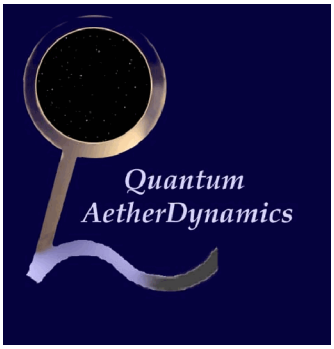

Quantum AetherDynamics Institute (QADI)

Mass–Energy Ledgers in QMU and Relativity: Constructive Aether Geometry versus Principle Theory

David W. Thomson III
Quantum AetherDynamics Institute (QADI), Alma, Illinois, USA
ORCID: 0000-0002-5830-5427

Version 1.0 – December 4, 2025

This article is published by the Quantum AetherDynamics Institute (QADI).

It develops the Aether Physics Model (APM)

Abstract

We compare the mass–energy relation in the Aether Physics Model (APM), written in Quantum Measurement Units (QMU), with the familiar relativistic ledger $E = mc^2$. In QMU the energy and mass bases are the units *enrg* and *mass*, with specific values and dimensions built from the quantum constants, whereas in relativity E and m are dimensionful variables defined only up to the postulated propagation constant c. In APM the propagation constant is not postulated but factored as the Ledger One identity $A_u\,\mathrm{curl} = {F_q}^2\,{\lambda_C}^2$, where A_u is the Aether unit and curl is the curl (torsional) unit, and where F_q and λ_C are the quantum frequency and quantum length. The QMU mass–energy ledger then reads $\mathrm{enrg} = \mathrm{mass}\,A_u\,\mathrm{curl} = \mathrm{mass}\,{F_q}^2{\lambda_C}^2$, with *mass* representing the mass of a single Aether unit fully occupied by the primary angular momentum emerging from the Singularity. Physical masses are counted as dimensionless multiples of this occupied Aether unit. In relativity $E = mc^2$ appears as a consequence of Lorentz symmetry with c taken as a primitive postulate. We analyze what "mass" and "energy" mean *within* each ledger, highlight that relativity provides a principle-theory account (Noether charges and Poincaré invariants) whereas APM provides a constructive account (Singularity-induced occupancy of quantized Aether units), and outline experimental classes that test the shared propagation constant and those that can discriminate between a postulated speed of light and a derived, geometrically factored Aether propagation ledger.

Keywords: QMU; APM; chronovibration; distributed charge; metrology

1 Introduction

Institutional attribution follows the QADI reference identity [Thomson III(2025a)]. The Aether Physics Model (APM) formulates physical law in a ledger-first framework using Quantum Measurement Units (QMU) [Thomson III(2024), Thomson III and Bourassa(2004)]. The minimal QMU base employs the electron mass m_e, quantum length λ_C (Compton length), quantum frequency F_q (chronovibrational tick), electrostatic charge e^2, and magnetic charge ${e_\mathrm{emax}}^2$, with derived units such as the Aether unit A_u and curl curl. The QMU bases for energy and mass are the units *enrg* and *mass*; any QMU energy quantity is a multiple of enrg, and any QMU mass quantity is a multiple of mass. These are fixed dimensional units built directly from quantum constants and the Singularity/Aether geometry, not free variables.

The Ledger One identity,

$$A_u\,\mathrm{curl} \;=\; {F_q}^2\;{\lambda_C}^2, \tag{1}$$

encodes the rotational–torsional self-identity of a single quantum of Aether and simultaneously reproduces the effective propagation constant of electromagnetic waves. In recent work this constructive QMU ledger has been applied to both cosmological and gravitational phenomena. A parameter-free prediction of the CMB polarization rotation angle $\beta_0 = 1/(16\pi^2)$ arises from Pontryagin topology on the boundary of a structured-vacuum cell [Minami and Komatsu(2020)], together with the chronovibrational ledger $F_q = \mathrm{mflx}\cdot\mathrm{aefp}$ and the charge-ratio invariant $\eta_c = e^2/{e_\mathrm{emax}}^2 = 8\pi\alpha$ [Thomson III and Bourassa(2025)]. In a complementary direction, the standard circular deflection angle associated with the Schwarzschild solution can be rewritten as an Aether density-gradient effect in which A_u and curl enter explicitly, and the relativistic deflection is recovered when $A_u\mathrm{curl}$ is identified with the propagation constant [Thomson III(2025b)].

