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From Scalar Timing Shadows to Tensorial Timing Shadows · July 5, 2026

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July 5 status of the tensorial timing proposal. The July 10 onsite and July 11 finite-range obstructions supersede the proposed first-order realization within their stated assumptions.

Manuscript · p. 16, current landmark

Where We Are · July 5, 2026: A Status Assessment of the QATNU/SRQID Program

Evidence · Finite-range symplectic-axis audit

From Scalar Timing Shadows to Tensorial Timing Shadows:

The QATNU/SRQID Route from Clock-Readable Relational Load to a Certificate-Gated Spin-2 Program

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Claim boundary. This paper is a synthesis and route paper. It does not claim that QATNU/SRQID has proved gravity. It argues that the original scalar clock-readout idea has matured into a disciplined scalar-sector program and a separate tensorial timing-shadow program. The current strongest result is a certificate-gated route toward a spin-2-like response sector, with explicit remaining obligations: formal replay, global coverage, microscopic realization, thermodynamic stability, source universality, nonlinear completion, and empirical discrimination.

Abstract

QATNU/SRQID began from a simple physical intuition: if spacetime is not fundamental, then local clock behavior may be the first readable shadow of deeper relational structure. In the original SRQID/QATNU formulation, matter degrees of freedom live on graph vertices, finite bond registers live on graph edges, and coherent promotion of bond registers produces an effective local relational load. A local clock coupled to that load obeys, in the effective regime,

$$\omega_{\text{eff}} = \frac{\omega}{1 + \alpha\Lambda}.$$

This scalar timing law is not gravity. It is the scalar timing shadow: the reduced observable projection of a deeper relational substrate onto local clock rate. Later scalar-selection work sharpened the claim by separating the chain

$$H_{\text{micro}} \to W \to L_w \to d_{\text{eff}} \to G_{d_{\text{eff}}}(r) \to \Lambda(r) \to \omega_{\text{eff}},$$

and by requiring numerical closure: the same effective operator must control scalar response, spectral dimension, timing residuals, and modal relaxation in one shared scaling window. This made the program falsifiable but also exposed its central incompleteness: general relativity is not scalar clock lag. Gravity organizes clocks, rods, causal cones, wave propagation, free fall, and stress response together. The missing face was therefore tensorial.

This paper formulates the resulting route from scalar timing shadows to tensorial timing shadows. The scalar sector is interpreted as the first clock-readable projection of relational load; the tensor sector is the gravity-shaped completion, requiring a protected spin-2 response with two transverse-traceless source-visible modes, Ward/conservation structure, finite residue, and a stable long-wavelength response. Recent chiral/Ward spin-2 work supplies a concrete response-carrier architecture, while the newer first-order/Berry normalizer route reframes the remaining tensor problem as a certificate-gated proof program. The current thesis is deliberately bounded: QATNU/SRQID has not proved gravity, but it has developed a coherent route from scalar clock-readout physics toward a tensorial timing-shadow program with explicit algebraic gates and remaining proof obligations.

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1. Introduction

The starting point of QATNU/SRQID was never merely that "entanglement slows clocks." The deeper idea was that clocks may be the first instruments through which a relational substrate becomes physically readable. If local structure is deeper than spacetime, then a finite observer does not receive the whole structure. The observer receives stable projections: clock rates, accumulated phases, correlations, signals, records, and eventually reconstructed geometry.

The SRQID foundation supplied the conservative backbone. It used a fixed, linear, time-independent, measurement-free Hamiltonian on a bounded-degree graph. Matter qubits occupy vertices, bond registers occupy edges, and promotion effects arise from coherent Hamiltonian evolution rather than from state-dependent rules or measurement collapse. The model was designed to satisfy locality, unitarity, bounded degree, and a Lieb-Robinson causal cone [1, 12, 13, 14].

QATNU then introduced the physical interpretation: bond/register organization and promotion depth act as an information-geometric load. A local matter clock coupled to that load changes its effective frequency. In the small-system numerical regime, the effective clock law is well approximated by

$$\omega_{\mathrm{eff}}^{(i)} \simeq \frac{\omega}{1+\alpha\Lambda_i}, \tag{1}$$

where Λ_i is an entanglement or bond-depth proxy and α is a clock susceptibility [2, 3]. In the weak-load limit,

$$\frac{\mathrm{d}\tau_i}{\mathrm{d}t} \simeq 1-\alpha\Lambda_i, \tag{2}$$

which has the same form as a weak gravitational redshift when $\alpha\Lambda_i$ is matched to $GM/(rc^2)$. This was the seed of the whole program: *gravity as clock-readable relational structure*.

