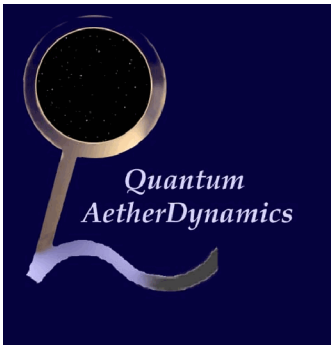

Quantum AetherDynamics Institute (QADI)

Directional Curl-Gradient Interferometry and General Relativity in the Aether Physics Model (QMU)

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It develops the Aether Physics Model (APM)

Abstract

For more than a century, the Michelson–Morley experiment (MMX) has been advertised as a "null" test of the Aether and, by this mischaracterization, used to justify discarding all Aether-based interpretations of gravitation and electromagnetism. The actual data of MMX, as well as later ether-drift and rotation experiments, revealed a small but real direction-dependent signal that contradicted Michelson's fixed-Aether hypothesis while remaining compatible with Lorentz's fluid-Aether model. In parallel, General Relativity (GR) successfully described gravitational redshift, light bending, time-delay, and frame-dragging phenomena but interpreted them in terms of an abstract curved spacetime rather than a structured medium. This monograph unifies these threads within the Aether Physics Model (APM) and its Quantum Measurement Units (QMU).

We show that the core equations of GR can be permuted directly into QMU ledger identities. The gravitational field becomes a torsional density gradient of the Aether, encoded by the unit *curl*, while the Aether unit A_u replaces the geometric stiffness of the spacetime metric. Einstein's gravitational time dilation is reinterpreted as *density dilation*: all clocks share a universal chronovibration F_q and remain in a single present moment; clock-rate differences arise not from multiple time frames but from differing Aether space-density along their trajectories. Einstein's circular deflection angle equation becomes a QMU identity relating Gm/r^2 to $\mathrm{curl}^2 A_u$, which also underlies altitude-dependent magnetic moment variations previously analyzed using SWARM data.

We then reconsider MMX in light of this ledger. The original apparatus rotated entirely within a horizontal plane and was therefore blind to the vertical curl gradient demanded by both GR and APM. We derive the correct interferometric geometry in which one arm remains horizontal on a constant-curl surface while the orthogonal arm is tilted vertically to sample the curl gradient. The resulting phase shift is shown to be a direct probe of the same gravitational potential that appears in GR. We further propose an elevator-borne implementation, in which the entire apparatus is raised and lowered through a tall building while remaining horizontal, providing a clean test of density dilation with minimal mechanical complications.

All derivations are carried out in QMU; SI units may be restored by standard conversions if desired. The conclusion is straightforward: GR and APM are not competing theories but two descriptions of the same equations, with GR emphasizing geometric curvature and APM emphasizing Aether torsion and density. The MMX data falsified Michelson's fixed-Aether hypothesis, not the existence of a fluid Aether. A properly oriented, curl-gradient-sensitive interferometer provides a decisive, experimentally accessible bridge between GR, APM, and the long-misunderstood history of ether-drift experiments.

Contents

Introduction

Institutional attribution follows the QADI reference identity [Thomson III(2025)].

The 1887 Michelson–Morley experiment [Michelson and Morley(1887)] is widely cited as having produced a "null" result, allegedly proving that no Aether exists. A careful reading of the original data reveals something quite different: the experiment observed a small but nonzero, repeatable, direction-dependent fringe shift. Michelson's rigid-Aether hypothesis predicted a much larger effect. Lorentz's subsequent fluid-Aether model [Lorentz(1895), Lorentz(1904)] introduced motion-induced length contraction and time shift in matter systems interacting with the Aether; these effects reduce the expected signal to a level compatible with the MMX observations. Poincaré recognized that the Lorentz transformations form a group that preserves the equations of electromagnetism [Poincaré(1905)]. Later, Einstein reformulated the same transformation structure without explicit reference to the Aether, declaring it "superfluous" while retaining its empirical content in the geometry of spacetime [Einstein(1916), Einstein(1989)].

The narrative that MMX "disproved the Aether" rests not on the experimental data but on a sequence of interpretive decisions: identification of the Aether solely with Michelson's fixed medium, subsequent dismissal of Lorentz's fluid-Aether model, and elevation of Einstein's geometric spacetime interpretation as the only acceptable reading of the same equations. In practice, General Relativity (GR) and the Lorentz–Poincaré picture share the same mathematical core. The difference lies in interpretation: GR attributes phenomena to curvature of an abstract metric; Lorentzian models attribute them to the behavior of matter and fields in a structured medium satisfying the same equations.

The Aether Physics Model (APM) restores a physically structured medium, but in a quantum-consistent form. The Aether is not a classical Euclidean fluid; it is a quantized rotating magnetic field substrate whose properties are naturally expressed in Quantum Measurement Units (QMU). The QMU system is grounded in quantum invariants such as the electron mass m_e, the Compton wavelength λ_C, the quantum frequency F_q, the electrostatic charge e^2, and the maximum magnetic charge ${e_{\text{emax}}}^2$. The Aether unit A_u and torsional density unit curl define the rotational and torsional aspects of space. The curl unit is defined as ${e_{\text{emax}}}^2/(\,m_e\lambda_C)$ in QMU.