In the present article we focus on the mass–energy ledger itself. In QMU it takes the form

$$\mathrm{enrg} = \mathrm{mass}\,A_u\,\mathrm{curl} = \mathrm{mass}\,{F_q}^2{\lambda_C}^2, \tag{2}$$

where the propagation constant is derived from the geometry and chronovibration of the Aether unit, and where *mass* is defined as the mass of exactly one Aether unit when it is fully occupied by the primary angular momentum (dark matter) originating from the Singularity. In Einstein's relativity the mass–energy relation is written [Einstein(1905)]

$$E = mc^2, \tag{3}$$

with E and m treated as variables with dimensions only, and c the constant photon speed in local space, taken as a postulate of the theory. Our goal is not to reformulate relativity in detail, but to compare what "mass" and "energy" are *within* each ledger, and to contrast the postulate-based foundation of (3) with the constructive, geometrically derived foundation of (2).

We proceed by first stating the Ledger One closure, then deriving each mass–energy ledger in its native paradigm, and finally tabulating experimental and conceptual tests of how well each ledger is grounded in physical reality.

2 Ledger Closure Check

A canonical closure used for sanity checks in APM/QMU is

$$A_u \,\mathrm{curl} \;=\; {F_q}^2 \; {\lambda_C}^2, \tag{4}$$

which in expanded form reads

$$A_u \cdot \mathrm{curl} = {F_q}^2 {\lambda_C}^2. \tag{5}$$

Here A_u is the quantum rotating magnetic field (Aether unit), curl is the curl unit (torsional "hardness" of the Aether), F_q is the quantum frequency defined by chronovibrational geometry, and λ_C is the quantum length defined as the Compton length. Equation (5) is the Aether rotational self-identity: the product of the rotational and torsional ledgers of a single Aether unit equals the square of the chronovibrational propagation, expressed entirely in QMU.

In mainstream notation one writes $c = F_q \lambda_C$ and $c^2 = 1/(\mu_0 \varepsilon_0)$ [Maxwell(1865)], so (5) corresponds to

$$A_u \cdot \mathrm{curl} = {F_q}^2 {\lambda_C}^2 = c^2 = \frac{1}{\mu_0 \varepsilon_0}, \tag{6}$$

but in the QMU ledger we regard F_q and λ_C as primary and A_u and curl as the Aether decomposition of the propagation constant; μ_0 and ε_0 appear only in SI cross-checks and do not enter the main ledger.

The mass–energy ledgers in each paradigm attach an energy–mass pair to this common propagation constant. In QMU we write

$$\mathrm{enrg} = \mathrm{mass} \times (\text{propagation constant}), \tag{7}$$

with the propagation constant fixed by Ledger One:

$$\mathrm{enrg} = \mathrm{mass}\, A_u \,\mathrm{curl} = \mathrm{mass}\, {F_q}^2 {\lambda_C}^2. \tag{8}$$

In relativity one writes

$$E = mc^2, \tag{9}$$

and then identifies c^2 experimentally with the same propagation constant. Ledger One thus plays the role of a geometric factorization of the constant that appears in both mass–energy ledgers.

3 Method / Derivation

All steps in this section are written to close dimensionally in QMU. We separate the derivation of the mass–energy ledger in each paradigm and then exhibit the mapping between them, with careful notation: *enrg* and *mass* for QMU units, and E and m for the relativistic variables.

3.1 Constructive mass–energy ledger in APM/QMU

In APM the starting point is a constructive geometric model of the Aether. The Aether unit A_u is a quantized, toroidal rotating magnetic field structure whose details are fixed by the QMU base and by distributed charge geometry. The curl unit curl characterizes the torsional stiffness of this Aether unit and appears in both electromagnetic device ledgers and gravitational deflection ledgers [Thomson III(2025b)]. The chronovibration ledger employs the quantum frequency F_q and quantum length λ_C as the fundamental tick and span, with the propagation constant defined by

$$F_q \lambda_C = c, \tag{10}$$

where c is now *derived* as the Aether propagation constant in QMU, not assumed as a postulate.

Ledger One,

$$A_u \cdot \mathrm{curl} = {F_q}^2 {\lambda_C}^2, \tag{11}$$

then expresses the self-identity of a single Aether unit in terms of rotation, torsion, and chronovibration. The QMU mass ledger introduces a matter configuration as a multiple of the mass unit, mass, understood as the mass of a single Aether unit when it is fully occupied by the primary angular momentum emerging from the Singularity. A physical object is then written as

$$\text{mass of object} = \eta_m \,\mathrm{mass}, \tag{12}$$

with η_m a dimensionless geometry factor. The quantization of mass thus arises from counting how many Aether units are occupied by the primary angular momentum; η_m is literally an occupancy count (possibly fractional in composite systems) rather than an arbitrary scaling factor.