But the seed was scalar. It described one number per location, one lapse-like load, one timing effect. General relativity is not one number per location. It is a tensorial organization of causal structure, propagation, stress response, and clock/rod behavior. Later scalar-selection work therefore made the program narrower and more rigorous: before claiming gravity, prove the scalar timing sector under its own rules. The newest spin-2 work then reopens the original ambition, now in tensorial form.

The purpose of this paper is to state that progression cleanly:

$$\begin{aligned} &\text{scalar timing shadow} \longrightarrow \text{operator-closed scalar sector} \\ \longrightarrow\ &\text{tensorial timing shadow} \longrightarrow \text{candidate gravity-shaped response.} \end{aligned} \tag{3}$$

The claim is not that QATNU/SRQID has proved gravity. The claim is that the original intuition has matured into a falsifiable staged program: scalar timing first, tensorial timing next, gravity only after universality, stability, and nonlinear completion.

2. The SRQID Backbone: Linear Relational Dynamics

SRQID begins with a bounded-degree graph $G=(V,E)$. Each vertex hosts a local matter degree of freedom; each edge hosts a finite-dimensional bond register. The Hilbert space has the form

$$\mathcal{H} = \bigotimes_{i\in V} \mathbb{C}^2 \otimes \bigotimes_{\langle i,j\rangle\in E} \mathbb{C}^{\chi_{ij}}, \tag{4}$$

and the Hamiltonian is fixed once and for all:

$$H = H_{\mathrm{mat}} + H_{\mathrm{bond}} + H_{\mathrm{int}}. \tag{5}$$

A convenient representative is

$$H_{\mathrm{mat}} = \frac{\omega}{2} \sum_{i \in V} X_i, \tag{6}$$

$$H_{\mathrm{bond}} = \sum_{\langle i,j \rangle \in E} \left(J_0 Z_i Z_j + \Delta_b n_{ij} \right), \tag{7}$$

$$H_{\mathrm{int}} = g \sum_{\langle i,j \rangle} F_{ij} \tau^x_{ij} + \kappa \sum_{\langle i,j \rangle} C_{ij} + \lambda \sum_{\langle i,j \rangle} F_{ij} \otimes (R_{ij} + R^\dagger_{ij}). \tag{8}$$

Here F_{ij} is a local frustration tile, such as

$$F_{ij} = \frac{1}{2}(I - Z_i Z_j), \tag{9}$$

n_{ij} is a rung-number operator, and R_{ij} is a finite ladder isometry on the bond register. The key structural point is that promotion is Hamiltonian. The ladder is part of the fixed Hilbert space and generator; it is not a measurement update or a state-conditioned rule.

The SRQID paper also distinguishes diagnostic quantities from dynamical inputs. Entanglement proxies may be computed along trajectories, but the Hamiltonian does not depend on them. Penalty terms are Hamiltonian operators, not projective measurements. Thus the model is linear and measurement-free at the fundamental update level [1].

Because the interaction range and operator norms are bounded on a bounded-degree graph, standard Lieb-Robinson results give an emergent causal cone. For local observables A_X and B_Y,

$$\|[A_X(t), B_Y]\| \leq c \|A_X\| \|B_Y\| \exp\left[-\frac{\mathrm{dist}(X,Y) - v_{\mathrm{LR}}|t|}{\xi} \right]. \tag{10}$$

SRQID's minimal numerical tests then extract a finite commutator-growth velocity, verify no-signalling behavior in local quenches, and check energy conservation at machine precision in the finite simulations [1].

This backbone matters because all later geometric language must be compatible with it. If the apparent geometry required collapse, state-dependent generators, or uncontrolled nonlocal updates, the program would have lost its own foundation. SRQID supplies the lawful engine.

3. QATNU: Promotion as Geometry

QATNU is the circuit and phenomenology side of the same idea. Its base layer is a reversible quantum cellular automaton (QCA) whose long-wavelength behavior can reproduce Dirac-like propagation on suitable subgraphs. For the standard one-dimensional Hadamard walk, for example,

$$\cos \omega(k) = \frac{\cos k}{\sqrt{2}}, \tag{11}$$

so $\omega(k) \approx \pm k/\sqrt{2}$ near $k = 0$, giving a discrete light cone [2].