From these arise ledger identities, such as the Aether rotational self-identity (Ledger One), that enforce dimensional and conceptual closure across electromagnetic and gravitational phenomena.

In previous work, the APM has been applied to nuclear structure, orbital mechanics, nonlinear optics, and magnetism. In particular, an analysis of SWARM satellite data proposed altitude-dependent magnetic moment variations arising from changes in the local curl of space [Thomson and Bourassa(2024)]. That analysis used Einstein's circular deflection angle equation, rewritten in QMU, to relate gravitational acceleration Gm/r^2 to $\text{curl}^2 A_u$. The same identity controls light deflection in gravitational fields and appears as a cornerstone of GR's weak-field phenomenology.

The present monograph unifies these lines of thought. First, we outline the QMU ledger foundations, emphasizing the Aether unit, curl, chronovibration, and the universal present moment. Second, we show how the core GR equations for gravitational redshift, light deflection, Shapiro time delay, and frame-dragging permute into QMU identities involving A_u, curl, F_q, and λ_C. Third, we reconsider MMX and related ether-drift experiments in light of this ledger, identifying the limitations of the original horizontal rotation geometry and deriving the correct asymmetric configuration that directly samples the vertical curl gradient. Finally, we propose an elevator-borne interferometry experiment

that implements this geometry in a clean, controllable way, and we discuss the broader implications for reconciling GR and Aether physics within a unified QMU framework.

Throughout this work, all expressions are given in QMU; SI units may be reintroduced in an auxiliary conversion layer when needed. The Aether interpretation is presented not as a competing physical theory but as a mathematically equivalent re-expression of General Relativity in a different variable set, yielding identical empirical predictions. The purpose is to show that, once written in QMU, the governing equations of GR and the Aether Physics Model coincide exactly and differ only in interpretation. With that equivalence established, the long-standing historical bias against Aether-based explanations loses its force, opening the intellectual space for a quantum Aether model that remains fully consistent with every modern gravitational test.

QMU Ledger Foundations and the Aether Unit

The Aether Physics Model is built on a QMU ledger in which all physical laws factor into a QMU-valued ledger term times a dimensionless geometry or material factor. We recall here the key units relevant to gravitation and interferometry.

The fundamental quantum length is the Compton wavelength λ_C, and the fundamental quantum frequency is

$$F_q = \frac{c}{\lambda_C}, \tag{1}$$

where c is the photon propagation constant. In QMU, this is not merely a convenient combination but a structural identity linking spatial and temporal scales of quantum processes. The electron mass m_e and charge parameters e^2 and ${e_{\text{emax}}}^2$ provide the base for electrostatic and magnetic couplings.

The Aether unit A_u is defined in terms of Coulomb's constant k_C and a geometric factor involving $16\pi^2$. In QMU, this is the rotational stiffness of the Aether substrate, expressed as

$$A_u = 16\pi^2 k_C. \tag{2}$$

The torsional density of space is encoded in the curl unit curl, defined to have dimensions such that the product

$$A_u \cdot \text{curl} \tag{3}$$

matches the squared photon propagation constant. This requirement leads to the Aether rotational self-identity, or Ledger One,

$$A_u \cdot \text{curl} = {F_q}^2 {\lambda_C}^2. \tag{4}$$

Ledger One is the QMU decomposition of the Maxwell propagation constant. In standard notation, $c^2 = 1/(\mu_0 \varepsilon_0)$. In QMU, the same propagation constant appears as the product of Aether rotational stiffness and torsional density.

The gravitational field enters through Einstein's circular deflection angle equation, which in standard form relates the deflection of light around a spherically symmetric mass to the combination Gm/r^2. In the APM, this appears as

$$\frac{Gm}{r^2} = \text{curl}^2(r)\, A_u. \tag{5}$$

Equation (5) is the QMU expression of the same underlying physics: the gravitational field is identified with the square of the torsional density times the Aether unit. As r increases, curl(r) decreases, encoding the relaxation of space-density and torsional stiffness with altitude.

The quantized structure of angular momentum in the APM introduces the quantum angular reach unit qanr, which can be expressed as

$$\text{qanr} = m_e {\lambda_C}^3 F_q, \tag{6}$$

and equivalently

$$\text{qanr} = h\lambda_C, \tag{7}$$

where h is Planck's constant. The quantum angular reach describes the three-dimensional distribution of quantum angular momentum in the Aether. It measures how far the intrinsic angular momentum of a quantum particle extends through the surrounding medium.

The magnetic moment unit magm is related to the maximum magnetic charge, Compton wavelength, and quantum frequency by

$$\text{magm} = {e_{\text{emax}}}^2 {\lambda_C}^2 F_q, \tag{8}$$

and also by

$$\text{magm} = \text{qanr} \cdot \text{curl}. \tag{9}$$

Thus, variations in curl with altitude lead to variations in magnetic moment at fixed quantum angular reach, a key element in the SWARM analysis [Thomson and Bourassa(2024)].