The QMU mass–energy ledger is then written

$$\mathrm{enrg} = \mathrm{mass} \times (\text{propagation constant}), \tag{13}$$

with the propagation constant fixed by Ledger One:

$$\mathrm{enrg} = \mathrm{mass}\, A_u\, \mathrm{curl} = \mathrm{mass}\, {F_q}^2 {\lambda_C}^2. \tag{14}$$

Any particular QMU energy quantity is a multiple of enrg,

$$\mathrm{enrg}_{\mathrm{object}} = \eta_m \,\mathrm{enrg} = \eta_m \,\mathrm{mass}\, A_u\, \mathrm{curl}, \tag{15}$$

with the same occupancy factor η_m that multiplies *mass*. In this way the QMU ledger treats enrg and mass as fixed dimensional units, and the physical content of a configuration is carried by how many occupied Aether units it represents.

3.2 Principle-theory mass–energy ledger in relativity

In special relativity and its field-theoretic extensions the mass–energy relation is a consequence of Lorentz symmetry and the postulate that photon speed is constant in all inertial frames. The energy–momentum 4-vector is written

$$P^{\mu} = \left(\frac{E}{c}, \boldsymbol{p}\right), \tag{16}$$

and the Lorentz-invariant norm is defined as

$$P^{\mu}P_{\mu} = \left(\frac{E}{c}\right)^2 - \boldsymbol{p}^2. \tag{17}$$

By fiat one identifies this invariant with the square of a mass parameter m,

$$P^{\mu}P_{\mu} = m^2c^2, \tag{18}$$

which yields the familiar dispersion relation

$$E^2 = p^2c^2 + m^2c^4. \tag{19}$$

In the rest frame $p = 0$, and the energy reduces to

$$E = mc^2. \tag{20}$$

In this paradigm,

- "Mass" m is the Casimir invariant [Wigner(1939)] of the Poincaré group (a representation label) and the coefficient that appears in the matter Lagrangian density.
- "Energy" E is the Noether charge [Noether(1971)] associated with time-translation invariance and the time component of the energy–momentum 4-vector [Einstein(1905)].
- The propagation constant c is postulated as the constant photon speed in local space; its numerical value is fixed empirically, and its appearance in both the dispersion relation and the mass–energy ledger is demanded by Lorentz symmetry.

No decomposition of c^2 into separate rotational and torsional contributions is made, and no explicit reference is made to a discrete Aether unit or quantum frequency–length factorization, even though $c^2 = 1/(\mu_0\varepsilon_0)$ may be imported from Maxwell theory in SI cross-checks.

3.3 Mapping the ledgers and interpreting "mass" and "energy"

Equations (14) and (3) share the same functional form:

$$\text{(energy)} = \text{(mass)} \times \text{(propagation constant)}, \tag{21}$$

but the objects on each side of the comparison carry different status and notation:

$$\text{QMU:} \quad \text{enrg} = \text{mass}\, A_u\, \text{curl} = \text{mass}\, {F_q}^2 {\lambda_C}^2, \tag{22}$$

$$\text{Relativity:} \quad E = mc^2. \tag{23}$$

In the QMU ledger, *enrg* and *mass* are fixed dimensional units constructed from the quantum constants and Aether geometry, while the physical content is carried by dimensionless multipliers such as η_m that count occupied Aether units. In the relativistic ledger, E and m are dimensionful variables whose only relation is $E = mc^2$; the units themselves are not fixed by an underlying ledger.

Identifying the propagation constants in a regime where both are valid amounts to

$$c^2 = A_u \,\mathrm{curl} = {F_q}^2 {\lambda_C}^2. \tag{24}$$

Within this identification one can regard

$$E = mc^2 \quad \Leftrightarrow \quad \mathrm{enrg} = \mathrm{mass}\, A_u \,\mathrm{curl}, \tag{25}$$

so the numerical predictions coincide whenever the propagation constant is fixed to the same value. The conceptual difference is that APM interprets

$$A_u \,\mathrm{curl} \tag{26}$$

as the rotational–torsional self-identity of a discrete Aether unit, with c derived as $F_q \lambda_C$, while relativity treats c as a primitive constant tied to spacetime symmetry.

In the relativistic ledger, "mass" and "energy" are variable slots determined by symmetry and invariance. In the QMU ledger, *mass* and *enrg* are fixed units built from the same quantum constants that define A_u, curl, F_q, and λ_C, and the physical content of a configuration is carried by how many quanta of that Aether rotational–torsional identity are occupied.

3.4 Comparative ledger table

For clarity we summarize the ontological differences between the two ledgers in a side-by-side table. The left column corresponds to Einstein's relativity; the right column corresponds to APM/QMU.

4 Results

In this section we summarize the comparison as explicit ledger identities and as a set of experimental classes that probe the propagation constant and its factorization.