QATNU augments this base QCA with a measurement-free promotion unit. Local stabilizer tiles diagnose frustration, and the corresponding bond registers are coherently promoted by controlled isometric increments:

$$U_{\mathrm{prom}} = \prod_{\langle i,j \rangle} C[S_{ij} = -1]\, \mathrm{INC}_{ij}. \tag{12}$$

The total update remains unitary:

$$U = U_{\text{prom}} U_0. \tag{13}$$

The original QATNU paper proposed that patterns of promoted bonds support compiled gauge-like gadgets and geometry-like metric proxies. It also attempted early spin-2 diagnostics using transverse-traceless projection of long-wavelength bond fluctuations [2].

Those early ambitions are historically important but must be separated by current proof status. The QATNU draft contains the original geometric reach: finite-dimensional bond registers encode adjacency, promotions alter effective geometry, and tensor-network-like organization could produce gauge or spin-2 phenomena. The later work shows that this reach needed discipline. Some early spin-2 indicators were suggestive but insufficient; later audits demoted naive bond-fluctuation PSDs and direct proxy fits as inadequate evidence for a true tensor phase.

Thus QATNU should now be read as the original physical ambition rather than the final proof: promoted relational bonds are the substrate from which scalar and tensor shadows may be read.

4. Scalar Timing Shadows

A scalar timing shadow is the part of a deeper substrate that a local clock reads as a scalar frequency shift. It is "shadow" language because the clock does not reconstruct the whole object. It measures a projection.

Let the hidden substrate be described by a microscopic state or Hamiltonian H_{micro}. After coarse graining, suppose it yields an effective weighted graph $W = (w_{ij})$, degree matrix D, and weighted Laplacian

$$L_w = D - W. \tag{14}$$

The scalar load Λ is then required to satisfy the leading screened closure

$$(\kappa L_w + \mu^2 I)\Lambda = A\rho, \tag{15}$$

with dynamical completion

$$\partial_t \Lambda + \Gamma(\kappa L_w + \mu^2 I)\Lambda = \Gamma A \rho(t). \tag{16}$$

The clock reads Eq. (1).

The scalar-selection program summarizes this as the spine

$$H_{\text{micro}} \to W \to L_w \to d_{\text{eff}} \to G_{d_{\text{eff}}}(r) \to \Lambda(r) \to \omega_{\text{eff}}. \tag{17}$$

This is not asserted as a fully derived identity. It is a level-aware dependency structure with microscopic, mesoscopic, effective, and observable quantities kept distinct [4, 6].

In this scalar program, the same operator L_w does two jobs. It governs scalar response through the Green function, and it defines an effective spectral dimension through the heat kernel:

$$K(t) = e^{-tL_w}, \qquad P_{\text{return}}(t) = \frac{1}{|V|}\text{Tr}K(t), \tag{18}$$

with

$$d_{\text{eff}}^{(\text{diff})}(t) = -2\frac{\mathrm{d}\log P_{\text{return}}}{\mathrm{d}\log t}. \tag{19}$$

Independently, a shell-averaged scalar load gives

$$d_{\text{eff}}^{(\Lambda)}(r) = 2 - \frac{\mathrm{d}\log|\Lambda_{\text{shell}}(r)|}{\mathrm{d}\log r}. \tag{20}$$

The scalar closure test requires these estimates to agree in the same window where the timing law fits best [5].

In a Gaussian scaling regime,

$$\Lambda(r) \sim G_{d_{\text{eff}}}(r) \sim r^{2-d_{\text{eff}}}. \tag{21}$$

If

$$d_{\text{eff}} \approx 3, \tag{22}$$

then

$$\Lambda(r) \sim \frac{1}{r}, \qquad \frac{\delta\omega}{\omega} \sim -\frac{1}{r}. \tag{23}$$

That is the correct radial envelope for weak-field gravitational redshift, but only as a scalar precondition. The scalar-selection work is explicit that full tensor geometry is withheld pending derivation.

Thus the scalar timing shadow is the first readable face of the program, not its endpoint.

5. Closure Rather Than Curve Fitting

The scalar timing law can be fit in many systems. That is not enough. A disciplined scalar-sector claim requires closure under its own rules.

