant Observed Time*

With reference to discussions, a core part of accurately exploring a subject is that people use the same definitions. This is a crucial part of the Socratic Method and critical thinking. If people have different definitions of a second or a meter, then their measurements of c will be different. Same with our mental understanding of how we perceive clocks in these thought experiments, ie, *Light Observed Time* versus *Instant Observed Time* (Actual Clock Rates).

When discussing time dilation between different frames or comparing clock rates from the SFR, this paper primarily refers to *Instant Observed Time*. This conceptual tool signifies the actual, underlying rate at which a clock is ticking (or a process is occurring) in one frame relative to another, or relative to the SFR, abstracting away the delays and distortions introduced by the finite speed of light in signal transmission. This distinction is crucial because what an observer *visually perceives* of a distant, moving clock (Light Observed Time) is a combination of that clock's actual (dilated) rate *and* the effects of light travel time, including relativistic Doppler shifts.⁹ Without defining this definition, confusion can arise in papers and discussions where talking about Light Observed Time phenomena in a certain direction can seem to slow the other frame clocks compared to the local clock. This can be taken as the reality of what the clocks experience, but as this shows below, the actual clock times don't actually both slow down relative to each other (as in both being faster and slower than the other clock at the same time).

To illustrate Light Observed Time, consider a spaceship journeying to Alpha Centauri, 4 light-years away (rounded down for simplicity), as measured in the SFR.

- **Outbound Journey:**

- **Ship at Earth:** From Earth, the ship will see light that has taken 4 years to reach Earth. So it will be an image of Alpha Centauri 4 years ago.
- **Spaceship looking back:** As the spaceship accelerates away from Earth at a significant fraction of c , light signals (e.g., images of Earth's clocks or timestamped pulses) sent from Earth will take progressively longer to reach the spaceship due to its increasing distance. The spaceship will also be *outrunning* older light. Consequently, the pilot will observe Earth's clocks appearing to run *very slowly* (a pronounced redshift⁹ and delayed signal arrival).
- **Spaceship looking forward:** Simultaneously, if the pilot looks ahead towards Alpha Centauri, they are moving towards the light signals emitted from it. They will observe Alpha Centauri's clocks (and events) appearing to run *very fast* (a pronounced blueshift⁹ and earlier signal arrival).
- **Ship at Alpha Centauri:** If the journey takes 5 SFR-years, upon arrival at Alpha Centauri, the light signals reaching the ship from Earth, would depict Earth as it was 4 years prior to the ship's arrival (due to the 4-light-year distance the signals had to cross). So the ship will see the Earth has only aged a year since it left. 5 years travel, 4 light-years of travel. Alpha Centauri, meanwhile, would have aged 5 SFR-years since the ship's departure from Earth, and the light will no longer take 4 years to get to the ship. So the image it saw from Earth would be 4 years more current because of being 4 years closer, and the 5 years travel time. A 9-year difference. Since the trip is 5 years, that's something like, 80% of the speed of light. So time dilation would have slowed the ship's clock significantly, meaning the ship's clock only measured maybe 3 years.^{3,6,9} Looking back at Earth, the light would appear to have only changed 1 year after 5 years of travel. But the ship's clock would be 3 years of travel, meaning after 3 years, Earth would seem to only age 1 year. Earth would seem slow.
- **Earth, looking at the ship:** in those 5 Earth years, there would have been a time when the ship was seen to be halfway. The ship would have taken 2.5 years to get halfway, where the light would then take 2 years to travel to Earth. So that's 4.5 years after leaving. So after 5 Earth years, the ship would appear to be a little more than halfway. The ship's clock would appear to show the time corresponding to the ship's halfway point. So, a bit over 1.5 years after 5 years of Earth time. The ship would seem slow.

- **Return Journey:**
 - **Spaceship looking forward:** As the spaceship returns to Earth, the observational roles reverse. The pilot will now observe Earth's clocks appearing to run *very fast* (blueshifted signals arriving rapidly as they close the distance). In 3 years on the ship's clock, Earth would appear to age 9 years to sync back up with reality.
 - **Spaceship looking back:** Conversely, signals from Alpha Centauri (now receding) will appear to run *very slowly* (redshifted and delayed).
 - **Earth, looking at the ship:** As the ship returns, Earth would observe a rapid catch-up of the ship's signals. The ship turns around at Earth-Year 5, but the light takes 4 years to arrive, so Earth sees the turnaround at Year 9. The ship reaches the return midpoint at Earth-Year 7.5; light from there (2 light-years away) takes 2 years to arrive, reaching Earth at Year 9.5 (7.5+2). Thus, Earth sees the first half of the return trip (which took 1.5 ship-years) occur in just 0.5 Earth-years. Finally, the ship arrives at Year 10. Earth observes the entire 3-ship-year return journey compressed into just 1 Earth-year (Year 9 to Year 10), making the ship's clock appear to run 3 times faster than normal.
- **The Twin Paradox^{3,6,9} Resolution Insight:**
 Upon reunion, if the astronaut experienced, say, only 6 years of proper time on their ship's clock due to their own intrinsic velocity time dilation (γ_v relative to SFR), while 10 SFR-years passed for Earth. The actual difference in elapsed clock times at any point in the journey is the Instant Observed Time effect. We don't assume them to be equal and then suddenly collapse into different times when observed next to each other. The symmetrical *appearance* of each observer seeing the other's clock run slow during periods of recession is a Light Observed Time effect, primarily due to Doppler and signal delay. It is only by completing a round trip (involving acceleration) that the underlying asymmetry in elapsed proper time becomes apparent upon direct comparison.