4.1 Canonical ledger mapping

We collect the key identities in QMU form:

$$\text{Ledger One (vacuum ledger):} \quad A_u \mathrm{curl} = {F_q}^2 {\lambda_C}^2, \tag{27}$$

$$\text{QMU mass–energy ledger:} \quad \mathrm{enrg} = \mathrm{mass}\, A_u \,\mathrm{curl} = \mathrm{mass}\, {F_q}^2 {\lambda_C}^2, \tag{28}$$

$$\text{Relativistic mass–energy ledger:} \quad E = mc^2, \tag{29}$$

and the mapping

$$c^2 \longleftrightarrow A_u \mathrm{curl} \longleftrightarrow {F_q}^2 {\lambda_C}^2. \tag{30}$$

In addition, previous QMU work provides independent appearances of the same propagation constant:

	Relativity (Principle Theory)	**APM/QMU (Constructive Theory)**
Mass	Parameter m; Casimir invariant of the Poincaré group; coefficient in the matter Lagrangian; not decomposed further.	Unit *mass* = mass of one Aether unit fully occupied by primary angular momentum (dark matter captured in an Aether unit); physical masses are occupancy counts η_m mass.
Energy	Variable E; Noether charge for time translations; T_{00} in the rest frame.	Unit *enrg* = mass A_u curl; physical energies are η_m enrg; counts occupied Aether units weighted by Ledger One.
Propagation constant	c postulated as constant photon speed in local space; c^2 enters dispersion and $E = mc^2$ as a single invariant factor.	$c = F_q \lambda_C$ with $c^2 = A_u \text{curl} = {F_q}^2 {\lambda_C}^2$; propagation constant factored into Aether rotation (A_u) and torsion (curl), built from QMU base.
Governing principle	Principle theory: Lorentz symmetry and constant c constrain E and m; vacuum is treated as a metric background.	Constructive theory: Singularity plus quantized Aether geometry determine enrg, mass, and the propagation constant; vacuum is a lattice of Aether units.

Table 1: Ontological comparison of mass–energy ledgers in relativity and APM/QMU.

- In the chronovibrational ledger,

$$F_q = \text{mflx} \cdot \text{aefp} = \frac{c}{\lambda_C}, \tag{31}$$

  so that ${F_q}^2 {\lambda_C}^2 = c^2$ in QMU [Thomson III and Bourassa(2025)].
- In the circular deflection ledger, the standard deflection angle associated with a central mass can be expressed in terms of the Aether unit, the curl, and the Aether density gradient, and the usual result is recovered when $A_u \text{curl} = c^2$ [Thomson III(2025b)].

These relations show that the same propagation constant appears in vacuum geometry, chronovibrational frequency, gravitational deflection, and the mass–energy ledger.

4.2 Experimental classes probing the ledgers

We divide relevant experiments into those that probe the combined propagation constant and those that can, in principle, probe its factorization.

Class I: Combined propagation constant tests. These experiments primarily check that energy scales as mass times a universal propagation constant, without distinguishing its internal structure [Will(2014)]:

- Annihilation and creation processes, in which mass deficits and photon-ledger energies satisfy

$E = \Delta m \times$ (propagation constant) in the relativistic notation, and the same relation holds in QMU once the propagation constant is expressed as $A_u$curl.

- Nuclear mass defects across fission, fusion, and binding transitions.
- Relativistic kinematics in accelerators, where the dispersion relation $E^2 = p^2c^2 + m^2c^4$ is tested.

Both APM and relativity agree in these regimes once the propagation constant is fixed. These tests confirm the *existence* and numerical value of the propagation constant but do not test whether c^2 has an Aether-geometric factorization.

Class II: Factorization tests via A_u and curl. These experiments aim to measure A_u and curl independently and verify Ledger One:

- Electromagnetic device metrology, where inductance, coil geometry, and material response are expressed in the Maxwell–Aether ledger; the curl unit appears as a magnet hardness index and can be inferred from hysteresis and spin-caloritronic data.
- Rotating-field experiments, in which the Aether unit A_u is inferred from rotating magnetic field thresholds and scaling laws.
- Chronovibrational and Compton experiments, which determine F_q and λ_C from high-precision spectroscopy and Compton scattering and thus fix ${F_q}^2{\lambda_C}^2$.

Ledger One then becomes a metrological closure condition:

$$A_u^{(\mathrm{rot})}\,\mathrm{curl}^{(\mathrm{mag})} \stackrel{?}{=} {F_q}^{2(\mathrm{spec})}\,{\lambda_C}^{2(\mathrm{Compton})}, \tag{32}$$

with each factor measured by an independent protocol.