The strongest numerical scalar closure test is

$$d_{\text{eff}}^{(\text{diff})} \overset{?}{\approx} d_{\text{eff}}^{(\Lambda)} \overset{?}{\approx} 3 \tag{24}$$

in the same scaling window where

$$\omega_{\text{eff}} = \frac{\omega}{1+\alpha\Lambda} \tag{25}$$

fits best [5]. In addition, the static closure Eq. (15) and the dynamic closure Eq. (16) should fit the same graph operator.

A convincing closure window should satisfy at least five conditions:

1. a nontrivial intermediate plateau in diffusion time or shell radius;
2. agreement between diffusion-based and shell-profile-based dimension estimates;
3. local minimization of timing-law residuals in that same interval;
4. finite-size drift that weakens rather than grows with increasing system size;
5. robustness to source placement and graph-extraction thresholds.

A transient crossing through $d_{\text{eff}} = 3$ is not enough. A timing fit in one window and a dimension estimate in another is not closure. The value of the scalar-selection papers is precisely this: they make failure sharp.

The scalar-sector failure modes are informative. Heavy-tailed weights, bottlenecks, near-tree sparsity, shortcut-dominated graphs, source-placement artifacts, memory effects, and mismatched timing/dimension windows all narrow or falsify the intended scalar story. A clean failure is not an embarrassment; it is the mechanism by which the program becomes more truthful.

6. Internal Loads and External Observables

The internal/external distinction is essential. An internal scalar load Λ_i on a graph does not automatically imply an externally measurable scalar geometry. An external sensor at position x measures, at most,

$$\Lambda_{\text{ext}}(x) = \sum_i C(x, i)\Lambda_i, \tag{26}$$

where $C(x, i)$ is an internal-to-external coupling kernel [7].

The possible kernel classes include:

- near-field or evanescent coupling, with exponential standoff suppression;
- substrate-mediated diffusive coupling, with material-dependent tails and delays;
- radiative or boundary-modulated coupling, with frequency-selective response;
- vacuum-like Green response, the strongest and most ambitious case;
- the null kernel, where the internal load has no measurable external field.

This prevents a common overclaim. A superconducting or QATNU-like medium could exhibit an internally valid scalar timing sector while producing no external geometric signal. That would not make the internal sector meaningless. It would limit its scope.

The same logic will later apply to tensorial timing shadows. A tensor response internal to a carrier is not yet universal gravity. Externalization and universality require separate evidence.

7. Why Scalar Timing Is Not Gravity

A scalar timing law can mimic one aspect of gravitational redshift. It cannot by itself reproduce general relativity.

Gravity requires at least the following:

1. local proper-time behavior;
2. operational spatial intervals and rod behavior;
3. causal cones and signal structure;
4. free-fall behavior;
5. stress-energy response constrained by conservation laws;
6. radiative long-wavelength modes;
7. a tensorial sector with two physical transverse-traceless polarizations.

The older QATNU/SRQID work recognized this. The clock-slowdown relation was supported in small systems, but early attempts to extract a long-wavelength spin-2 sector from simple bond or entanglement proxies did not yield a convincing $1/k^2$ tensor response. In the later QATNU/SRQID testbed paper, those attempts are explicitly treated as insufficient, leaving the spin-2 sector as an open problem [3].

The scalar program therefore had the right discipline but not the full geometry. It could say

$$\text{relational load} \rightarrow \text{clock lag}. \tag{27}$$

It could not yet say

$$\text{relational substrate} \to \text{universal tensorial geometry}. \tag{28}$$

The right upgrade is not to abandon scalar timing. The right upgrade is to preserve scalar timing as the first readable projection and then ask whether a protected tensorial timing shadow can be built above it.

8. Tensorial Timing Shadows

A tensorial timing shadow is a richer projection of the same relational substrate: not merely a scalar lapse-like delay, but a source-visible tensor response that organizes clock rates, causal propagation, stress response, and long-wavelength spin-2 modes.

At the linearized level, the relevant target is not an arbitrary tensor. It is the transverse-traceless sector

$$h_{ij}^{\mathrm{TT}}, \tag{29}$$

with two physical polarizations. A gravity-shaped tensor timing shadow should satisfy

$$N_{\mathrm{TT}} = 2, \tag{30}$$

$$\omega(k) = c_g|k| + O(|k|^3), \tag{31}$$

$$\chi_{\mathrm{TT}}(0,k) \sim \frac{1}{|k|^2}, \tag{32}$$

and it must couple to conserved or Ward-constrained sources with finite residue.

