

Matrix Node Theory (MNT): A Unified Structural Framework for Emergent Spacetime, Matter, and Quantitative Unification

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Abstract

Matrix Node Theory (MNT), also referred to as the Evans Node Dialect (END) in previous work, proposes that spacetime, matter, and the effective field content of high-energy physics emerge from a discrete node lattice subjected to a fundamental limit on total change per progression step. Reality is modelled as an ordered sequence of frames, each frame being a configuration of node states on a graph $G(V, E)$ with characteristic length scale ℓ_0 and progression step $\delta\tau$. A limit functional C_{tot} bounds the allowed frame-to-frame change, and the familiar continuum constants ($c, \hbar, G, \Lambda$) arise as collective response parameters of this constraint.

This unified white paper consolidates and systematizes the core architectural components developed across earlier internal documents. Part I presents the ontological foundations: five postulates defining proto-potentials, frame stacks, and the interpretation of gravity as “asymmetric actuation” of progression under the fundamental limit. Part II formalizes the mathematical lexicon: the node graph $G(V, E)$, the local update rule F_i , the limit functional C_{tot} , and the unified effective Lagrangian $\mathcal{L}_{\text{eff}}$ that governs the continuum limit. Part III articulates the methodology, with emphasis on the *One Graph / Parameter Lock Rule*: a single microscopic specification (graph topology, limit scale, and couplings) must simultaneously generate all observables, providing a structural defence against fine-tuning and *post hoc* parameter fitting. Part IV outlines the quantitative derivation pipeline for a key dimensionless observable, the lepton mass ratio $m_\mu/m_e \approx 206.7$, using a pattern operator $\hat{\mathcal{P}}$ on G and a progression-cost mapping from eigenvalues to effective masses. The same lattice topology and microscopic parameters are then used, in principle, to determine the electromagnetic coupling and fine-structure constant $\alpha \approx 1/137$ and to constrain gravitational-wave propagation.

Taken together, these elements define MNT as a unified structural framework with clear falsifiability criteria: if one locked microscopic model reproduces the lepton hierarchy, the fine-structure constant, and gravitational constraints, the theory qualifies as a serious contender for a unified description of fundamental physics. If it fails, it does so in a transparent and diagnostically useful way.

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1.0 Part I: Foundations & Ontology (The “Constitution”)

1.1 1.1 Postulates and Proto-Potentials

The foundations of Matrix Node Theory are encoded in a small set of postulates that define the pre-geometric substrate, the emergence of time, and the role of the fundamental limit. A convenient formulation is as follows.

Postulate 1 (Proto-potential substrate). There exists a pre-geometric configuration space of “proto-potentials” $\mathcal{P}$, representing latent possibilities for local excitations. At this level there is no metric, no continuum spacetime manifold, and no distinguished notion of distance or duration. Only relations of potential compatibility and incompatibility are defined.

Postulate 2 (Frames and progression). Physical reality is realized as an ordered sequence of discrete frames

$$\mathcal{F} = \{F_n\}_{n \in \mathbb{Z}},$$

where each frame F_n is a concrete selection of compatible possibilities from $\mathcal{P}$, organized as a node graph $G(V, E)$ with node states $\phi_i(n)$ and internal labels (spin, gauge indices, lexicon labels). The ordering index n defines a progression parameter, and physical time is identified in the continuum limit as $t_n = n \delta\tau$ for some fixed progression step $\delta\tau$.

Postulate 3 (Fundamental limit on change). Between successive frames F_n and F_{n+1} , the total change in node states and phases is subject to a universal constraint,

$$C_{\text{tot}}(n) \leq \Lambda_{\text{lim}}, \quad (1)$$

where C_{tot} is a non-negative functional of frame-to-frame differences and Λ_{lim} is a fundamental limit scale. All dynamics of the emergent continuum, including the appearance of forces and fields, are consequences of how configurations evolve while respecting (1).

Postulate 4 (Node lattice and locality). Within each frame, the realized configuration is a node graph $G(V, E)$, with V the set of nodes and E the set of edges encoding adjacency relations. A characteristic spacing ℓ_0 defines the scale at which the graph can be coarse-grained to an effective continuum. Dynamics are local: allowed updates at a node i depend only on the node and its neighbors $\text{nbr}(i)$.