Class III: Gradient-ledger tests via circular deflection and potentials. These experiments probe how the same curl unit mediates Aether density gradients:

- Light bending and time delay in gravitational lensing, expressed as Aether density-gradient effects with curl as the torsional coupling coefficient. Locally, the circular deflection angle would be imperceptible if measured with a protractor near the surface of a star, but over astronomical baselines the tiny angle accumulates into a measurable deflection. This is consistent with the standard relativistic result when $A_u\mathrm{curl} = c^2$, but the QMU ledger interprets the effect as an Aether-density gradient acting through curl.
- Gravitational redshift interpreted as differing tick counts per sidereal orbit through regions of differing Aether density, with F_q held fixed and ρ_{Aether} varying.
- Tiny Aether-induced electric potential differences associated with space-density gradients, as in the comet and nebula examples: the potential per unit length is very small, so local bodies do not experience large shocks or discharges merely by moving through the field. However, when that small potential gradient is integrated over astronomical unit scales in a comet tail or over many light-time spans in a nebula, the accumulated potential energy becomes large. In QMU this is a redistribution of distributed charge in a stretched or compressed Aether lattice, with the total electromagnetic energy tracking both the Aether density gradient and curl. In purely gravitational models the same large scale structures are usually attributed to unseen mass distributions; here they appear naturally as integrated Aether and charge-ledger effects.

Relativity interprets these phenomena as spacetime curvature and metric corrections acting on passive E, m, and charge parameters. APM interprets them as space-density gradients of the Aether with curl mediating the deflection and potential shift. Agreement between the two pictures at leading order tests the shared propagation constant; any higher-order deviations that track curl and Aether density could differentiate the paradigms, particularly in large-scale magnetic distributions such as nebulae where tiny per-length effects are spread over enormous regions.

4.3 Torsion blindness of the relativistic mass–energy ledger

Ledger One factors the propagation constant into a rotational and a torsional component,

$$A_u\text{curl} = {F_q}^2{\lambda_C}^2, \tag{33}$$

so that the quantum Aether carries two distinct geometric attributes:

1. A_u, the rotational ledger of a quantized, toroidal Aether unit; and
2. curl, the torsional "hardness" ledger that governs how strongly the Aether resists twist, shear, and density gradients.

The QMU mass–energy ledger

$$\text{enrg} = \text{mass}\, A_u\, \text{curl} \tag{34}$$

therefore knows, by construction, that rest energy is the occupancy of an Aether unit weighted by *both* its rotation and its torsion.

By contrast, the relativistic ledger

$$E = mc^2 \tag{35}$$

uses only the *product* of these Aether attributes. In the mapping

$$c^2 \longleftrightarrow A_u\text{curl}, \tag{36}$$

all information about how much of c^2 comes from rotation and how much comes from torsion is compressed into a single scalar. The relativistic ledger is therefore *torsion blind*: it constrains the value of $A_u$curl as a whole, but it has no internal handle on curl itself. Any two Aether configurations with

$$(A_u)_1\text{curl}_1 = (A_u)_2\text{curl}_2 \tag{37}$$

produce the same c^2 and therefore the same relativistic mass–energy ledger, even if their torsional hardness differs.

In QMU this distinction is physically meaningful. The torsion ledger curl appears explicitly in:

- the curl–based magnet hardness index that organizes spin and magnetic response in materials;
- the circular deflection and Aether density–gradient ledgers, where curl controls how density gradients deflect trajectories through an otherwise uniform propagation constant; and
- topological ledgers such as the cosmic birefringence prediction, where the Pontryagin index of a structured-vacuum cell couples to the same torsional stiffness that enters $A_u$curl.

These are all examples of **torsion-resolved physics**: phenomena that depend on curl and its coupling to distributed charge and Aether density, not merely on the combined product $A_u$curl.

From the QMU point of view, the relativistic ledger $E = mc^2$ can be regarded as the *torsion-averaged* limit of the Aether ledger, valid whenever experiments are sensitive only to the total propagation constant and not to how it is factored. Class I tests (annihilation energies, accelerator kinematics, nuclear mass defects) fall into this category and therefore do not see torsion at all: they measure c^2 but are indifferent to how c^2 decomposes.

The distinctive predictions of the Aether Physics Model arise in Class II and Class III experiments, where curl enters separately. In those regimes one can vary the torsion ledger while keeping the product $A_u\mathrm{curl}$ fixed, or compare systems with the same propagation constant but different torsional hardness. Relativity, with its torsion-blind mass–energy ledger, has no parameter that can track such variations, while the QMU ledger does so naturally through curl.