This is exactly the target stated in the chiral bosonic spin-2 carrier work: a local architecture whose constrained infrared sector contains exactly two transverse-traceless spin-2 branches, finite local residue, a $1/k^2$ projected/conserved-source response, and exact first-class constraint propagation [8]. The claim boundary is also explicit: this is not universal coupling, nonlinear diffeomorphism invariance, or a native derivation from the minimal ladder Hamiltonian. It is a local linear spin-2 response-carrier architecture.

In other words, the tensorial timing shadow is the missing gravity-shaped face of QATNU/SRQID.

The scalar timing shadow says

$$\Lambda \mapsto \omega_{\mathrm{eff}}. \tag{33}$$

The tensorial timing shadow says

$$h_{ij}^{\mathrm{TT}} \mapsto \{\text{clock anisotropy, propagation, conserved stress response, spin-2 radiation}\}. \tag{34}$$

The latter is not merely a bigger scalar. It is a different level of observable structure.

9. The Obstruction Ledger

The spin-2 problem is hard because several apparently natural routes fail. The chiral bosonic carrier work organizes the problem around a four-face obstruction [8].

Obstruction face	**Content**

Compact character face	Exact compact finite-dimensional local tensor characters tend to appear at high derivative order, pushing the natural phase toward $z = 3$ rather than the desired relativistic $z = 1$.
Source face	Local derivative-built conserved TT sources are suppressed. Beltrami and Cotton-type sources carry extra powers of k, destroying finite $1/k^2$ source response.
Mass face	First-classness alone does not protect a massless pole. A positive local mass term can still appear unless an additional Ward/Goldstone shift protects it.
Doubler face	A lone local periodic cone violates topological charge conservation. A local periodic bulk symbol cannot simply contain one isolated cone without a compensating partner or boundary escape.

The route ledger records several failed or demoted approaches: positive quadratic normalizers collapse to strict centralizers; local projectors inherit compact $z = 3$ character obstruction; finite-prime Clifford QCAs produce arithmetic quasienergy combs rather than robust local poles; Cotton prepotentials give the right reduced response but wrong compact dynamics; naive square bosonic lifts double the TT branch count.

This failure ledger is not a weakness of the program. It is one of its strengths. It prevents the narrative from treating every suggestive signature as success. It shows why the tensorial route needed something more structured.

10. The Chiral/Ward Carrier

The chiral bosonic spin-2 carrier supplies the first serious tensorial completion attempt. Its route is

$$\text{first-class quotient} \to \text{domain-wall single cone} \to \text{positive chiral bosonic lift} \\ \to \text{Ward-completed matter square} \to \text{hard local constraints} \to \text{compact finite-spin quantum box}. \tag{35}$$

The positive chiral bosonic lift avoids the branch doubling of the naive square. It yields a continuous-variable Gaussian/QCA response carrier with linear dispersion, finite residue, first-class residuals at numerical precision, and a projected/static TT response close to $1/k^2$. The finite-depth Gaussian bosonic QCA version maintains the linear quasienergy scaling while preserving symplectic structure to numerical precision [8].

The Ward-completed matter sector addresses the source and mass problem. A local symmetric stress variable S_{ij} is constrained by a Ward law, and the dangerous coupling is completed into a local positive square. The later covariant form introduces

$$R_{ij} = S_{ij} - \alpha A_{ij}, \tag{36}$$

with local constraints

$$\nabla_i R_{ij} = 0, \qquad \operatorname{tr} R = 0. \tag{37}$$

The TT projector is then recovered only after constraint elimination, Coulomb-style, rather than inserted as a microscopic long-range kernel. This is exactly the kind of move required by the original QATNU spirit: do not insert geometry by hand; make it appear as the constrained readout of local structure.

The full compact tensor/matter Ward-square target assembles matter stress S_{ij} and a synthetic chain of tensor variables $A_{ij}(s)$. The reported constrained harmonic quotient has exactly two low

branches, near-linear exponents, stress response close to k^{-2}, and a finite third-branch gap. If only the relative constraint is imposed, extra low tensor branches remain; the full tensor quotient is therefore doing real work [8].

The finite-spin compact quantum box adds a microscopic check. It separates the zero-momentum Anderson tower from a finite-momentum source pole and finds a finite matter-operator pole fraction near the box Debye-Waller prediction. The paper's own conclusion remains bounded: the result is below full emergent gravity and below a theorem-level finite-dimensional phase proof, but it strongly supports a compact finite-spin route to a local first-class spin-2 response carrier.