Postulate 5 (Emergent laws and observables). Continuum notions such as metric structure, field strengths, charges, and stress-energy are emergent summary variables constructed from statistics of node configurations across many frames. The familiar constants ($c, \hbar_{\text{eff}}, G_{\text{eff}}, \Lambda_{\text{eff}}$) are not fundamental inputs but collective parameters that arise jointly from the lattice geometry, the limit scale Λ_{lim} , and the microscopic couplings in C_{tot} .

The primitive objects of the theory are thus:

- the proto-potential space $\mathcal{P}$,
- the frame stack $\{F_n\}$,
- the node graph $G(V, E)$ in each frame,
- and the limit functional C_{tot} .

Everything else is emergent.

1.2 1.2 Frame Stack and Emergent Time

Time appears as the ordering of frames:

$$F_n \rightarrow F_{n+1}, \quad n \in \mathbb{Z}.$$

We assign a progression step $\delta\tau$ and define $t_n = n\delta\tau$. The continuum limit $t \in \mathbb{R}$ emerges when we consider coarse-grained observables averaged over many frames, in which discrete jumps are effectively smoothed.

In this view, “causality” is a constraint propagation property of the allowed transitions consistent with (1). Local updates cannot instantaneously reconfigure distant regions without consuming progression capacity in intermediate frames.

1.3 Gravity as Asymmetric Actuation

Within MNT, gravity is not introduced as a fundamental geometric field. Instead, it is interpreted as a structural consequence of *asymmetric actuation* of the progression under the limit:

Concentrations of energy–momentum locally consume a larger share of the available change budget C_{tot} , forcing surrounding regions to adjust their progression in a way that mimics spacetime curvature and free-fall trajectories.

More explicitly:

- In regions with higher energy density, more of the limit Λ_{lim} is consumed by local updates, leaving less capacity for other configurations to change. This can be encoded as a modulation of an effective progression rate.
- Coarse-grained, these modulations can be summarized by an emergent metric $g_{\mu\nu}$ in which geodesics describe the paths of minimally constrained progression for test patterns.
- The effective gravitational constant G_{eff} is then a *collective* parameter linking energy density to the required progression adjustments expressed as curvature.

This interpretation of gravity as “progression adjustment” under a limit provides a conceptual bridge between the discrete frame-stack and the continuum Einstein equations, which are recovered in an appropriate coarse-grained limit of the underlying dynamics.

2.0 Part II: Mathematical Formalism (The “Lexicon”)

2.1 Node Graph and Update Rule

Each frame F_n contains a node graph $G = (V, E)$ with:

- V the set of nodes, indexed by $i = 1, \dots, N$,
- E the set of edges, each edge $(i, j) \in E$ representing adjacency between nodes i and j .

Each node carries dynamical degrees of freedom $\phi_i(n)$ (matter-like variables) and phases $\theta_i(n)$ (gauge-like variables), along with EQEF/latent variables as needed.

The local update rule is:

$$\phi_i(n+1) = F_i(\{\phi_j(n)\}_{j \in \text{nbr}(i)}, \{\theta_j(n)\}_{j \in \text{nbr}(i)}, \text{parameters}), \quad (2)$$

with an analogous evolution for $\theta_i(n)$, and with the constraint that the resulting configuration $(\phi(n+1), \theta(n+1))$ satisfies the limit condition (1).

The precise form of F_i is chosen so that, after coarse-graining, the emergent dynamics reproduce a relativistic field theory with the desired symmetries. The update rule is local and consistent with graph automorphisms that approximate continuum Lorentz invariance in the long-wavelength limit.

2.2 Limit Functional and Emergent Speed of Light

The limit functional is specified as:

$$C_{\text{tot}}(n) = C_{\text{matter}}(n) + C_{\text{gauge}}(n) + C_{\text{EQEF}}(n) + \dots, \quad (3)$$

$$C_{\text{matter}}(n) = \sum_{i \in V} \left[\alpha_\phi \left(\frac{\phi_i(n+1) - \phi_i(n)}{\delta\tau} \right)^2 + \beta_\phi \sum_{j \in \text{nbr}(i)} (\phi_i(n) - \phi_j(n))^2 \right], \quad (4)$$

$$C_{\text{gauge}}(n) = \sum_{\langle ij \rangle} \left[\kappa_\theta \left(\frac{\theta_i(n+1) - \theta_i(n)}{\delta\tau} \right)^2 + \kappa_A (\theta_i(n) - \theta_j(n))^2 \right]. \quad (5)$$

The constants $(\alpha_\phi, \beta_\phi, \kappa_\theta, \kappa_A)$ are microscopic couplings and Λ_{lim} is the fundamental limit scale.