In summary, the equality

$$E = mc^2 \quad \Leftrightarrow \quad \mathrm{enrg} = \mathrm{mass}\, A_u\, \mathrm{curl} \tag{38}$$

holds whenever only the combined propagation constant is probed. The *extra structure* of the APM mass–energy ledger is that it identifies a specific torsion ledger curl inside c^2, and this torsion component is exactly what is required to organize curl-sensitive phenomena such as magnet hardness, Aether density–gradient deflection, and topological polarization rotation. From this perspective the relativistic mass–energy ledger is complete as a statement about c^2, but incomplete as a statement about the underlying rotational–torsional geometry of the quantum Aether.

4.4 Experimental outlook: torsion–resolved astrophysics.

From an experimental point of view, the torsion blindness of $E = mc^2$ means that any test which is sensitive only to the combined propagation constant c^2 cannot discriminate between a purely relativistic ledger and the QMU factorization $A_u\mathrm{curl} = {F_q}^2{\lambda_C}^2$. To probe the extra structure of the APM ledger one must look for phenomena in which curl or $\mathrm{curl}^2 A_u$ enter explicitly, not merely through their product. Recent QMU applications already do this in two complementary astrophysical regimes.

First, the Galactic-center nonthermal filament work constructs a torsion–gravity index $\Xi_{\mathrm{GC}}(r_{\mathrm{GC}})$ in which the enclosed length density $M_{\mathrm{enc}}(r_{\mathrm{GC}})/r_{\mathrm{GC}}$ is mapped, via the Schwarzschild deflection ledger, into a scalar torsion–energy density $\mathrm{curl}^2 A_u$. In that ledger the confinement and radial envelope of bright nonthermal filaments are interpreted as a locking band where Ξ_{GC} exceeds a threshold for Aether-unit torsion alignment, and the approximate angular spacing of filaments is tied to a discrete winding condition on the integrated torsion around the Galactic center. These predictions are written entirely in QMU, with conventional observational inputs entering only through dimensionless profiles, and they depend on the *value* and *radial variation* of $\mathrm{curl}^2 A_u$, not just on the product $A_u\mathrm{curl}$ as a single propagation constant.[Thomson(2025a)] In terms of the present paper, this is a direct, torsion-resolved test of the same curl ledger that appears in the mass–energy relation $\mathrm{enrg} = \mathrm{mass}\, A_u\, \mathrm{curl}$.

Second, the Aether Lagrangian for galactic black holes uses the reference curl $\mathrm{curl}_{\mathrm{ref}} = {e_{\mathrm{emax}}}^2/(m_{\mathrm{e}}\lambda_C)$ together with the Aether unit to set the effective propagation constant via $c^2 = A_u\,\mathrm{curl}_{\mathrm{ref}}$ in a QMU/Gaussian ledger, and then defines the event-horizon radius as the location where the deflection angle reaches one radian. This yields an APM horizon scale $r_s^{\mathrm{APM}} = 2f_{\mathrm{eff}} r_s^{\mathrm{GR}}$, where f_{eff} encodes the neutron-to-unbound-matter ratio and thus the degree of Aether compression. Fits to the Event Horizon Telescope shadows of M87* and Sgr A* correspond to $f_{\mathrm{eff}} \approx 0.5$, while $f_{\mathrm{eff}} = 1$ provides a falsifiable baseline prediction in environments dominated by fully bound matter.[Thomson(2025b)]