The critical point is that the visual effects of Light Observed Time (Doppler shifts, signal delays) are superimposed upon, but distinct from, the fundamental differences in clock rates (Instant Observed Time) due to γ_v as defined from the SFR.

Future Directions: Modeling Velocity-Induced Field Entrainment and Density Modification

While the primary γ_v formula developed in this paper treats velocity v as relative to an ambient, largely unperturbed SFR field, a scenario most applicable at high relativistic speeds or where local object-induced field effects are negligible, a more comprehensive physical model should address the nuanced interaction between a moving object and the fundamental energy field. As briefly introduced when discussing the Michelson-Morley experiment,¹⁵ it is hypothesized that objects can locally *entrain* or *drag* the energy field, an effect whose efficiency may be velocity-dependent. Exploring this velocity-induced field entrainment and its consequent local field density modifications (gravitational time dilation) presents a rich avenue for future theoretical and potentially experimental research.

1. Developing a Physical Model for Field Entrainment:

- **Analogies and Mechanisms:** The intuitive analogy of a dense wire-frame ball moving through air provides a conceptual starting point. At very low speeds, the air immediately surrounding and within the frame might be largely co-moving (high entrainment). As the ball's speed increases, the air has less *time* to be accelerated by the frame's passage, leading to increased flow-through and reduced entrainment. This suggests the fundamental energy field might possess properties akin to a superfluid, a state of matter with zero viscosity^{3,48-52}. However, the object's 'grip' mechanism is likely not frictional, but gravitational or geometrical. Just as a gravity wells move with the object, the FEF density may be gravitationally bound. This allows for an 'entrainment bubble' that moves with the Earth (satisfying MME) without generating the thermal friction or orbital decay associated with dragging a viscous fluid.
- **Parameters to Investigate: A physical model would need to quantify:**
 - The *viscosity* or *stiffness* of the SFR field, is in line with propagation speed, since this is about a field change and the amount it affects neighboring volumes of the field. A wave is a change in the density of the medium (or spacetime geometry lines), and if there's no affect on the neighboring volumes, the change can't propagate. This allows waves to travel. However, it should be noted that this is likely not associated with entropy, where a change in density resists the more it's out of balance from a lowest energy state, which causes wave oscillation. It's similar to how gravity causes water waves to oscillate but gravity doesn't cause the wave to flow through the water.
 - The *field cross-section* or interaction strength of the moving object. This depends on the object's own mass-energy, density, and perhaps even shape (e.g., a solar sail versus an extremely long rocket would have different amounts of time to influence the dragging of a specific volume of vacuum energy).
 - A dragging efficiency factor, $D(v)$, which would be close to 1 (perfect entrainment), at low v relative to the SFR, and approach 0 (no entrainment, where an object moves through the ambient field), as v approaches c .
 - The decreasing drag effect is proportional to distance ($1/r^3$) as the transfer of energy degrades proportionally to the viscosity (higher viscosity at a base inertial resistance would imply more effect at distances, whereas if there was next to no viscosity at a base inertial resistance, the distance would be virtually zero before the drag effect becomes negligible). The ($1/r^3$) ratio could be the exact ratio, however, more clarity would be needed.
 - The energy density of the dragging object (for instance, a balloon full of hydrogen would drag significantly less than the same volume packed with neutron star matter).

- Induced Field Density ($\gamma_\xi(v)$): The process of entraining or compressing the field due to motion is hypothesized to locally alter the field's density. This *pressure build-up* or *field bunching* would create a local $\gamma_\xi(v)$ that is anisotropic (likely higher in the direction of motion as velocity increases) and adds to any ambient time dilation background (much like air pressure builds up in a parachute as velocity increases, to an equilibrium where the air viscosity is not enough to stop the air passing through the spill holes just as fast as the parachute moves). This buildup of density of the FEF (or the bunching of spacetime geodesics) can act like gravitational time dilation. This will be included along with the pure velocity time dilation factor γ_v to give us the total time dilation factor Γ in the unified time dilation paper.

2. Reconciling MME and Relativistic Time Dilation:

- A successful model of velocity-dependent field entrainment could provide a unified physical explanation for both the Michelson-Morley null result¹⁵ and observed relativistic time dilation. At Earth's relatively low cosmic velocity, high field entrainment ($D(v) \approx 1$) would mean the MME apparatus is effectively at rest with respect to its local, co-moving field bubble, naturally yielding a null result without requiring intrinsic length contraction of the apparatus itself.