The emergent invariant speed of propagation c is determined by the ratio of the spatial and temporal discretization scales:

$$c = \frac{\ell_0}{\delta\tau}, \quad (6)$$

in the regime where the discrete Laplacian and time-step operator approximate a Lorentz-invariant wave operator at long wavelengths.

2.3 Unified Effective Lagrangian

Upon coarse-graining the graph over scales $L \gg \ell_0$ and many frames, the discrete dynamics and limit functional can be summarized by a unified effective Lagrangian density $\mathcal{L}_{\text{eff}}$:

$$\mathcal{L}_{\text{eff}} = \mathcal{L}_{\text{grav}} + \mathcal{L}_{\text{gauge}} + \mathcal{L}_{\text{matter}} + \mathcal{L}_{\text{latent}} + \mathcal{L}_{\text{corr}}. \quad (7)$$

A canonical choice is:

$$\mathcal{L}_{\text{grav}} = \frac{1}{16\pi G_{\text{eff}}} (R + \mathcal{O}(R^2/M_*^2)), \quad (8)$$

$$\mathcal{L}_{\text{gauge}} = -\frac{1}{4} \sum_a \frac{1}{g_a^2} F_{\mu\nu}^a F^{a\mu\nu}, \quad (9)$$

$$\mathcal{L}_{\text{matter}} = \sum_{\text{fermions } f} \bar{\psi}_f (i\gamma^\mu D_\mu - m_f) \psi_f + \sum_{\text{scalars } s} (D_\mu H_s)^\dagger (D^\mu H_s) - V(H_s, \{\Sigma_A\}). \quad (10)$$

Here R is the Ricci scalar, M_* is an effective suppression scale for higher-curvature corrections, $F_{\mu\nu}^a$ are gauge field strengths, and V is the scalar potential for Higgs-like and latent fields. The effective constants $(G_{\text{eff}}, g_a, m_f, \dots)$ are all functions of the MNT microscopic parameters.

The limit functional enters this continuum description through:

- the emergent G_{eff} , derived from the response of the lattice to localized energy perturbations;
- the gauge couplings g_a , derived from the stiffness of phase differences in C_{gauge} ;
- the vacuum energy density and Λ_{eff} , derived from the unused portion of Λ_{lim} in typical configurations.

3.0 Part III: Methodology (The “Rules”)

3.1 3.1 The One Graph / Parameter Lock Rule

A central methodological principle of MNT is the *One Graph / Parameter Lock Rule*. It can be stated as follows:

There exists a single microscopic specification

$$\text{MMPs} = (G, \ell_0, \delta\tau, \Lambda_{\text{lim}}, \epsilon_{\text{node}}, \{\text{couplings}\})$$

such that all emergent observables of interest—lepton mass ratios, gauge couplings, gravitational constants, black-hole entropy—are functions of this one set of parameters. The graph topology G and fundamental limit Λ_{lim} cannot be changed or sector-tuned between observables.

In more operational terms:

- one must choose a single class of graph topologies G with well-defined statistical properties (e.g. an E_8 -inspired lattice patch or a quasi-random regular graph ensemble) and fix it;
- once G , ℓ_0 , $\delta\tau$, Λ_{lim} , and the couplings in C_{tot} are fixed to match coarse scales, the same model must be used to derive all dimensionless observables;
- it is not permitted to select “Graph A” to fit lepton masses, then switch to “Graph B” to fit the fine-structure constant, and “Graph C” for gravity. That would amount to multiple distinct effective theories.

This parameter lock is the structural defense against fine-tuning: it forces the theory to succeed or fail as a single coherent entity. Any genuine success in matching multiple observables with the same microscopic specification is thus highly non-trivial.

3.2 3.2 Non-Circularity and Dimensionless Targets

A second methodological pillar is *non-circularity*. Derived quantities must not be fed back as input parameters for the same sector. In practice:

- dimensionless ratios such as m_μ/m_e , m_τ/m_μ , and α are targeted because they are independent of human units;
- Standard Model masses and couplings are not allowed as free inputs; instead, they must emerge from the pattern spectrum and the limit functional;
- structural relations (e.g. $M_Z^2/M_W^2 = \cos^2 \theta_W$) may be used as consistency checks but do not constitute predictive power on their own.

Within this framework, the “hero calculations” are specific, dimensionless predictions derived from lattice eigenvalues and microscopic couplings, subject to the parameter lock.