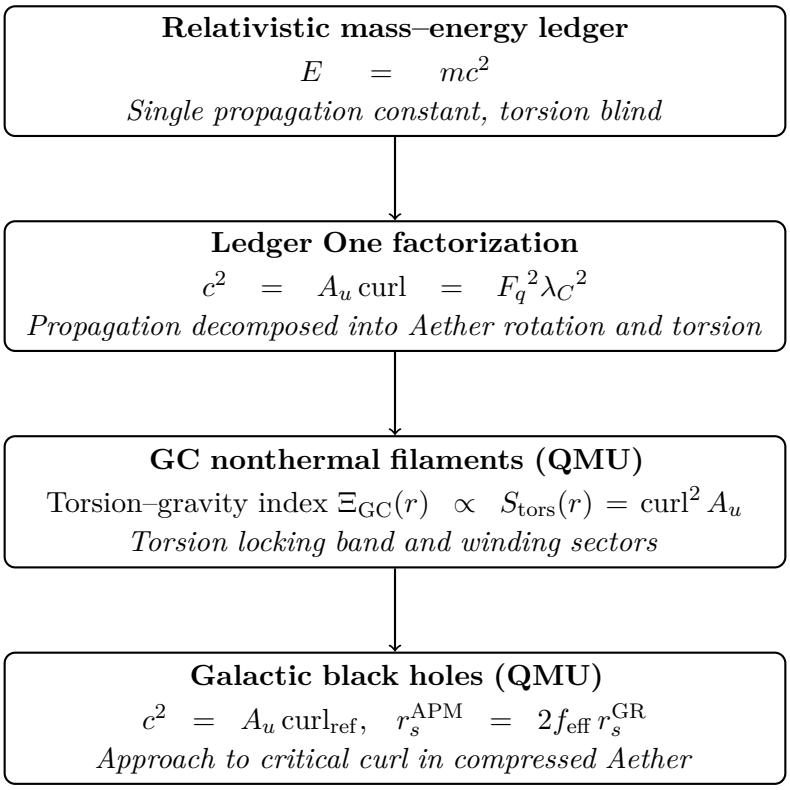

Figure 1: Ledger summary. Top: the relativistic mass–energy ledger $E = mc^2$ is sensitive only to the combined propagation constant c^2 and is therefore torsion blind. Next: Ledger One factors c^2 into an Aether rotation ledger A_u and a torsion ledger curl, with $c^2 = A_u\mathrm{curl} = {F_q}^2{\lambda_C}^2$. Bottom panels: QMU applications that resolve curl separately — the Galactic-center torsion–gravity index $\Xi_{\mathrm{GC}}(r)$ and the Aether Lagrangian for galactic black holes — provide torsion-sensitive tests of the same curl ledger that underlies the QMU mass–energy relation enrg = mass A_u curl.

Here again, the observables are controlled by the same curl ledger that enters enrg = mass A_u curl, but in a strong-field regime where curl is driven toward a critical value $\mathrm{curl}_{\mathrm{ref}}$ associated with the maximum Aether length density.

Together, these torsion-resolved applications suggest a concrete program for testing the "missing torsion component" of $E = mc^2$. Class I experiments (annihilation energies, accelerator kinematics, nuclear mass defects) remain propagation-constant tests that fix $A_u\mathrm{curl}$ as a whole. By contrast, Galactic-center filament statistics probe $\mathrm{curl}^2 A_u$ and its gradients across tens to hundreds of parsecs, while galactic black-hole horizon scales probe the approach to a critical curl ledger near compact objects. If the QMU mass–energy ledger is correct as a constructive completion of $E = mc^2$, then a single torsion ledger curl should simultaneously (i) close Ledger One, (ii) organize the filament locking band and winding counts, and (iii) reproduce the effective f_{eff} factors inferred from horizon imaging. Any future inconsistency among these torsion-sensitive tests would not merely falsify a choice of parameter inside relativity; it would directly challenge the identification of curl as the missing torsion component underlying the relativistic mass–energy ledger.

5 Discussion

The comparison performed here can be summarized in two sentences:

> In relativity, the mass–energy ledger $E = mc^2$ is a principle-theory consequence of Lorentz symmetry and a postulated constant photon speed, with E and m functioning as variables whose only constraint is the propagation constant c.
>
> In APM/QMU, the mass–energy ledger enrg $=$ mass A_u curl $=$ mass ${F_q}^2{\lambda_C}^2$ is a constructive-theory consequence of a quantized Aether geometry, with enrg and mass as fixed dimensional units and the same Aether units controlling chronovibration, gravitational deflection, and topological duality effects.

The two ledgers are numerically equivalent whenever the propagation constant is identified via $c^2 = A_u\text{curl} = {F_q}^2{\lambda_C}^2$, but the ontological content is different. Relativity leaves c^2 as an undifferentiated constant of nature; APM factors it into Aether rotation and torsion and connects it to a specific quantum frequency and length.

From a metrological perspective the advantage of the QMU ledger is that it invites the explicit construction of closure tests. Ledger One already appears as the backbone of topological predictions for cosmic birefringence and charge ratios [Minami and Komatsu(2020)], and as the geometric kernel of Aether density-gradient re-expressions of general-relativistic phenomena [Thomson III and Bourassa(2025), Thomson III(2025b)]. The QMU mass–energy ledger completes this picture by tying rest energy directly to the same rotational and torsional Aether identity that governs propagation, deflection, and large-scale potential differences.

The relativistic corrections to electric potential provide a concrete example of the ontological distinction. In GR, a small potential shift is a metric effect on an invariant charge parameter. In APM, the same shift is a slight re-weighting of distributed charge in a space whose Aether density is modulated by mass distributions. Locally, the potential difference per unit length is negligible; one does not acquire a large potential merely by walking across a gravitational field. For extended systems such as comets, planetary magnetospheres, and nebulae, however, the same tiny gradient integrates into a substantial total potential and magnetic energy. In that regime the QMU ledger suggests that relativistic potentials, curl-driven Aether gradients, and large-scale magnetic morphology are all aspects of a single Aether ledger, offering an avenue to test the constructive ontology against the principle ontology.