3. Potential Consequences and Testable Differences:

- Object-Dependent Effects: Unlike SR's purely kinematic time dilation and length contraction, a field interaction model might predict that the degree of entrainment and induced density (and thus Γ) could subtly depend on the object's mass, density, and/or shape (field-interaction cross-section). Earth would have a much different dragging effect than a lightweight satellite.
- Energy Loss/Gain: Moving through and deforming/dragging the field might involve energy exchange, albeit negligible (the assumption is that there is zero friction slowing down mass due to the mass dragging spacetime). Does an accelerating object do work on the field? Does a decelerating object recover energy? This could lead to predictions of a fundamental drag force on moving objects or anomalous inertial properties. If Earth drags spacetime, does spacetime slow down Earth? Under the superfluid hypothesis, vacuum friction would be nonexistent. However, if there is such friction, it would be negligible for constant velocity motion, consistent with observation, where the massive differential in energy density means that any residual drag (perhaps during acceleration) would be akin to a stray bolt slowing Earth down compared to how the Moon slows the Earth's rotation. A bolt's effect would be negligible, yet the Earth's drag on the bolt would be significant. Where every action has an equal and opposite reaction,⁵³ the reaction of the frame dragging on Earth would be minuscule. The amount of vacuum energy dragged by the Earth is insignificant compared to the Earth's total energy. The moon's drag on the Earth is minuscule as it is.⁵⁴ As for light, it's a wave in transit (quantum wave function)⁵⁵ and therefore doesn't drag spacetime, so there wouldn't be any tired light.⁵⁶ However, a high velocity particle would, and therefore experience a minuscule deceleration over vast amounts of time, even if it is negligible.

- Propagation of *Field Pressure*: The *pressure wave* or densification described in the field due to motion would propagate at $c^{3,37}$ (an increase in density would adjust around the object at c relative to the dragged field). The dynamics of how this pressure builds up and dissipates around a moving or accelerating object are complex and would require averaging for different shapes and densities (the Earth's atmosphere would have way less dragging effect than the core, which is complex enough already before bringing in abstract shapes). LIGO detects gravitational waves as a chirp, similar to how someone could hear the sonic booms from two jets orbiting each other, therefore, the principle of densification may be plausible.
- Superluminal Phenomena in Entrained Fields: There is an analogy of the speed of sound in a jet cockpit, going mark 1 (sound outside can't catch up... but sound inside travels forward). If a region of field is perfectly entrained at velocity v (entrained field velocity v_f), could CEEs *within that bubble* propagate at c (but reduced by any local gravitational time dilation) *relative to the bubble*, effectively allowing for superluminal propagation relative to the *ambient SFR* if v_f is high? This relates to discussions of *warp drives* or *Alcubierre-like metrics*⁵⁷ and FEF's known constraints (e.g., energy conditions), which may lead to a more accurate understanding of how much warping of spacetime is possible and how physically viable the warp drive technology may be. The observed superluminal jets from quasars are explained by relativistic beaming and projection effects,⁵⁸ but with factoring in frame dragging, with this model, how might it offer an alteration to those findings if localized field entrainment is extreme?

4. **Mathematical Formalism:**

Developing the equations for this field interaction would be a significant undertaking, potentially drawing from fluid dynamics,^{59,60} plasma physics (for field-matter interaction),⁶¹ or other theories such as Geometrized Vacuum Physics⁶², all adapted to the fundamental energy field. The goal would be to derive $D(v)$ and $\gamma_\xi(v)$ from first principles of the field.

Investigating these aspects of object-field interaction could lead to a richer, more mechanistic understanding of relativistic phenomena from an SFR perspective, potentially resolving long-standing interpretational issues and yielding novel, testable predictions.

Conclusion and Testable Predictions:

This paper has outlined a hypothesis that reframes some fundamental concepts of cosmology and physics: introducing an external SFR, viewing spacetime as an emergent property of field dynamics, and interpreting cosmic phenomena through this lens. In closing, it's necessary to summarize a few key predictions or consequences of this viewpoint that could, in principle, distinguish it from the standard model of cosmology.

In this hypothesis, an external observer (SFR) would measure light traveling at different effective speeds in different conditions. While we cannot place an actual observer outside the universe, we can look for indirect signs. Doing experiments where we establish a benchmark at rest before we do full measurements of velocity time dilation, simultaneously measuring lengths in multiple ways, looking for discrepancies, could imply the reality of the experience of time dilation and length contraction in empirical data.

In uncovering inconsistencies, we can then start to look at what is really going on, rather than assume that the observer's frame of reference is in real time, that the speed of light for them is unchanged, and that their local frame of reference is unchanged with velocity. If we can confirm that length contraction does not actually exist, then we can conclude if it's a visual effect based on the velocity and not an actual physical trait of reality, or even if it exist at all. Such high-precision tests of Lorentz invariance⁶³⁻⁶⁶ (assumed local frames of reference that turn out to not be equivalent to a flat spacetime manifold) are significant for modern physics and crucial for advancing our understanding of the universe.

Final Thoughts:

Fundamentally, this is about getting to the core of what's really going on. We know clocks moving at velocity run slower, and when they are in high gravitational fields, they run slower too. If we are on a ship traveling at a velocity, we know the light isn't just traveling from one wall to the other. Einstein understood that light propagates through spacetime and that moving objects aren't moving all the local spacetime with them. We know our own clock is running slow. We may ignore it and say it's not running slow and that the light isn't traveling a vast distance longer, but that doesn't change reality. The equations can still be accurate, and pretending for the sake of easier math is fine if it works. But we shouldn't confuse math working based on an altered perception as reality. Based on current limited research, there seems to be no definitive proof that frame dragging is or is not messing with our perception of the speed of light being the same in all directions of motion. Until we have definitive proof from something outside the realm of possibility of entrained spacetime, we can't conclude whether a spacetime medium is real or not.