4.0 Part IV: Quantitative Evidence (The “Hero Calculation”)

4.1 4.1 Objective: The Lepton Mass Ratio

The primary quantitative target in this unified white paper is the dimensionless lepton mass ratio:

$$R_{\mu e} \equiv \frac{m_\mu}{m_e} \approx 206.7.$$

It serves as a clean test of predictive power because:

- it is unitless and independent of human choices of length or time;
- it involves non-trivial structure across generations;
- it is precisely measured and therefore highly constraining.

4.2 4.2 Pattern Operator on the Node Graph

Particles are modelled as stable patterns on the node graph G , i.e., as eigenmodes of a Hermitian pattern operator $\hat{\mathcal{P}} : \mathcal{H} \rightarrow \mathcal{H}$ acting on the space of node amplitudes $\mathcal{H} \cong \mathbb{C}^N$:

$$(\hat{\mathcal{P}}\psi)_i = \sum_{j \in \text{nbr}(i)} w_{ij} \psi_j + u_i \psi_i, \quad (11)$$

where $w_{ij} = w_{ji}^*$ are edge weights and $u_i \in \mathbb{R}$ are local potentials derived from the microscopic couplings and the limit functional.

A particularly transparent choice uses the graph Laplacian $\hat{L}$:

$$\hat{L}_{ij} = \begin{cases} d_i & \text{if } i = j, \\ -1 & \text{if } (i, j) \in E, \\ 0 & \text{otherwise,} \end{cases} \quad (12)$$

and sets

$$\hat{\mathcal{P}} = \gamma_0 \mathbb{I} + \gamma_1 \hat{L}, \quad (13)$$

with (γ_0, γ_1) determined by the same couplings that enter the limit functional C_{tot} . The eigenproblem is:

$$\hat{\mathcal{P}}\psi^{(a)} = \Lambda_a \psi^{(a)}, \quad (14)$$

with eigenvalues

$$\Lambda_a = \gamma_0 + \gamma_1 \lambda_a^{(L)}, \quad (15)$$

where $\lambda_a^{(L)}$ are Laplacian eigenvalues.

4.3 4.3 Stable Patterns and Progression Cost

A candidate lepton pattern $\psi^{(a)}$ is a mode that:

- recurs with high probability across many frames under the update rule F_i ,
- consumes a statistically stable fraction of the progression limit Λ_{lim} per frame,

- is robust under small perturbations, corresponding to a long-lived excitation.

For normalized eigenmodes $\|\psi^{(a)}\| = 1$, the average frame-to-frame cost in the matter sector is:

$$C_{\text{matter}}^{(a)} \approx \alpha_\phi \left(\frac{m_a c^2}{\hbar_{\text{eff}}} \right)^2 + \beta_\phi \lambda_a^{(L)} + \dots, \quad (16)$$

where m_a is the effective mass of the pattern. The total fraction of the limit used by pattern a is:

$$\eta_a \equiv \frac{\langle C_{\text{tot}} \rangle_{\psi^{(a)}}}{\Lambda_{\text{lim}}}, \quad (17)$$

which, for massive leptons, is dominated by the rest-energy term and can be approximated as:

$$\eta_a \approx \mathcal{F}_\eta(\Lambda_a), \quad (18)$$

for some monotonic function $\mathcal{F}_\eta$ determined by the limit functional and the update rule.

Solving for m_a yields:

$$m_a \approx \frac{\hbar_{\text{eff}}}{c^2} \sqrt{\frac{\eta_a \Lambda_{\text{lim}}}{\alpha_\phi}} \propto \sqrt{\mathcal{F}_\eta(\Lambda_a)}. \quad (19)$$

Therefore, the lepton mass ratio becomes:

$$\frac{m_\mu}{m_e} = \sqrt{\frac{\mathcal{F}_\eta(\Lambda_\mu)}{\mathcal{F}_\eta(\Lambda_e)}}, \quad (20)$$

where Λ_e and Λ_μ are the eigenvalues associated with the electron- and muon-like patterns, respectively.

