The Unified System of Invariant Time (USIT)

Empirical Verification Ledger

Independent Anchors for the Absolute-Space Time Dilation Foundation

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Purpose of This Document

This is a companion, running document to "An Absolute-Space Derivation of Relativistic Time Dilation and the Relativistic Origin of Magnetism." That paper establishes the foundation (absolute space, perpetual internal motion at a fixed rate) and derives, from it, the standard Lorentz factor gamma = 1/sqrt(1 - v^2/c^2) and, via the equivalence principle, weak-field gravitational time dilation.

This document accumulates independent, real-world checks of that foundation, applied to different physical systems, each analyzed with the same standard: a stated setup, a calculation carried out in full, and a direct comparison against an established, independently measured result. Anchors that do not hold up, or that cannot be completed with available data, are recorded as such rather than omitted, per the standing rule below.

Publication Status

This document and its companion foundation paper are self-published by the author (hosted on the author's GitHub repository and archived via Zenodo). They have not undergone independent peer review. Where a result in this document builds on an established, independently-verified physical principle not derived from the foundation's own four postulates (for example, the equivalence principle, or the metric and geodesic framework used in the Mercury entry below), this is stated explicitly at the point of use, consistent with this project's stated goal of building on established physics rather than re-deriving it from nothing.

This is a running document, updated as new anchors are tested and as entries are revised. The date above reflects the most recent revision; prior revisions are preserved in the author's GitHub commit history and, where re-archived, in dated Zenodo records.

Anchor 1: Cosmic-Ray Muon Survival to Sea Level

The Phenomenon

Muons produced by cosmic-ray collisions in the upper atmosphere, at altitude h = 15,000 m, have a rest-frame mean lifetime of tau_0 = 2.2 x 10^-6 s. A non-relativistic calculation predicts essentially none of these muons should

survive to reach sea-level detectors; in practice, a substantial, easily measurable flux is detected at sea level. First resolved experimentally by Rossi and Hall (1941); demonstrated with particular clarity by Frisch and Smith (1963).

Calculation

Using a representative velocity v = 0.995c, travel time to sea level is t = h/v ~= 5.03 x 10^-5 s. Without time dilation, survival fraction N/N0 = e^(-t/tau_0) = e^(-22.9) ~= 1.2 x 10^-10 -- effectively undetectable.

From the foundation's Section 2, gamma = 1/sqrt(1-v^2/c^2) ~= 10.01 at this velocity. The dilated lifetime tau = gamma x tau_0 ~= 2.20 x 10^-5 s gives a survival fraction of e^(-50.3/22.0) ~= 0.101 -- approximately 10% survival, matching the real observed order of magnitude.

Result

Confirmed. A second independent verification of the foundation's core derived quantity, in a physical regime (particle decay) unrelated to satellite clock offsets.

Note: an earlier version of this analysis considered whether reduced atmospheric density, rather than velocity-based time dilation, could account for the extended survival. This was ruled out: the same gamma-based lifetime extension is observed in particle accelerator experiments conducted in a hard vacuum, with no atmosphere present. The effect depends only on velocity, consistent with Section 2.

Anchor 2: The Ives-Stilwell Experiment (1938)

The Phenomenon

Ives and Stilwell accelerated hydrogen ions (H2+, H3+) through voltages of roughly 6,700-18,400 V, producing ion speeds around 0.003c-0.007c, and measured the Balmer hydrogen-beta emission line (rest wavelength lambda_0 = 4861 angstroms). Rather than measuring decay or survival, this isolates time dilation directly via the transverse Doppler effect: averaging the forward- and backward-shifted spectral lines cancels the ordinary, first-order Doppler shift, leaving only the second-order relativistic residual.

Calculation

Expanding the relativistic Doppler formula for light emitted toward and away from the observer and averaging: lambda_avg = lambda_0 x (1 + beta^2/2), where beta = v/c. This is exactly the leading-order expansion of the foundation's gamma factor (gamma ~= 1 + beta^2/2 for small beta) -- built here using only the foundation's Section 2 output (the moving ion's internal oscillator ticks slow by 1/gamma) combined with ordinary, non-relativistic Doppler shift, with no additional imported formula.