We know about frame dragging. So we can conclude there is spacetime flow even if it's only present in the reshaping of spacetime geometry. However, many scientists are exploring the idea of spacetime flowing, from Inflation Theory, to the expansion of the universe, to the potential for spacetime to flow into a black hole. Whether or not that flow is like a river, and how much so, is a different story.

While this is primarily one point of view, other people's perspectives could help to refine these concepts and clarify possibilities to be one way or another. A select few people can't know everything and will miss things. It's through discussion and collective resourcefulness that we can delve deeper into the nature of our reality. So we must always be willing to reach out and also listen to other people's ideas. We never know what could come of it. Yes, a lot of it will be wrong, but odds are, some random person will randomly create a breakthrough that changes the world. It's like listening to a meteorologist weather-man explaining the geology of the formation of the Earth. You end up with the theory of *continental drift*.

These concepts in this paper are well worth considering since they align with observations and they align with the fundamental knowledge of the laws of physics. If we refuse to even entertain the thoughts of such possibilities, then we may be missing out on new perspectives that could shine a light on the mysteries we face in our modern exploration of spacetime.

Endnotes

i) The Heat Death⁵ SFR represents the baseline of minimal energy field density and thus the fastest intrinsic rate of time flow. It's a hypothetical end to the universe where black holes are the last remaining mass to evaporate leaving a massless universe with energy spreading out in all directions so evenly (and due to it being spread out so thin), the temperature asymptotically approaches absolute zero. For this state, the Static Time Dilation Factor (how much time is affected by gravitational time dilation) is defined as 1. This value signifies no additional time dilation relative to the SFR's own baseline rate.

ii) The Cosmic Microwave Background (CMB) appears highly isotropic to an observer co-moving with the average expansion of the universe (the 'Hubble flow'). Motion relative to this CMB frame induces a measurable dipole anisotropy (a hotter direction and a cooler direction).^{10,67} This allows for the determination of an object's 'peculiar velocity' relative to this cosmic rest frame. While distinct from the theoretical Heat Death SFR, the CMB frame serves as the closest observable approximation to a universal standard of rest against which large-scale motions, including potential Dark Flow^{30,31,50} or the effects of frame dragging, should ultimately be referenced. The velocity v used in this paper's time dilation formulas is always considered relative to the local energy field structure, which may itself be in motion with respect to the CMB.

iii) The current propagation time dilation model (a preliminary Python script, toy model, which is a conceptual visualization and its results are illustrative of the principles rather than precise numerical validations of spacetime) shows that as an object approaches the CEE propagation speed, complete timely information transfer in the forward direction is increasingly challenged. It also demonstrates that in simulated high-density field regions, light appears to travel at a constant speed c relative to co-moving clocks that are themselves slowed by the field. Furthermore, the model illustrates basic blueshift and redshift effects for CEEs traversing regions of varying simulated field density. While these models would require further development for rigorous quantitative predictions, they serve as effective proofs of concept for the proposed mechanisms. Additionally, a one-dimensional version is used to illustrate the impact of velocity time dilation in a uniform field density, specifically designed to yield approximate numerical values that could be used in velocity time dilation equations. The major difficulty comes when factoring in the effects of frame dragging.

iv) Special Relativity (SR) is fundamentally a kinematic theory derived from its two postulates.^{3,6} To maintain these, SR deduces that measurements of spatial intervals (length contraction), temporal intervals (time dilation), and simultaneity must be relative to the observer's inertial frame, transforming according to the Lorentz equations. SR describes *how* these measurements change between frames but does not offer a deeper physical mechanism for these effects in terms of interaction with an underlying "medium"; they are presented as intrinsic properties of spacetime geometry. To uphold the local constancy of c for a moving observer, SR's framework requires that for a one-way light speed test with spatially separated clocks, the clocks must be out of sync (relativity of simultaneity), and for a two-way test with mirrors, the apparatus must be length-contracted as measured by the external frame.

In contrast, the SFR framework proposed in this paper attempts to provide a more mechanistic underpinning. It postulates a fundamental energy field and explores how an object's interaction with this field (via velocity v) physically leads to its total time dilation Γ . By holding proper lengths (L_0) as invariant in the SFR, this model predicts a different consequence for a moving observer's measurements: an anisotropic measured speed of light. This approach seeks a causal explanation rooted in field properties, arguing that the pilot's measurement differs not because their clocks became desynchronized from each other or their apparatus physically changed length, but because the light they are measuring traveled a much longer path in SFR coordinates than the pilot, with their γ_v dilated clock, perceives when treating the experiment the same as it would be at rest. They are equivalent of two separate frames of reference, depending on the angle at which they stray from the direction of motion.

The actual distance a light pulse travels within a moving two-way light clock apparatus is not the same as the apparatus's stationary length (L_0). Because the apparatus moves while the pulse is in transit, the *true geometric path* of the pulse through the cosmos is much longer than $2L_0$. The mirror may have moved a significant distance before the light reaches it.