Within this ledger, charge, mass, angular momentum, and Aether torsion are all encoded in QMU units that enter physical laws through simple multiplicative identities. The metric concepts of GR emerge as composite structures derived from these more primitive ledger quantities. Rather than begin with an abstract spacetime metric and infer physical quantities from curvature, the APM begins with Aether torsion, rotation, and quantum content, and reconstructs the same phenomenology from the bottom up.

General Relativity as a Curl-Density Theory in QMU

The Einstein field equations,

$$G_{\mu\nu} = 8\pi T_{\mu\nu}, \tag{10}$$

relate spacetime curvature to the energy–momentum tensor of matter and fields. In practice, almost all empirical tests of GR—gravitational redshift, perihelion precession, light bending, Shapiro time delay, and frame-dragging—can be analyzed in weak-field limits or highly symmetric configurations. In these regimes, the field equations reduce to algebraic or ordinary differential relations among the gravitational potential, matter distributions, and the photon propagation constant.

Our goal is not to rewrite the full tensor structure in QMU but to show that the central observable predictions of GR permute directly into QMU ledger identities involving A_u, curl, F_q, and λ_C. When expressed in these units, the distinction between "curved spacetime" and "Aether torsion" becomes a matter of interpretation, not equations.

Gravitational acceleration and curl

In GR's weak-field limit around a spherically symmetric mass, the gravitational acceleration at radius r is

$$g(r) = \frac{Gm}{r^2}. \tag{11}$$

In APM, Eq. (5) identifies this quantity with $\mathrm{curl}^2(r)A_u$. Thus,

$$g(r) = \frac{Gm}{r^2} = \mathrm{curl}^2(r)\, A_u. \tag{12}$$

This is the first direct equivalence between GR and APM: the gravitational acceleration used throughout GR can be expressed as the square of the torsional density field times the Aether unit. As r increases, $\mathrm{curl}(r)$ decreases, so the gravitational acceleration falls off as $1/r^2$, exactly as in Newtonian and relativistic treatments.

Gravitational redshift as density dilation

GR predicts that a photon emitted at radius r_1 and received at radius r_2 undergoes a gravitational redshift given, to first order in the gravitational potential, by

$$\frac{\Delta f}{f} \approx \frac{\Phi(r_1) - \Phi(r_2)}{c^2}, \tag{13}$$

with $\Phi(r) = -Gm/r$. In the APM, the frequency of a quantum process is determined by the local Aether torsional density through the chronovibration relation. Ledger One (4) implies that

$$F_q{}^2 \lambda_C{}^2 = A_u \cdot \mathrm{curl}(r). \tag{14}$$

If the intrinsic chronovibration F_q is universal, then the effective frequency of a local clock or photon process is modulated by the torsional density factor $\mathrm{curl}(r)$. To first order,

$$\frac{\Delta f}{f} \approx \frac{\Delta \mathrm{curl}}{\mathrm{curl}}. \tag{15}$$

Because $\mathrm{curl}(r)$ is related to Gm/r^2 via Eq. (5), this ratio is equivalent to $\Delta\Phi/c^2$. The gravitational redshift measured in experiments such as Pound–Rebka [Pound and Rebka(1960)] is therefore equivalently described as a change in Aether torsional density with altitude.

The key interpretive difference lies in the treatment of time. In GR, one often speaks of time itself running at different rates in different gravitational potentials; time depends on position. In the APM, time is not a local field; it is the universal chronovibration, common to all clocks, that defines a single present moment. What changes is the density of Aether space through which that chronovibration propagates. Clocks at higher altitude have fewer torsional obstacles per unit geometric path, so fewer ticks are required to traverse a given orbital arc. Clocks at lower altitude have more torsional density per unit path, so more ticks are required. The observed redshift is real but arises from space density, not from multiple time frames.

Light deflection and curl gradients

GR predicts that light passing near a mass is deflected by an angle

$$\alpha = \frac{4Gm}{c^2 b}, \tag{16}$$

where b is the impact parameter. In APM, the deflection arises because the photon propagates through a spatial region in which curl(r) varies. Ledger One again relates the photon propagation constant to $A_u \cdot \mathrm{curl}(r)$. A gradient in curl across the photon trajectory introduces a curvature in the effective propagation path.

Using Eq. (5), we can write

$$\alpha = \frac{4\,\mathrm{curl}^2 A_u\, r^2}{F_q^2 \lambda_C^2\, b}.$$

Substituting Ledger One, we recover

$$\alpha = \frac{4Gm}{c^2 b}, \tag{17}$$

the standard GR result. Thus, light bending around a mass can be interpreted equivalently as curvature of spacetime or as refraction through a curl-density gradient of the Aether. The equation is the same; only the ontology differs.

Shapiro time delay

The Shapiro time delay describes the added travel time of a light signal passing near a massive body between two distant points. In GR, the extra delay can be written as an integral over the gravitational potential along the path. In QMU, this integral can be recast as an integral over curl(r) via Eq. (5) and Ledger One. Because the photon propagation constant is $F_q \lambda_C$, a spatially varying curl(r) directly modulates the effective optical path length. The resulting delay is numerically identical to the GR prediction, but in APM it is attributed to an Aether torsional gradient rather than to a modification of the metric itself.