Using a representative v = 0.005c: Delta-lambda = lambda_0 x beta^2/2 = 4861 x (0.005)^2/2 ~= 0.0608 angstroms.

Result

The historical record states that at v = 0.005c, the predicted shift was a 4861.06 angstrom line -- a shift of about 0.06 angstroms from the 4861 angstrom rest line. This matches the calculation above almost exactly. Ives and Stilwell's actual measurements (shifts up to 0.047 angstroms in 1938, up to 0.11 angstroms in an improved 1941 run at higher voltage) confirmed this pattern and ruled out non-relativistic emission theories, which predicted no such shift at all. Confirmed -- a third independent anchor, and the most direct spectroscopic test of the three.

Anchor 3: The Pound-Rebka Experiment (1959)

The Phenomenon

Pound and Rebka measured the gravitational redshift of 14.4 keV gamma rays from Fe-57 decay across a 22.5-meter tower at Harvard's Jefferson Physical Laboratory, using the Mossbauer effect to achieve the extreme precision required to detect a shift this small.

Calculation

Applying the foundation's Section 3 result directly: Delta-f/f = gh/c^2 (uniform-field approximation, valid over this height).

$$\text{Delta-f/f} = (9.81 \times 22.5) \,/\, (3\text{x}10\text{^}8)\text{^}2 = 220.7 \,/\, 9\text{x}10\text{^}16 \sim= 2.453 \times 10\text{^}-15$$

Result

The historically predicted value was 2.46 x 10^-15; the historically measured value was (2.56 +/- 0.25) x 10^-15. The foundation's Section 3 formula, applied with nothing but g, h, and c, reproduces the prediction almost exactly. Confirmed -- the cleanest of the anchors, isolating the gravitational term alone with no orbital mechanics or rotatingframe complications.

Attempted, Inconclusive: The Hafele-Keating Experiment (1971)

Real cesium clocks were flown eastward and westward around the world; predicted effects were +144 ns (gravitational) and -184 ns (velocity) eastward, +179 ns and +96 ns westward, against measured totals of -59 ns and +273 ns.

Using real flight data (eastward: 41.2 hours airborne, 8.90 km average altitude; westward: 48.6 hours, ~9.4 km average altitude), the foundation's Section 3 formula reproduced the gravitational term almost exactly: 143.9 ns predicted vs. 144 ns official (eastward), 179.3 ns vs. 179 ns (westward).

The velocity term could not be reproduced with the same precision. It requires integrating actual ground speed and latitude leg-by-leg along the real flight paths (Earth's rotation means velocity must be measured relative to Earth's center, not the ground, and the sign flips between eastward and westward flight). A representative single-averagelatitude estimate gave the correct sign and order of magnitude but not an exact match, and the detailed flight-log data needed for an exact reproduction was not available. Per the standing rule below, this is recorded as attempted and inconclusive rather than omitted or forced to an approximate match presented as exact.

Partially Resolved: Mercury's Perihelion Precession

The Phenomenon

Mercury's orbit is an ellipse whose orientation slowly rotates (precesses) over time. After subtracting the Newtonian gravitational effect of all other planets (531 arcseconds per century, with Venus as the single largest contributor at 227.9 arcseconds per century), a leftover advance of 43 arcseconds per century remains unexplained by Newtonian mechanics alone. The standard general-relativistic prediction, Delta-phi = 6*pi*GM/(c^2*a*(1-e^2)), gives 43.03 arcseconds per century using Mercury's real orbital data (a = 5.791 x 10^10 m, e = 0.2056). The same formula correctly predicts the effect for Venus (8.63"/century), Earth (3.84"/century), and the Hulse-Taylor binary pulsar (~4.2 degrees/year), confirming this is one mass-and-distance-dependent effect present at every orbital scale.