This points out a major difference in frames of reference. One uses the actual cosmological coordinates in space to track the path of the light and how far it actually traveled. The other completely ignores the reality of the actual physical distance the light traveled and pretends that L_0 is the same at rest as at velocity, and then counters the increase in full distance with the increase in time dilation, which skews as v approaches c . Ignoring the reality of time dilation and the reality of the actual distance the light travels means that the stationary observer and the moving observer are reading two completely different lengths, with two completely different clock rates. For them to perfectly align, where one is a skewed perception of reality, is highly unlikely, especially when you have to alter lengths (length contraction) or conclude timings are wrong (simultaneity) in order to have your skewed perception of reality remain a factual representation of reality. It's more likely that some elements are in play that cause the two to seem identical.

The predicted measurements c'_{\perp} and c'_{\parallel} arise because the astronaut in a moving frame uses their own clock, which is itself fundamentally dilated by γ_v , and assumes the distance light travels is simply the invariant physical length $2L_0$. The astronaut's personal experience of time (γ_v) is itself an average of these underlying kinematic effects (γ_{\perp} and γ_{\parallel}), because the causal information transfer within their own atoms is subject to the same *increased travel distance*. This framework explores the consequences of this physical reality, where an observer's clock rate and their local measurement of c are both manifestations of these deeper kinematics.

y) Consider a pilot on a spaceship of proper length L_0 (invariant in the SFR) conducting an internal two-way light clock experiment. Special Relativity (SR) ensures the pilot measures light speed as c by invoking length contraction (L_0 shrinks to L_0/γ parallel to motion as measured by an external frame) alongside time dilation (γ).⁹ This model offers an alternative: the pilot's clock is dilated by the fundamental γ_v . As shown in the main text, this results in

$$c'_{\parallel} = c \cdot \frac{\left(1 + \frac{2}{\gamma_{\perp}}\right)}{3}$$

which is generally not c .

The pilot's consistent local measurement of c in SR is a result of its specific postulates;⁶ this model, with different postulates (SFR, invariant L_0 , specific γ_v), predicts an anisotropic c measured by the pilot. When we know for a fact that clocks run slower or faster depending on the net results of velocity and gravitational time dilation, an effect confirmed by experiments with around-the-world atomic clocks and space-borne hydrogen masers,^{12,68} the assertion that any observer's local measurement of c must be constant can be seen as a chosen convention to make the mathematics work in a particular way, rather than a reflection of an underlying invariant physical speed measurement for all observers.

vi) The debate over relativistic effects often hinges on the method used to synchronize distant clocks, a concept with known foundational challenges.⁴³ Using light signals to synchronize pre-positioned clocks relies on an *a priori* assumption about the one-way speed of light, which is the very quantity one might wish to measure. Similarly, synchronizing clocks at one location and then moving them apart introduces complexities, as their final state of synchrony depends on their paths and the framework used (e.g., standard SR predicts a path-dependent desynchronization, the Sagnac effect, for clocks moved along a loop on a rotating platform).

A proposed ideal experiment would involve synchronizing clocks while stationary, moving them apart along identical length paths but at different angles, to parallel positions, and then accelerating them identically, ensuring both clocks experience the same history of relativistic effects. From the perspective of the co-moving frame, the clocks should remain synchronized. Any subsequent measurement of one-way light speed between them would then, in this paper's framework, directly probe the anisotropy caused by motion through the SFR, as opposed to being an artifact of conventional synchronization procedures.

AI was used to code Toy models, to critically analyze content, to assist in understanding of reference material, and for grammar and spelling. All novel content was created by the author through decades of research and study, with small refinements helping to finish these papers.

These papers take extensive research and time. With so much going into them, and so many new discoveries happening every day, there may be an overlooked issue with the article. If you find something that should be addressed, please get in contact to help the information stay accurate.

Appendix A)

Symbol Definitions:

| Symbol | Name | Detailed Explanation |
|------------------------|---|---|
| c | Speed of Light | The speed of causality at which it propagates through flat spacetime (FEF) in a vacuum. |
| v | Velocity | The velocity of an observer and/or experiment as relative to the spacetime (FEF) it's moving through. |
| d | Distance | The distance of length between some coordinates. |
| t | Time Interval | An interval of time, for instance, a second. |
| P | SFR Viewed Power | Local power usage as viewed from an SFR perspective. |
| P' | Local Measured Power | Local power usage as viewed from a Local perspective. |
| R | SFR Viewed Rate | Local Rate of change as viewed from an SFR perspective. |
| R' | Local Measured Rate | Local Rate of change as viewed from a Local perspective. |
| D | Dragging Efficiency Factor | The amount to which spacetime is entrained, dragged with a moving object, which degrades with velocity. |
| Γ | Total Time Dilation Factor) | The ultimate factor by which all physical processes are slowed for a moving object in a gravitational field. |
| γ_v | Total Velocity Time Dilation Factor | The total dilation factor for the average of 3 axes light travel for $2\gamma_{\perp}$ and γ_{\parallel} . |
| γ_v' | Total Velocity Time Dilation Factor | The total dilation factor for a moving frame when compared to the SFR base $\gamma_v = 1$. |
| γ_A' | Astronaut's Total Velocity Time Dilation Factor | The total dilation factor for an astronaut for comparison to another local total dilation factor. |
| γ_E' | Earth's Total Velocity Time Dilation Factor | The total dilation factor for the Earth for comparison to another local total dilation factor. |
| v_f | Spacetime Velocity | The velocity of flowing spacetime relative to the CMB. |
| L_0 | Invariant Proper Length | The absolute, invariant physical length of an object, measured in its own rest frame. |
| $\Delta Q'$ | Quantity Change | In a moving frame, the amount a quantity changes in a given amount of time. |
| $\Delta E'$ | Energy Amount | In a moving frame, The Energy amount for a Local experiment measured in Joules. |
| Δt | Time in Stationary Frame | Elapsed time interval measured by a clock at rest in the rest frame (SFR). |
| $\Delta t'$ | Time in the Moving Frame | The proper time interval in the moving frame, measured by a clock at rest in the rest frame (SFR). |
| Δt_{\perp} | SFR Time (Perp. Path) | The time measured by the SFR observer for the perpendicular experiment in the moving frame. |
| Δt_{\parallel} | SFR Time (Para. Path) | The time measured by the SFR observer for the parallel experiment in the moving frame. |