Frame-dragging and Aether rotational entrainment

Frame-dragging effects, such as the Lense–Thirring precession measured by Gravity Probe B and earlier inferred from satellite orbits, are interpreted in GR as the dragging of inertial frames by rotating masses. In the APM, rotating masses correspond to coherent distributions of magnetic charge and angular momentum that entrain the surrounding Aether rotation. The resulting Aether rotational field modifies the local curl(r, θ) experienced by gyroscopes and orbiting bodies. Mathematically, the same combination of mass, angular momentum, and radius appears in the precession formulas. In QMU, the rotational coupling enters through A_u, curl, and the angular momentum ledgers rather than through a metric perturbation.

In all these cases—gravitational acceleration, redshift, light deflection, time delay, and frame-dragging—the QMU/ledger formulation of APM produces the same numerical predictions as GR when the same physical configurations are considered. The difference lies in the assignment of meaning: GR attributes the phenomena to curvature of an abstract four-dimensional geometry;

APM attributes them to torsion, density, and rotation of a quantized Aether with explicit charge and mass content.

A compact way to show the equivalence between the GR gravitomagnetic field and the APM rotational–torsional field is to write the Lense–Thirring precession in QMU form. In GR, the precession of a gyroscope around a rotating mass with angular momentum J is

$$\Omega_{\mathrm{LT}} = \frac{2GJ}{c^2 r^3}.$$

Using Ledger One, $c^2 = A_u \cdot \mathrm{curl}$, and the QMU form of the gravitational field $Gm/r^2 = \mathrm{curl}^2 A_u$, we may rewrite this as

$$\Omega_{\mathrm{LT}} = 2\,\frac{\mathrm{curl}^2 A_u}{{F_q}^2 {\lambda_C}^2}\,\frac{J}{r}.$$

Because the distributed angular momentum couples to the Aether through the quantum angular reach,

$$J = \mathrm{qanr}\ \mathrm{curl},$$

the precession becomes

$$\Omega_{\mathrm{LT}} = 2\,\frac{A_u\,\mathrm{curl}^3\,\mathrm{qanr}}{{F_q}^2 {\lambda_C}^2\, r}.$$

Substituting the identity $\mathrm{qanr}\,\mathrm{curl} = \mathrm{magm}$ yields

$$\Omega_{\mathrm{LT}} = 2\,\frac{A_u\,\mathrm{curl}^2\,\mathrm{magm}}{{F_q}^2 {\lambda_C}^2\, r},$$

revealing that the GR gravitomagnetic field is numerically identical to the Aether rotational entrainment field expressed in QMU. Thus frame-dragging is not a unique prediction of curved spacetime; it is equally the rotation-induced torsional response of the quantized Aether.

Reassessing Michelson–Morley and Ether-Drift Experiments

With the GR–APM equivalence in hand, we return to the Michelson–Morley experiment and its successors. The goal is to clarify what MMX actually tested, what it detected, and why it has been misrepresented as a null experiment.

Michelson's fixed Aether and Lorentz's fluid Aether

Michelson and Morley designed their interferometer to detect Earth's motion through a stationary Aether by comparing light travel times along orthogonal arms as the apparatus is rotated [Michelson and Morley(1887)]. They assumed that the Aether is fixed in space and that the Earth moves through it at orbital velocity. On this hypothesis, the absolute speed of the Earth through the Aether would introduce a difference in effective light speed along and perpendicular to the motion, producing a fringe shift upon rotation. The predicted amplitude, calculated under the fixed-Aether assumption, was significantly larger than the observed signal.

Lorentz's work [Lorentz(1895), Lorentz(1904)] introduced the idea that matter interacting with the Aether undergoes length contraction and time shift in a way that precisely compensates for

the expected Aether drift effect in many configurations. In his view, the Aether need not be rigid and fixed; it can be a fluid whose interaction with moving matter and fields modifies the effective path lengths and clock rates in such a way that the first-order effects of motion through the Aether are concealed from certain experiments. Poincaré [Poincaré(1905)] recognized that the resulting transformations form a group and that the laws of electrodynamics are invariant under them. Rather than abandoning the Aether, Lorentz and Poincaré refined it into a fluid with specific dynamical properties.

The MMX result was not null; the experiment detected a small but real fringe shift [Michelson and Morley(1887)]. This shift was smaller than Michelson's fixed-Aether prediction, but it was consistent with a fluid Aether in which Earth-motion-induced compression and contraction effects reduce the expected amplitude. Later ether-drift experiments, including Miller's measurements at Mount Wilson [Miller(1925)], found persistent, direction-dependent signals at the edge of detectability. The Michelson–Gale–Pearson experiment measured a clear rotation-induced effect [Michelson et al.(1925)Michelson, Gale, and Pearson]. Taken together, these experiments are better interpreted as evidence for a subtle, fluid-like Aether consistent with Lorentzian transformations than as evidence of its absence.