Future work can sharpen the experimental program sketched here. On the QMU side one can develop enrg- and mass-based metrology protocols that never leave the QMU system, extend the circular deflection ledger to more complex mass distributions, and explore whether subtle curl-dependent corrections arise in strong-gravity regimes where relativity remains featureless in its treatment of c^2. On the relativity side one can use the Aether factorization as a diagnostic tool: if all factorization tests succeed, then the APM interpretation becomes an allowed constructive completion of the relativistic ledger; if any fail, the deviations will point to where the constructive picture must be refined or abandoned.

In either case the ledger-first comparison clarifies what is firmly grounded in experiment (the existence and value of the propagation constant) and what is a matter of paradigm choice (postulate versus constructive Aether geometry, variable versus unit-based energy and mass) in the mass–energy relation.

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.

References

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

[Thomson III(2024)] David W. Thomson III. Quantum Measurement Units (QMU): A System Based on Quantum Constants and Distributed Charge Geometry. *ResearchGate preprint*, 2024. doi: 10.13140/RG.2.2.16468.21125. URL https://doi.org/10.13140/RG.2.2.16468.21125.

[Thomson III and Bourassa(2004)] David W. Thomson III and James D. Bourassa. *Secrets of the Aether*. Quantum AetherDynamics Institute, Alma, Illinois, USA, 2004. doi: 10.13140/2.1.1633.7926. URL https://doi.org/10.13140/2.1.1633.7926. Updated electronic edition available online.

[Minami and Komatsu(2020)] Yuto Minami and Eiichiro Komatsu. New Extraction of the Cosmic Birefringence from the Planck 2018 Polarization Data. *Physical Review Letters*, 125(22):221301, 2020. doi: 10.1103/PhysRevLett.125.221301. Reports a non-zero best-fit cosmic birefringence angle from Planck polarization data.

[Thomson III and Bourassa(2025)] David W. Thomson III and James D. Bourassa. From Atomic to Galactic: Eight Parameter-Free Retrodictions of the Aether Physics Model. *ResearchGate preprint*, 2025. doi: 10.13140/RG.2.2.10363.63527. URL https://doi.org/10.13140/RG.2.2.10363.63527. Includes the CMB polarization rotation prediction $\beta_0 = 1/(16\pi^2)$ in QMU.

[Thomson III(2025b)] David W. Thomson III. General Relativity is an Aether Theory: A Novel Approach to Gravitational Physics. *ResearchGate preprint*, 2025b. doi: 10.13140/RG.2.2.23676.00642. URL https://doi.org/10.13140/RG.2.2.23676.00642. Derives GR-style corrections to electric potential in the Aether Physics Model.

[Einstein(1905)] Albert Einstein. Ist die Trägheit eines Körpers von seinem Energieinhalt abhängig? *Annalen der Physik*, 323(13):639–641, 1905. doi: 10.1002/andp.19053231314. Short note giving the original derivation of the mass–energy relation.

[Maxwell(1865)] James Clerk Maxwell. A Dynamical Theory of the Electromagnetic Field. *Philosophical Transactions of the Royal Society of London*, 155:459–512, 1865. doi: 10.1098/rstl.1865.0008. Derives electromagnetic waves in vacuum and the relation $c^2 = 1/(\mu_0\varepsilon_0)$.

[Wigner(1939)] Eugene P. Wigner. On Unitary Representations of the Inhomogeneous Lorentz Group. *Annals of Mathematics*, 40(1):149–204, 1939. doi: 10.2307/1968551. Classifies Poincaré representations; identifies mass and spin as Casimir invariants.

[Noether(1971)] Emmy Noether. Invariant Variation Problems. *Transport Theory and Statistical Physics*, 1(3):186–207, 1971. doi: 10.1080/00411457108231446. English translation of Noether's 1918 paper establishing the link between symmetries and conservation laws.

[Will(2014)] Clifford M. Will. The Confrontation between General Relativity and Experiment. *Living Reviews in Relativity*, 17(4):4, 2014. doi: 10.12942/lrr-2014-4. Comprehensive review of experimental tests of GR, including light deflection and gravitational redshift.

[Thomson(2025a)] David W. Thomson. Galactic center nonthermal radio filaments in qmu: Aether torsion, relativistic potential, and length–density ledgers, 12 2025a. URL https://doi.org/10.5281/zenodo.17849476. Preprint, Version v1.

[Thomson(2025b)] D. W. Thomson. Aether lagrangian for galactic black hole parameters. *Physics Essays*, 38(1):1, 2025b. doi: 10.4006/0836-1398-38.1.1.