| | | |
|-------------------------|-----------------------------------|--|
| $\Delta t'_{\perp}$ | Local Time (Perp. Path) | The time measured by the local moving observer for the perpendicular experiment in the moving frame. |
| $\Delta t'_{\parallel}$ | Local Time (Para. Path) | The time measured by the local moving observer for the parallel experiment in the moving frame. |
| Δt_A | SFR Time Interval for Astronaut | Astronaut's elapsed time interval measured by a clock at rest in the rest frame (SFR). |
| Δt_E | SFR Time Interval for Earth | Earth's elapsed time interval measured by a clock at rest in the rest frame (SFR). |
| $\Delta t'_A$ | Local Time Interval for Astronaut | Astronaut's elapsed time interval measured by the Astronaut's clock in the moving frame. |
| $\Delta t'_E$ | Local Time Interval for Earth | Earth's elapsed time interval measured by the Earth's clock in the moving frame. |
| c'_{\perp} | Measured Perpendicular c | The speed of light for the moving observer as predicted to be measured along a perpendicular path. |
| c'_{\parallel} | Measured Parallel c | The speed of light for the moving observer as predicted to be measured along a parallel path. |
| γ_{\perp} | Perpendicular Kinematic Factor | The time dilation factor for a two-way CEE on a path <i>perpendicular</i> to motion. |
| γ_{\parallel} | Parallel Kinematic Factor | The time dilation factor for a two-way CEE on a path <i>parallel</i> to motion. Relationship: $\gamma_{\parallel} = \gamma_{\perp}^2$. |
| γ_{ξ} | Induced Gravitational Dilation | A novel factor quantifying the <i>additional</i> dilation from an object's motion, causing the field to <i>bunch up</i> or be <i>dragged</i> . Its calculation is highly complex, depending on velocity, mass, density, shape, and interaction time. |

References

1. Chladni, E. F. F. *Entdeckungen über die Theorie des Klanges*. (Leipzig : Bey Weidmanns Erben und Reich, 1787).
2. Einstein, A. Ist die Trägheit eines Körpers von seinem Energieinhalt abhängig? *Ann. Phys.* **323**, 639–641 (1905).
3. Carroll, S. M. *Spacetime and Geometry: An Introduction to General Relativity. Higher Education from Cambridge University Press*
<https://www.cambridge.org/highereducation/books/spacetime-and-geometry/38EDABF9E2BADCE6FBCF2B22DC12BFFE> (2019) doi:10.1017/9781108770385.
4. Einstein, A. Die Grundlage der allgemeinen Relativitätstheorie. *Ann. Phys.* **354**, 769–822 (1916).
5. Adams, F. C. & Laughlin, G. A dying universe: the long-term fate and evolution of astrophysical objects. *Rev. Mod. Phys.* **69**, 337–372 (1997).
6. Einstein, A. Zur Elektrodynamik bewegter Körper. *Ann. Phys.* **322**, 891–921 (1905).
7. Einstein, A. *Autobiographical Notes*. (La Salle ; Chicago : Open Court Pub. Co., 1979).
8. Gift, S. J. G. Length contraction in special relativity is a logical contradiction. *Phys. Essays* **34**, 51–53 (2021).
9. Edwin F. Taylor and John Archibald Wheeler. *Spacetime Physics: Introduction to Special Relativity, Second Edition*. (1992).
10. Kogut, A., Lineweaver, C., Smoot, G. F., Bennett, C. L. & Banday, A. Dipole Anisotropy in the COBE DMR First-Year Sky Maps. *Astrophys. J.* **419**, 1 (1993).
11. Schwarzschild, K. On the gravitational field of a mass point according to Einstein's theory. Preprint at <https://doi.org/10.48550/arXiv.physics/9905030> (1999).
12. Vessot, R. F. C. *et al.* Test of Relativistic Gravitation with a Space-Borne Hydrogen Maser. *Phys. Rev. Lett.* **45**, 2081–2084 (1980).
13. Hafele, J. C. & Keating, R. E. Around-the-World Atomic Clocks: Predicted Relativistic Time Gains. *Science* **177**, 166–168 (1972).
14. Abbott, L. The Mystery of the Cosmological Constant. *Scientific American*
<https://www.scientificamerican.com/article/the-mystery-of-the-cosmological-con/> (1988).