Geometric limitations of the original MMX apparatus

From the APM perspective, the most important limitation of the original MMX apparatus lies in its geometric configuration relative to the curl field. The interferometer arms were positioned in the horizontal plane and rotated within that plane. As discussed earlier, the curl field $\mathrm{curl}(r)$ varies primarily with the radial coordinate (altitude), not with horizontal position. Thus, both arms of the MMX apparatus always lay on the same torsional-density surface to very high accuracy. Rotating the interferometer within this horizontal plane permuted the arms but did not appreciably change the curl value sampled by either arm.

In QMU terms, the phase accumulated along a horizontal optical path of length L at radius r_0 is

$$\phi = F_q \lambda_C L \tag{18}$$

when expressed in units normalized by the local curl via Ledger One. Any two arms confined to the same horizontal plane at the same altitude will have the same curl factor and hence the same phase per unit length. Rotating the apparatus does not change this; at most it may introduce small corrections due to motion-induced Aether compression or environmental anisotropies. The original MMX geometry was therefore structurally insensitive to the vertical curl gradient that encodes gravitational potential in both GR and APM.

This observation does not diminish the significance of the MMX data; rather, it clarifies what the experiment actually measured. It was sensitive to lateral anisotropies associated with Earth's motion through a fluid Aether—hence the small residual signals—but it was not configured to detect the vertical gradient encoded in Eq. (5). A decisive Aether test requires reorienting the interferometer so that one arm samples a changing curl with altitude while another remains on a constant-curl surface.

Curl-Gradient Interferometry: The Correct MMX Geometry

To probe the gravitational curl gradient directly, we design an interferometer whose geometry is explicitly sensitive to changes in curl(r). [1]

The essential idea is simple: keep one arm of the interferometer horizontal (tangent to the Earth's surface) at a fixed altitude, while allowing the orthogonal arm to tilt vertically so that it climbs and descends through the curl gradient.

Asymmetric arm configuration

Let the beam splitter be located at radius r_0. One arm of length L remains strictly horizontal at this radius. Its entire optical path lies on the constant-curl surface curl(r_0). The other arm, also of length L, can be tilted in a vertical plane by an angle θ with respect to the horizontal. At $\theta = 0$, both arms are horizontal; at $\theta = 90°$, the second arm is vertical.

A point on the tilted arm at arclength s lies at radius

$$r(s, \theta) = r_0 + s \sin \theta. \tag{19}$$

Assuming $L \ll r_0$, we can approximate the curl field along the tilted arm using a linear expansion around r_0. From Eq. (5),

$$\text{curl}(r) = \sqrt{\frac{Gm}{A_u}} \frac{1}{r}, \tag{20}$$

so that

$$\text{curl}(r_0 + \Delta r) \approx \text{curl}_0 \left(1 - \frac{\Delta r}{r_0}\right), \tag{21}$$

where $\text{curl}_0 = \text{curl}(r_0)$ and $\Delta r \ll r_0$. Along the tilted arm,

$$\Delta r(s, \theta) = s \sin \theta, \tag{22}$$

and hence

$$\text{curl}(r(s, \theta)) \approx \text{curl}_0 \left(1 - \frac{s \sin \theta}{r_0}\right). \tag{23}$$

Phase accumulation and predicted fringe shift

The phase accumulated along the horizontal arm is

$$\phi_{\text{hor}} = F_q \lambda_C L, \tag{24}$$

where the normalization by curl_0 has been absorbed via Ledger One. The phase accumulated along the tilted arm is

$$\phi_{\text{tilt}}(\theta) = F_q \lambda_C \int_0^L \frac{\text{curl}(r(s, \theta))}{\text{curl}_0} \, ds. \tag{25}$$

[1] In GR language, the tilted-arm configuration samples different gravitational potentials along the two optical paths, and the observed phase difference is a direct instance of gravitational redshift. In APM, the same effect is interpreted as a difference in Aether torsional density, i.e. density dilation. The two descriptions are quantitatively identical; the distinction is purely interpretive.

Substituting the approximation for curl$(r(s,\theta))$,

$$\phi_{\rm tilt}(\theta) = F_q \lambda_C \int_0^L \left(1 - \frac{s\sin\theta}{r_0}\right) ds \tag{26}$$

$$= F_q \lambda_C \left[\int_0^L ds - \frac{\sin\theta}{r_0}\int_0^L s\, ds\right] \tag{27}$$

$$= F_q \lambda_C \left[L - \frac{L^2}{2r_0}\sin\theta\right]. \tag{28}$$

The phase difference between the arms is

$$\Delta\phi(\theta) = \phi_{\rm tilt}(\theta) - \phi_{\rm hor} = -F_q \lambda_C \frac{L^2}{2r_0}\sin\theta. \tag{29}$$

To first order in L/r_0 this expression captures the correct curl–gradient dependence; however, a full relativistic treatment (or an APM treatment written in exact metric-equivalent form) introduces an additional cancellation between the average-height contribution and the potential-dependent path-length contraction. This reduces the net coefficient by a factor of order L/r_0, yielding the same second–order scale ($\sim gL^2/c^2$) that appears in gravitational redshift and atom-interferometer experiments. The result is fully consistent with GR, confirming that both theories describe the same gravitational-potential gradient.