Candidate Mechanisms Tested and Ruled Out

An extended search, using only real, checkable data at each step, ruled out: the orbiting body's own heat; the Sun's magnetic field at any field strength (via the Hulse-Taylor pulsar, whose stars carry magnetic fields up to a

quadrillion times the Sun's yet obey the identical formula); magnetism as a generative source of gravity (via magnetars vs. ordinary neutron stars of equal mass); gravitomagnetism from solar rotation (real, but ~0.01-0.02 arcseconds per century, too small); composition, atmosphere, and water content; solar oblateness (~0.01 arcseconds per century, too small); other planets' gravity (already fully included in the 531 arcsecond Newtonian baseline); solar radiation, solar wind, reflected light, and radioactive emission (too weak by many orders of magnitude); periodic solar-cycle patterns; orbital plane tilt; simple delayed gravitational propagation (reintroduces the orbitaldecay problem identified by Laplace); and a measurement-based account in which a mass-slowed clock alone distorts distance measurement (collapses back into the existing time-dilation effect, in the wrong direction).

Mechanism: Mismatched Radial and Angular Rates

A closed, non-precessing orbit requires the angular sweep rate and the radial (near-far-near) oscillation rate to match exactly; this exact match is a special property of a pure inverse-square force (Bertrand's theorem) and is why plain Newtonian orbits do not precess. A correction to the force law that departs from pure 1/r^2 breaks this match, causing the orbit's near-point to arrive at a slightly different angle each orbit -- the precession.

Derivation of the Flow Speed (Independently Derived From the Foundation)

A candidate physical picture supplying a correction of the necessary size and shape treats space itself as flowing radially inward toward a mass, with the flow speed at distance r derived as follows. The foundation's postulate of eternal, undirected motion implies that, at infinite distance from any mass, this motion has no net inward component -- a boundary condition of zero inward flow speed at r = infinity. Treating the inward-organizing motion as falling freely under the foundation's existing mass-attraction mechanism from this zero-speed boundary condition, ordinary energy conservation gives:

$$(1/2)v^2 = GM/r, \text{ so } v\_flow(r) = sqrt(2GM/r)$$

This reproduces the Newtonian escape velocity as the flow speed at any radius, derived here from the foundation's own boundary condition at infinity combined with energy conservation, rather than adopted directly from the published river-model literature.

Combining the Flow With Orbital Motion (Adopted From Established Physics)

Combining this flow with a planet's own orbital motion to obtain the full orbit equation requires treating the flowing space as a complete space-and-time measuring structure (a metric) and assuming a free-falling body follows the path that extremizes its own elapsed time through that structure (the geodesic principle). Direct calculation confirms that applying this framework to the derived flow speed reproduces the exact orbit equation, d^2u/dphi^2 + u = GM/L^2 + (3GM/c^2)u^2, and, following through as a small correction to a closed ellipse, gives:

$$\text{Delta-phi (per orbit)} = 6*pi*GM / [a(1-e^2)c^2] \sim= 0.1035 \text{ arcseconds; total} \sim= 43.0 \text{ arcseconds per century}$$

This matches the accepted value (43.03 arcseconds per century) essentially exactly. The metric and geodesic framework used to combine the flow speed with orbital motion is an established, independently-verified tool of General Relativity, adopted here rather than derived from the foundation's four original postulates -- the same status as the equivalence principle used in Section 3 of the foundation paper.

Status

The flow speed v_flow(r) = sqrt(2GM/r) is now derived independently from the foundation's own postulates (undirected motion at infinity, plus energy conservation), rather than adopted from the literature. The framework used to combine this flow with a planet's own motion (the metric and geodesic principle) remains an adopted, established tool, on the same footing as the equivalence principle used elsewhere in this work. With both pieces in place, the mechanism reproduces the correct, real value for Mercury, and is known to do the same for every other planet and for extreme cases such as the Hulse-Taylor pulsar, since the underlying framework is an exact reformulation of General Relativity rather than an approximation.

Standing Note

Each anchor added to this document is subject to the same requirement: a full, shown calculation, checked against a real, independently published measurement, with no free parameters adjusted after the fact to fit the result. An anchor that does not hold up under this standard, or that cannot be completed with available data, is recorded as such, not omitted.