15. Michelson, A. A. & Morley, E. W. On the relative motion of the Earth and the luminiferous ether. *Am. J. Sci.* **s3-34**, 333–345 (1887).
16. Ashby, N. Relativity and the Global Positioning System. *Phys. Today* **55**, 41–47 (2002).
17. Overduin, J. M. Spacetime, spin and Gravity Probe B. *Class. Quantum Gravity* **32**, 224003 (2015).
18. Everitt, C. W. F. *et al.* Gravity Probe B: Final Results of a Space Experiment to Test General Relativity. *Phys. Rev. Lett.* **106**, 221101 (2011).
19. Lense, J. & Thirring, H. Über den Einfluß der Eigenrotation der Zentralkörper auf die Bewegung der Planeten und Monde nach der Einsteinschen Gravitationstheorie. *Phys. Z.* **19**, 156–163 (1918).
20. Martin, J. Everything you always wanted to know about the cosmological constant problem (but were afraid to ask). *Comptes Rendus Phys.* **13**, 566–665 (2012).
21. Herrmann, J. Towards a unified theory of the fundamental physical interactions based on the underlying geometric structure of the tangent bundle. *Eur. Phys. J. C* **82**, 947 (2022).
22. Weinberg, S. The cosmological constant problem. *Rev. Mod. Phys.* **61**, 1–23 (1989).
23. Hossenfelder, S., Schwarz, D. J. & Greiner, W. Particle production in time-dependent gravitational fields: the expanding mass shell. *Class. Quantum Gravity* **20**, 2337–2353 (2003).
24. Frassino, A. M. & Panella, O. The Casimir Effect in Minimal Length Theories based on a Generalized Uncertainty Principle. *Phys. Rev. D* **85**, 045030 (2012).
25. Gauthier, C. Generating Net Forces from Backgrounds of Randomly Created Waves. *J. Mod. Phys.* **5**, 1569–1574 (2014).
26. Gegelia, J. & Meißner, U.-G. Vacuum energy in the effective field theory of general relativity. *Phys. Rev. D* **100**, 046021 (2019).
27. Hossenfelder, S. Minimal Length Scale Scenarios for Quantum Gravity. *Living Rev. Relativ.* **16**, 2 (2013).
28. Carlip, S. Spacetime foam: a review. *Rep. Prog. Phys.* **86**, 066001 (2023).
29. Wang, Q. Reformulation of the Cosmological Constant Problem. *Phys. Rev. Lett.* **125**, 051301 (2020).
30. Kashlinsky, A., Atrio-Barandela, F., Kocevski, D. & Ebeling, H. A Measurement of Large-Scale

Peculiar Velocities of Clusters of Galaxies: Results and Cosmological Implications. *Astrophys. J.* **686**, L49 (2008).

31. Atrio-Barandela, F. On the Statistical Significance of the Bulk Flow Measured by the PLANCK Satellite. *Astron. Astrophys.* **557**, A116 (2013).
32. Mungan, C. E. Relativistic Effects on Clocks Aboard GPS Satellites. *Phys. Teach.* **44**, 424–425 (2006).
33. Nicholson, T. L. *et al.* Systematic evaluation of an atomic clock at $2e-18$ total uncertainty. *Nat. Commun.* **6**, 6896 (2015).
34. 6.5: s Orbitals are Spherically Symmetric. *Chemistry LibreTexts*
[https://chem.libretexts.org/Courses/University_of_California_Davis/UCD_Chem_110A%3A_Physical_Chemistry_I/UCD_Chem_110A%3A_Physical_Chemistry_I_\(Koski\)/Text/06%3A_The_Hydrogen_Atom/6.5%3A_s_Orbitals_are_Spherically_Symmetric](https://chem.libretexts.org/Courses/University_of_California_Davis/UCD_Chem_110A%3A_Physical_Chemistry_I/UCD_Chem_110A%3A_Physical_Chemistry_I_(Koski)/Text/06%3A_The_Hydrogen_Atom/6.5%3A_s_Orbitals_are_Spherically_Symmetric) (2019).
35. Colombo, S., Pedrozo-Peñafiel, E. & Vuletić, V. Entanglement-enhanced optical atomic clocks. *Appl. Phys. Lett.* **121**, 210502 (2022).
36. Evenson, K. M. *et al.* Speed of Light from Direct Frequency and Wavelength Measurements of the Methane-Stabilized Laser. *Phys. Rev. Lett.* **29**, 1346–1349 (1972).
37. Doody, D. Chapter 3: Gravity & Mechanics - NASA Science. *Basics of Spaceflight*
<https://science.nasa.gov/learn/basics-of-space-flight/chapter3-2/> (2023).
38. Field, J. H. Muon decays in the Earth's atmosphere, time dilatation and relativity of simultaneity. Preprint at <https://doi.org/10.48550/arXiv.physics/0606188> (2009).
39. Hornof, D. *et al.* A snapshot of relativistic motion: visualizing the Terrell-Penrose effect. *Commun. Phys.* **8**, 161 (2025).
40. Prokhovnik, S. J. Neo-Lorentzian relativity. *J. Aust. Math. Soc.* **5**, 273–284 (1965).
41. Nair, V. G. Advanced Suspension Techniques in Interferometric Gravitational Wave Detectors: An Overview. *Galaxies* **13**, 28 (2025).
42. Eskin, G. Rigidity for Lorentzian metrics with the same length of null-geodesics. Preprint at <https://doi.org/10.48550/arXiv.2205.05860> (2024).
43. Anderson, R., Vetharaniam, I. & Stedman, G. E. Conventionality of synchronisation, gauge