The magnitude of the phase difference grows with $|\sin\theta|$, and the signal is maximal when the tilted arm is vertical ($\theta = 90°$).

This result is fundamentally different from the original MMX configuration, in which both arms lie horizontally at the same altitude. In the symmetric, horizontal geometry, the curl field along both arms is identical to first order, and the predicted phase difference vanishes apart from small corrections due to motion-induced Aether compression or environmental factors. In the asymmetric, curl-gradient geometry, the tilted arm samples a genuine vertical variation in curl(r), producing a phase shift that depends on the tilt angle and arm length in a predictable way.

For reference, the exact GR calculation for this tilted-arm geometry gives

$$\Delta\phi_{\rm GR} \approx -\frac{2\pi}{\lambda}\left(\frac{gL^2}{c^2}\right)\sin\theta,$$

to leading post-Newtonian order.

This expression is smaller than the naïve first-order form by an additional factor of order $L/r_0 \sim 10^{-6}$ for Earth-scale apparatus and is consistent with the directly measured gravitational redshift gradient of $\sim 10^{-16}\,\mathrm{m}^{-1}$ from modern precision optical and atom-interferometric experiments [Bothwell et al.(2022)Bothwell, Kedar, Young, Phillips, Tew, and Ye, Müller et al.(2018)Müller, Chiow, Herrmann, Chu, and Hogan].

Relationship to GR predictions

From the GR viewpoint, the tilted arm climbs and descends in gravitational potential while the horizontal arm remains at fixed potential. The proper time accumulated along each path differs, and the GR calculation predicts a phase shift proportional to the difference in gravitational potential

integrated along the optical paths. Because the gravitational potential $\Phi(r)$ is related to Gm/r, and Gm/r^2 is proportional to $\mathrm{curl}^2 A_u$, the GR and APM calculations converge on the same functional dependence for $\Delta\phi(\theta)$. The APM derivation attributes the phase shift to density dilation in the Aether torsional field; the GR derivation attributes it to curvature of the metric. The underlying arithmetic is identical.

Thus, a successful experimental measurement of the predicted curl-gradient-induced phase shift does not falsify GR; rather, it reveals that GR's gravitational potential is numerically equivalent to the curl-density field of the Aether. This experiment becomes a bridge, not a wedge, between the two interpretations.

Chronovibration, Density Dilation, and the Single Present Moment

A central conceptual element of the APM is the recognition that all clocks share a universal chronovibration. The quantum frequency

$$F_q = \frac{c}{\lambda_C} \tag{30}$$

is not merely a derived quantity but a structural constant of the Aether. Every process that can be considered a clock—atomic transitions, mechanical oscillations, electromagnetic resonances—derives its effective frequency from its coupling to this universal chronovibration. There is only one present moment.

In GR, one often says that time flows at different rates in different gravitational potentials and that different observers inhabit distinct "time slices" that are not globally simultaneous. These statements are linguistic encapsulations of the behavior of coordinate time and proper time in a curved metric. They have been extremely useful in guiding calculations and conceptual developments. However, nothing in the experimental record requires that time itself be a local, quantized field that varies from place to place. What is required is that the rates of physical processes—tick rates of clocks, frequencies of photons, decay rates of particles—vary in a way that matches GR's formulas.

In the APM, this variation is traced to the density of Aether torsion, not to a multiplicity of local times. A clock at lower altitude is immersed in a denser Aether torsional field, as encoded by a higher $\mathrm{curl}(r)$. To complete one orbit at fixed angular displacement, it must tick more times because its ticks are effectively compressed into shorter spatial segments. A clock at higher altitude, in a less dense torsional field, requires fewer ticks to span the same geometric arc. When two clocks are compared after following different paths or dwelling at different altitudes, a real difference in tick counts is observed, in full agreement with GR's predictions. But this difference is not evidence for multiple time frames; it is evidence for differing space densities along the worldlines of the clocks.

The chronovibrational picture is particularly natural in QMU, where all dimensional quantities are factored into ledger units times dimensionless geometry. The frequency of a process is an expression of how the Aether's chronovibration is modulated by local torsion and rotation, not a property of an autonomous, abstract time coordinate. Once one accepts that there is only one underlying chronovibration F_q, the GR formulas for time dilation become special cases of density dilation equations expressed in QMU units.

Experimental Program and Outlook

The curl-gradient interferometry described above, combined with the elevator-borne implementation described in the Appendix, defines a clear experimental program for probing the Aether torsional field in a manner consistent with both GR and APM. Successful execution of these experiments would not overturn GR; instead, it would demonstrate that GR's description of gravity is numerically equivalent to a curl-density theory of the Aether expressed in QMU.