4.4 Prediction Pipeline and Parameter Lock

Given the locked MMPs, the practical pipeline for the hero calculation is:

1. **Fix G and C_{tot} .** Choose the graph topology G once and for all, along with ℓ_0 , $\delta\tau$, Λ_{lim} , and the couplings $(\alpha_\phi, \beta_\phi, \kappa_\theta, \kappa_A)$.
2. **Construct $\hat{\mathcal{P}}$.** Define $\hat{\mathcal{P}}$ in terms of $\hat{L}$ and the microscopic couplings, consistent with earlier sections.
3. **Diagonalize $\hat{\mathcal{P}}$.** Compute eigenvalues Λ_a and eigenvectors $\psi^{(a)}$ numerically on large finite graphs, using boundary conditions compatible with the intended coarse continuum limit.
4. **Identify lepton patterns.** Select three eigenmodes as candidates for e, μ, τ , based on their spectral positions and stability properties.
5. **Evaluate $\mathcal{F}_\eta$.** For each candidate mode, use C_{tot} (via analytic approximations or Monte Carlo progression simulations) to estimate $\eta_a = \mathcal{F}_\eta(\Lambda_a)$.
6. **Compute m_μ/m_e .** Insert η_e and η_μ into (20) and compare with 206.7.

All steps use the same microscopic model. Any agreement with the experimental ratio within a percent-level margin would be highly non-trivial; any systematic failure is a clear falsification of the particular microscopic choice.

4.5 4.5 Extension: Fine-Structure Constant from the Same Graph

As an immediate extension of the hero calculation, the fine-structure constant α can be structurally related to the same microscopic model. From the gauge sector of C_{tot} , the electromagnetic coupling emerges as:

$$g_{\text{EM}}^2 \sim \frac{\Lambda_{\text{lim}}}{\kappa_A} \left(\frac{\delta\tau}{\ell_0} \right)^2 \frac{1}{\mathcal{N}_{\text{links}}}, \quad (21)$$

where $\mathcal{N}_{\text{links}}$ is determined purely by the graph G . The fine-structure constant is then:

$$\alpha = \frac{g_{\text{EM}}^2}{4\pi} \sim \frac{1}{4\pi} \frac{\Lambda_{\text{lim}}}{\kappa_A} \left(\frac{\delta\tau}{\ell_0} \right)^2 \frac{1}{\mathcal{N}_{\text{links}}}. \quad (22)$$

No new free parameters are introduced: all quantities have already been fixed by the locked MMPs. Thus, in principle, the same lattice that produces the lepton mass ratio must also produce (after appropriate running) $\alpha \approx 1/137$, providing a second stringent test of unification.

5.0 Conclusion & Outlook

This unified white paper assembles the foundational ontology, formal lexicon, methodological rules, and quantitative pipeline of Matrix Node Theory into a single coherent document suitable for community review. The key claims can be summarized as follows:

- **Ontological clarity.** MNT adopts a discrete, frame-based ontology with a fundamental limit on change, providing a conceptually clean origin for time, spacetime, and gravity as progression adjustment.
- **Unified lexicon.** The node graph $G(V, E)$, limit functional C_{tot} , and unified Lagrangian $\mathcal{L}_{\text{eff}}$ furnish a single mathematical language connecting pre-geometric dynamics to continuum effective field theory.
- **Parameter lock.** The One Graph / Parameter Lock Rule forces all observables to emerge from a single microscopic model, providing a structural defense against fine-tuning and *post hoc* parametrization.
- **Hero calculation framework.** A precise derivational scheme is given for the lepton mass ratio m_μ/m_e , based on pattern eigenvalues of $\hat{\mathcal{P}}$ and a mapping from progression cost to effective mass. The same model, without modification, is capable in principle of predicting the fine-structure constant and gravitational-wave propagation.

Compared with continuum-first approaches such as string theory, which often rely on vast ensembles of vacua and flexible compactification choices, MNT makes a different trade-off: it *localizes* all freedom in a single discrete microscopic structure and then allows that structure to succeed or fail globally. This is both its strength and its vulnerability:

- If a locked graph and limit functional can be found that match lepton hierarchies, α , G_{eff} , and black-hole entropy, the result is extremely robust and difficult to dismiss as coincidence.

- If no such model exists, MNT is falsified in a sharp and informative way, guiding the search for alternative architectures.

The immediate next steps are clear:

1. commit to a concrete graph topology and microscopic parameter set;
2. perform the full numerical hero calculation for m_μ/m_e and α ;
3. compute lattice-induced corrections to gravitational wave speed and compare with LIGO/Virgo bounds;
4. extend horizon node counting to recover black-hole entropy.

This document is intended to serve as the authoritative “Unified White Paper” for the MNT framework, consolidating earlier internal files into a single, stable reference for Zenodo deposition and external theoretical and phenomenological review.