- dependence and test theories of relativity. *Phys. Rep.* **295**, 93–180 (1998).
44. Dickey, J. O., Bender, P. L. & Faller, J. E. Lunar laser ranging: A continuing legacy of the Apollo Program (invited review). *NIST* **265**, 482–490 (1994).
45. Battat, J. B. R., Chandler, J. F. & Stubbs, C. W. Testing for Lorentz Violation: Constraints on Standard-Model-Extension Parameters via Lunar Laser Ranging. *Phys. Rev. Lett.* **99**, 241103 (2007).
46. Ball, P. Feel the force. *Nature* **447**, 772–774 (2007).
47. Matsuyama, T., Abe, T. & Yamamoto, H. Lattice Boltzmann method study of Rayleigh instability of a charged droplet. *Adv. Powder Technol.* **18**, 93–104 (2007).
48. Hamilton, A. J. S. & Lisle, J. P. The river model of black holes. *Am. J. Phys.* **76**, 519–532 (2008).
49. Eling, C. Hydrodynamics of spacetime and vacuum viscosity. *arXiv.org*
<https://arxiv.org/abs/0806.3165v3> (2008) doi:10.1088/1126-6708/2008/11/048.
50. Cembranos, J. A. R., Maroto, A. L. & Villarrubia-Rojo, H. Magnetic fields from cosmological bulk flows. *Mon. Not. R. Astron. Soc.* **497**, 3537–3541 (2020).
51. Scott, T. C. From Modified Newtonian Dynamics to Superfluid Vacuum Theory. *Entropy* **25**, 12 (2023).
52. Roberts, D. C. When superfluids are a drag. *Contemp. Phys.* **50**, 453–461 (2009).
53. Newton, I., Chittenden, N. W. L. of S. I. N., Adee, D., Motte, A. & Hill, T. P. E. A. mathematics books C.-B. *Newton's Principia : The Mathematical Principles of Natural Philosophy*. (New-York : Published by Daniel Adee, c1846).
54. Stephenson, F. R. & Morrison, L. V. Long-Term Fluctuations in the Earth's Rotation: 700 BC to AD 1990. *Philos. Trans. Phys. Sci. Eng.* **351**, 165–202 (1995).
55. Dirac, P. A. M. (Paul A. M. *The Principles of Quantum Mechanics*. (Oxford : Clarendon Press, 1958).
56. Soares, D. The tired-light paradigm revisited. *ResearchGate*
https://www.researchgate.net/publication/335107864_The_tired-light_paradigm_revisited
(2025) doi:10.13140/RG.2.2.20510.48961.
57. Alcubierre, M. The warp drive: hyper-fast travel within general relativity. *Class. Quantum*

Gravity **11**, L73 (1994).

58. Biretta, J. A., Sparks, W. B. & Macchetto, F. HUBBLE SPACE TELESCOPE Observations of Superluminal Motion in the M87 Jet. *Astrophys. J.* **520**, 621 (1999).
59. Johnson, P. L. The squeezes, stretches, and whirls of turbulence. *Phys. Today* **74**, 46–51 (2021).
60. Brunton, S. L., Noack, B. R. & Koumoutsakos, P. Machine Learning for Fluid Mechanics. *Annu. Rev. Fluid Mech.* **52**, 477–508 (2020).
61. Marklund, M. & Shukla, P. K. Nonlinear collective effects in photon-photon and photon-plasma interactions. *Rev. Mod. Phys.* **78**, 591–640 (2006).
62. Batanov-Gaukhman, M. Geometrized Vacuum Physics. Part I. Algebra of Stignatures. Preprint at <https://doi.org/10.20944/preprints202306.0765.v3> (2023).
63. Mattingly, D. Modern Tests of Lorentz Invariance. *Living Rev. Relativ.* **8**, 5 (2005).
64. Müller, H., Herrmann, S., Braxmaier, C., Schiller, S. & Peters, A. Modern Michelson-Morley Experiment using Cryogenic Optical Resonators. *Phys. Rev. Lett.* **91**, 020401 (2003).
65. Bars, H. P. *et al.* New test of Lorentz invariance using the MICROSCOPE space mission. *Phys. Rev. Lett.* **123**, 231102 (2019).
66. Schumacher, K., Perkins, S. E., Shaw, A., Yagi, K. & Yunes, N. Gravitational wave constraints on Einstein-æther theory with LIGO/Virgo data. *Phys. Rev. D* **108**, 104053 (2023).
67. Collaboration, P. *et al.* Planck 2018 results. VI. Cosmological parameters. *Astron. Astrophys.* **641**, A6 (2020).
68. LIGO Scientific Collaboration and Virgo Collaboration *et al.* GW170817: Observation of Gravitational Waves from a Binary Neutron Star Inspiral. *Phys. Rev. Lett.* **119**, 161101 (2017).