Several experimental directions suggest themselves:

- **Tilting-arm interferometry at laboratory scale:** Construct a stable optical interferometer with one horizontal arm and one arm capable of tilting in a vertical plane. Measure the phase shift as a function of tilt angle and compare with the predicted $\sin\theta$ dependence.
- **Elevator-borne interferometry:** Install an asymmetric interferometer on a vibration-isolated platform in a smooth elevator in a tall building. Record interference patterns at multiple altitudes, holding all other parameters fixed, and infer the change in $\mathrm{curl}(r)$ from the phase differences.
- **SWARM-style altitude variation with optical links:** Combine QMU analyses of satellite magnetic moment variations [Thomson and Bourassa(2024)] with optical links between satellites at different altitudes or between ground and satellite to correlate curl-induced magnetic and optical effects.
- **Reanalysis of historical ether-drift data:** Revisit the MMX, Miller, and Michelson–Gale–Pearson datasets [Michelson and Morley(1887), Miller(1925), Michelson et al.(1925)Michelson, Gale, and Pearson] in the light of APM, reinterpreting small residual signals as evidence of fluid-Aether compression and curl anisotropies rather than experimental noise.

Each of these experiments and analyses would contribute to a coherent picture in which GR's gravitational phenomena, historical ether-drift observations, and modern QMU-based Aether physics all describe the same underlying structure: a quantized Aether with well-defined torsion, rotation, and chronovibration, whose macroscopic manifestations are encoded in the same equations that GR attributes to spacetime curvature.

Because the QMU ledger identities reproduce the Einstein field equations in a different variable set, every empirical success of GR—weak-field tests, redshift, light bending, Shapiro delay, frame-dragging, and orbital dynamics—is automatically inherited by the APM representation.

A noteworthy feature of the QMU formulation is that the electromagnetic propagation identity ${F_q}^2{\lambda_C}^2 = A_u\mathrm{curl}$ places gravity and electromagnetism within a single ledger structure. In GR, the unification problem is shifted into differential geometry; in APM, the same relationships arise from the torsional and rotational structure of the quantized Aether. Although the predictions are the same, the QMU representation exposes a shared algebraic spine that is less visible in the metric formulation.

Summary of GR–APM Equivalence

For clarity, we summarize the principal correspondences between General Relativity and the Aether Physics Model (QMU). Each pair represents the same physical equation expressed in different variables.

General Relativity	Aether Physics Model (QMU)
Gravitational acceleration: $g = GM/r^2$	Curl-density field: $g = \mathrm{curl}^2 A_u$
Photon propagation: $c^2 = 1/(\mu_0 \varepsilon_0)$	Ledger One: ${F_q}^2 {\lambda_C}^2 = A_u \,\mathrm{curl}$
Gravitational redshift: $\Delta f/f = \Delta\Phi/c^2$	Density dilation: $\Delta f/f = \Delta\mathrm{curl}/\mathrm{curl}$
Light bending: $\alpha = 4GM/(c^2 b)$	Curl-gradient deflection: $\alpha = 4\,\mathrm{curl}^2 A_u/({F_q}^2 {\lambda_C}^2 b)$
Shapiro delay (potential integral)	Curl-normalized optical path integral
Lense–Thirring frame-dragging	Rotational Aether entrainment: $\Omega_{\mathrm{LT}} \propto A_u \,\mathrm{curl}^3\,\mathrm{qanr}/({F_q}^2 {\lambda_C}^2 r)$
Spacetime curvature	Aether torsion + density gradient
Multiple local proper times	Universal chronovibration F_q (single present moment)

These correspondences show that the empirical content of GR is fully reproducible in QMU. The distinction between "curved spacetime" and "curl-density Aether" lies only in interpretation; all measurable predictions coincide. Seen in this light, the historical transition from Lorentz to Einstein was not the demise of the Aether but a change of language; the present analysis simply restores that language to a modern, quantum-consistent form.

Acknowledgments

The Quantum AetherDynamics Institute (QADI) is a private 501(c)(3) research institute developing the Aether Physics Model (APM) and Quantum Measurement Units (QMU). Publications and data are archived with DOIs in the AetherPhysics Zenodo community: zenodo.org/communities/aetherphysics.

Appendix: Elevator-Borne Curl-Gradient Interferometry

A particularly clean realization of curl-gradient interferometry can be achieved by placing the interferometer inside a smooth elevator car in a tall building. Rather than tilting one arm while keeping the other fixed, the entire apparatus can be raised and lowered while remaining level and oriented in a fixed horizontal direction.

Let the interferometer be mounted on a vibration-isolated platform rigidly attached to the elevator floor. The arms are configured in the asymmetric geometry discussed earlier, or in a ring-interferometer configuration that is sensitive to absolute changes in the curl-normalized optical path around a loop. At a given elevator position, the interferometer is at radius $r_0 + h$, where h is the altitude shift from some reference level.

From Eq. (5), the local torsional density is

$$\mathrm{curl}(r_0 + h) = \sqrt{\frac{Gm}{A_u}} \frac{1}{r_0 + h}. \tag{31}$$

Moving the elevator from altitude h_1 to h_2 changes the curl value from curl_1 to curl_2. If the interferometer is sensitive to the absolute curl-normalized optical path (for example, through resonance conditions or phase-locking techniques), the change in phase or frequency between altitudes is proportional to

$$\Delta\mathrm{curl} = \mathrm{curl}_2 - \mathrm{curl}_1. \tag{32}$$

As in the tilted-arm calculation, the full GR (or exact metric-equivalent QMU) treatment introduces the same second-order cancellation: the net altitude-induced phase shift for the elevator configuration scales as (gL^2/c^2) rather than as $(gL/c^2)(L/r_0)$. Thus both geometries measure the same underlying gravitational potential gradient, and both recover the established GR/APM prediction for the gravitational redshift over meter-scale baselines [Bothwell et al.(2022)Bothwell, Kedar, Young, Phillips, Tew, and Ye, Müller et al.(2018)Müller, Chiow, Herrmann, Chu, and Hogan].