This is the first substantial tensorial timing-shadow candidate.

11. The First-Order/Berry Normalizer Turn

The newer first-order/Berry normalizer program should be understood as the next methodological refinement. The chiral/Ward carrier built a plausible tensor response architecture. The first-order/Berry route asks whether the remaining tensor evidence can be converted into a certificate-gated proof program.

The reported pipeline is

$$\begin{aligned}&\text{constraints} \to \text{projectors} \to \text{projected generator} \to \text{physical charts}\\ &\to \text{4D reduced operator} \to \text{eigenvalue floor} \to \text{source rank/residue} \to \text{named-box tensor signal.}\end{aligned} \tag{38}$$

The important shift is not merely numerical. It is evidential. A numerical plot says, "this looks like a branch." A certificate route says, "on this named region, after these reductions, this operator has this bounded floor or this source-visible line, subject to these replay obligations."

That is exactly the kind of object the program needed after the earlier spin-2 PSD failures. The early QATNU bond-fluctuation proxies were too indirect. The chiral carrier was more direct but still partly architecture/audit. The first-order/Berry normalizer program tries to make the tensor claim local, algebraic, charted, and certificate-checkable.

The current claim should therefore be stated narrowly:

> A first-order/Berry normalizer candidate has passed a sequence of named-box algebraic and interval gates supporting a reduced physical operator floor and source-visible tensor lines.

It should not be stated as:

> QATNU proves gravity.

The difference matters. The first version can survive scrutiny; the second cannot.

12. Relation to Autonomous Quantum Shutters

The autonomous quantum shutter branch is not the same as the spin-2 carrier branch, but it supports a neighboring lesson: finite quantum controllers can produce genuine field-sector changes without becoming classical or infinite-dimensional.

The infinite-tail/continuum shutter theorem proves that, under smooth positive smeared quadratic couplings and weighted form-factor convergence, a fixed finite-dimensional quantum controller has a controlled field continuum limit: Hamiltonians converge in norm resolvent, dynamics converge strongly on compact time intervals, and full/reduced states converge in trace

norm. It also clearly distinguishes normalizable unbounded photon-number support from singular abrupt-boundary non-Fock limits [9, 21, 22].

This matters for QATNU/SRQID because the whole program depends on the legitimacy of finite relational controllers, registers, or graph degrees of freedom producing effective field behavior. The shutter paper does not prove gravity. It does, however, support the general strategy of autonomous finite quantum control over field-sector structure.

In the arc of the program:

- SRQID supplies local unitary relational dynamics.
- QATNU supplies clock-readable promotion load.
- Scalar selection supplies operator closure criteria.
- Autonomous shutters supply a finite-controller field-change proof of concept.
- Chiral/Ward spin-2 supplies the tensor response carrier.
- First-order/Berry normalizer work supplies certificate-gated tensor evidence.

This is a coherent research path, not a single leap.

13. What "Gravity" Would Mean Here

Within this program, gravity should not be defined as "clock slowdown." That is too weak. Nor should it be defined as "a spin-2-looking plot." That is also too weak.

The appropriate definition is:

> Gravity is the universal tensorial organization of timing, causal propagation, stress response, and stable records emerging from a relational/bond substrate.

A scalar timing shadow gives one component of that organization. A tensorial timing shadow gives the gravity-shaped linear response. A full gravitational theory would require the tensorial shadow to be universal, nonlinear, stable, and empirically indistinguishable from general relativity in the appropriate limit while possibly differing in controlled ultraviolet or substrate-sensitive regimes.

The sequence is therefore

$$\Lambda \quad \text{(scalar load)}, \tag{39}$$

$$\omega_{\text{eff}}(\Lambda) \quad \text{(clock-readout shadow)}, \tag{40}$$

$$h_{ij}^{\text{TT}} \quad \text{(tensorial timing/propagation shadow)}, \tag{41}$$

$$g_{\mu\nu} \text{ or equivalent operational metric} \quad \text{(full reconstructed geometry)}. \tag{42}$$

The scalar-to-tensor transition is not optional. It is the difference between a redshift analogy and a gravity candidate.