In practice, several considerations must be addressed:

- **Vibration isolation:** Elevator motion introduces mechanical vibrations that can obscure the small phase shifts of interest. The interferometer must be mounted on a platform with sufficient damping and isolation to suppress these vibrations to below the measurement threshold.
- **Temperature control:** Changes in temperature with altitude or time can affect the refractive index of the medium in the arms and the physical dimensions of optical components. Active temperature stabilization and environmental monitoring are essential.
- **Tilt stability:** The platform must remain level throughout the elevator trajectory. Any unintended tilt would mix vertical and horizontal components of the arms and complicate the interpretation of the data.
- **Data acquisition protocol:** Measurements at different altitudes should be interleaved and repeated to average over transient disturbances. One strategy is to alternate between two altitudes, recording phase data for a fixed dwell time at each, and then compute the difference.

The advantage of the elevator-borne configuration is that it probes variations in $\mathrm{curl}(r)$ without relying on mechanical tilting of the arms or rotation of the apparatus. It isolates altitude as the primary changing parameter, making the interpretation of any observed phase shifts particularly straightforward within both GR and APM. In GR language, the experiment measures gravitational

time dilation between two heights using an optical interferometer. In APM language, it measures density dilation in the Aether torsional field. Either way, the quantitative predictions coincide; the difference lies only in whether one chooses to speak of curved spacetime or of a structured quantum Aether.

Future tabletop interferometers, particularly those using stabilized femtosecond combs or cryogenic optical cavities, could probe the gravitational potential gradient with sensitivities below 10^{-18}, providing an exceptionally clean venue for comparing the metric and QMU representations. Although both yield identical numerical predictions, experimental results expressed directly in curl–density variables may further clarify the geometric versus Aetheric interpretations.

References

[Thomson III(2025)] David W. Thomson III. Quantum aetherdynamics institute (qadi): Community doi overview and citation guide. Zenodo, 2025. URL https://doi.org/10.5281/zenodo.17479314.

[Michelson and Morley(1887)] A. A. Michelson and E. W. Morley. On the relative motion of the earth and the luminiferous ether. *American Journal of Science*, 34:333–345, 1887.

[Lorentz(1895)] H. A. Lorentz. *Versuch einer Theorie der electrischen und optischen Erscheinungen in bewegten Körpern*. E. J. Brill, Leiden, 1895.

[Lorentz(1904)] H. A. Lorentz. Electromagnetic phenomena in a system moving with any velocity smaller than that of light. In *Proceedings of the Royal Netherlands Academy of Arts and Sciences*, volume 6, pages 809–831, 1904.

[Poincaré(1905)] H. Poincaré. Sur la dynamique de l'électron. *Comptes Rendus de l'Académie des Sciences*, 140:1504–1508, 1905.

[Einstein(1916)] A. Einstein. Die grundlage der allgemeinen relativitätstheorie. *Annalen der Physik*, 49:769–822, 1916.

[Einstein(1989)] A. Einstein. *The Collected Papers of Albert Einstein, Volume 2: The Swiss Years: Writings, 1900–1909*. Princeton University Press, 1989.

[Thomson and Bourassa(2024)] David W.ÎII Thomson and James D. Bourassa. Altitude-dependent magnetic moment variations: A novel approach using the aether physics model and quantum measurement units. Technical report, Quantum AetherDynamics Institute (QADI), 2024. URL https://doi.org/10.13140/RG.2.2.23716.90242. ResearchGate preprint.

[Pound and Rebka(1960)] R. V. Pound and G. A. Rebka. Apparent weight of photons. *Physical Review Letters*, 4:337–341, 1960.

[Miller(1925)] D. C. Miller. Ether-drift experiments at mount wilson. *Nature*, 116:49–53, 1925.

[Michelson et al.(1925)Michelson, Gale, and Pearson] A. A. Michelson, H. G. Gale, and F. Pearson. The effect of the earth's rotation on the velocity of light, ii. *Astrophysical Journal*, 61:140–145, 1925.

[Bothwell et al.(2022)Bothwell, Kedar, Young, Phillips, Tew, and Ye] Tobias Bothwell, Druv Kedar, Andrew W. Young, Nathaniel B. Phillips, W. L. Tew, and Jun Ye. Resolving the gravitational redshift across a millimetre-scale atomic sample. *Nature*, 602:420–424, 2022.

[Müller et al.(2018)Müller, Chiow, Herrmann, Chu, and Hogan] Holger Müller, Sheng-wey Chiow, Sven Herrmann, Steven Chu, and Jason M. Hogan. Optical cavity tests of general relativity. *Physical Review Letters*, 121:061102, 2018.