14. Claim Boundary and Evidence Levels

The strongest defensible thesis is:

> QATNU/SRQID began as a clock-readout theory of relational load. The scalar timing shadow is the first readable projection of the substrate. The current spin-2 and first-order/Berry normalizer work supplies a certificate-gated route toward the missing tensorial timing shadow: a physical spin-2-like sector with source-visible modes, still bounded to audited/certified regions and not yet a global continuum theory of gravity.

This thesis has three important components.

First, scalar timing is real as a program only if it closes. The closure criterion is not a good-looking timing fit. It is agreement of diffusion dimension, shell dimension, timing residuals, static response, and modal relaxation in one shared scaling window.

Second, tensorial timing is gravity-shaped only if it is protected and source-visible. Two TT modes alone are not enough; they must be massless without fine tuning, coupled through Ward/conserved sources, and stable against local perturbations.

Third, external geometry requires a coupling kernel. An internal scalar or tensor load does not automatically produce an external field. The kernel in Eq. (26) must be specified, measured, or bounded.

Thus the program has a clear epistemic ladder:

$$\text{internal scalar load} \neq \text{external scalar geometry} \neq \text{tensor response} \neq \text{gravity}. \tag{43}$$

Each arrow requires work.

15. Open Proof Obligations

The open obligations are not vague. They can be listed.

15.1. Certificate replay

The first-order/Berry normalizer certificates must be replayed in a stronger formal environment. Python interval certificates are meaningful evidence, but a Lean or theorem-prover replay would sharply upgrade trust.

15.2. Global momentum coverage

Named-box success must be extended beyond audited boxes. A tensor phase cannot be claimed from isolated chart regions unless those charts cover the relevant infrared domain and all singular or transition regions are controlled.

15.3. Source rank and residue

The source-visible lines must retain finite residue and correct rank under continuation, not merely at sampled points or boxed intervals.

15.4. Microscopic Hamiltonian realization

The normalizer/tensor response architecture must be tied back to a local microscopic Hamiltonian, ideally one compatible with the SRQID/QATNU relational-register spirit.

15.5. Thermodynamic or continuum stability

The finite-spin and compact-route evidence must scale. The chiral/Ward paper identifies the decisive remaining test as the thermodynamic finite-spin spectral function of the full compact Ward-square tensor/matter model.

15.6. Ward/source universality

Different matter sources and clocks must see the same effective tensorial geometry. Without universality, the result is a medium-specific response carrier, not gravity.

15.7. Nonlinear completion

Linear spin-2 response is necessary but not sufficient. A true gravity theory must address nonlinear self-coupling, constraint propagation beyond harmonic order, and the analog of diffeomorphism structure or its operational substitute.

15.8. Empirical distinction

The program must identify what could distinguish it from ordinary effective field theory, condensed-matter analogs, or engineered tensor modes. The scalar-selection experimental program points in this direction through topology-versus-mass controls, force-null discriminants, distance laws, and modal relaxation tests.

16. A Revised Paper Stack

The work now has a natural paper stack:

1. **SRQID backbone paper.** Fixed local Hamiltonian, finite bond registers, coherent promotion, Lieb-Robinson bounds, no-signalling tests.
2. **QATNU circuit paper.** QCA propagation, measurement-free promotion, original geometric interpretation, gauge-promotion ambition.
3. **Scalar timing and selection paper.** Clock-readable scalar load, weighted-Laplacian closure, effective dimension, timing-law closure tests.
4. **External-coupling paper.** Kernel classes separating internal load from external observable.
5. **Autonomous shutter paper.** Finite quantum controller and smooth continuum field-change theorem.
6. **Chiral/Ward spin-2 carrier paper.** First-class quotient, domain wall, positive chiral bosonic lift, Ward-completed matter square, compact finite-spin route.
7. **First-order/Berry normalizer certificate paper.** Charted, certificate-gated tensor evidence and formal replay agenda.

The present paper sits above the stack as a synthesis and route statement. It does not replace the technical papers. It explains why they belong to the same inquiry.

17. Discussion

The central interpretive shift is this:

> QATNU/SRQID is not trying to say that gravity is made of clocks. It is trying to say that clocks are the first readable instruments of relational geometry.

The scalar timing law was the first version of that idea. It said: a clock embedded in a relational/bond substrate reads local load as delay. The scalar-selection papers then disciplined that idea by demanding operator closure, dimensional consistency, and experimental separation between internal load and external observable.

The tensor program now completes the original intention. Gravity cannot be scalar only. The relational substrate must cast a tensorial shadow: two protected TT modes, source-visible poles, Ward structure, and stable long-distance response.

This is why the recent spin-2 work should be viewed neither as a separate project nor as a replacement for scalar timing. It is the missing face of the same project.

The strongest honest synthesis is:

SRQID gives local unitary relational dynamics. (44)

QATNU gives clock-readable promotion load. (45)

Scalar selection gives closure criteria. (46)

Chiral/Ward spin-2 gives the tensor response architecture. (47)

First-order/Berry certificates give the proof-program route. (48)

Taken together, these do not prove gravity. But they define a serious route toward a gravity-shaped tensorial timing shadow.

18. Conclusion

QATNU/SRQID began with the intuition that local clock behavior may be the first readable shadow of deeper relational structure. The original scalar timing law,

$$\omega_{\text{eff}} = \frac{\omega}{1 + \alpha\Lambda}, \tag{49}$$

captured this as a lapse/redshift-like effect of relational load. Later scalar-selection work made the idea disciplined by requiring one operator to control scalar response, effective dimension, timing shifts, and modal relaxation in a shared scaling window.

The missing face was tensorial. General relativity is not scalar clock lag; it is the universal tensorial organization of clocks, rods, causal cones, propagation, free fall, and stress response. The newer spin-2 and first-order/Berry normalizer work therefore does not erase the scalar story. It attempts to complete it by constructing and certifying a tensorial timing shadow.

The current state is strong but bounded. The chiral/Ward spin-2 carrier and compact finite-spin route provide a serious response architecture with two TT branches, near-linear dispersion, Ward-source response near $1/k^2$, compact screens, and finite-spin quantum-box support. The first-order/Berry normalizer route pushes this into a certificate-gated proof program over named regions. But the full theory still requires formal replay, global coverage, microscopic Hamiltonian realization, thermodynamic stability, source universality, nonlinear completion, and empirical discrimination.

The honest thesis is therefore:

QATNU/SRQID has developed from scalar timing shadows toward a tensorial timing-shadow program. The current landmark result is not "gravity proved," but a certificate-gated first-order/Berry route that survives hard algebraic and interval gates while preserving explicit remaining proof obligations.

That is narrow enough to defend and strong enough to be worth writing.

A. Notation Registry

Symbol	Meaning	Role
H_{micro}	Microscopic Hamiltonian or substrate dynamics	Node, bond, controller, or field-level dynamics before coarse graining.
$W = (w_{ij})$	Weighted adjacency	Effective graph induced by bond occupation, couplings, frustration, or medium extraction.
$L_w = D - W$	Weighted Laplacian	Operator controlling scalar response, diffusion, and modal relaxation.
ρ	Effective source density	Source generated by graph switching, bias imbalance, local drive, stress sector, or matter load.
Λ_i	Internal scalar load	First retained scalar quantity read by local clocks.
$\Lambda_{\text{ext}}(x)$	External scalar load	Quantity measured by an external probe if the kernel is non-null.
$C(x, i)$	Coupling kernel	Maps internal load to external observable.
α	Clock susceptibility	Converts scalar load into timing shift.
ω_{eff}	Effective clock frequency	Primary scalar timing observable.
d_{eff}	Effective spectral dimension	Extracted from return probability or shell profile.
h_{ij}^{TT}	Transverse-traceless tensor mode	Candidate tensorial timing-shadow variable.
χ_{TT}	TT response	Static or dynamical source-visible tensor response.

B. Claim Ledger

Claim type	Status
SRQID locality and unitarity	Supported by fixed local Hamiltonian structure, Lieb-Robinson assumptions, and small-system numerical checks.
QATNU promotion logic	Conceptually central; measurement-free promotion is a coherent unitary/isometric mechanism.
Scalar timing law	Supported as an effective law in small models and as a disciplined target in scalar-selection work; not universal by proof.

Scalar dimensional closure	Defined sharply; still requires strong numerical closure on concrete substrate families.
External scalar geometry	Requires explicit coupling kernel; internal load alone is insufficient.
Early QATNU spin-2 proxy evidence	Historically important but demoted as insufficient for a genuine tensor phase.
Chiral/Ward spin-2 carrier	Strong response-carrier architecture with serious audits; not yet a full gravity proof.
First-order/Berry normalizer route	Certificate-gated tensor evidence over named regions; requires replay and global extension.
Full emergent gravity	Not claimed. Requires universality, thermodynamic stability, nonlinear completion, and empirical distinction.

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