# Fine–Structure Constant in Matrix Node Theory / Evans Node Dialect: A Reproduction Note and SymPy Check

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November 27, 2025

**Abstract**

This short note gives a self–contained template for deriving and numerically checking the fine–structure constant $\alpha$ within the Matrix Node Theory / Evans Node Dialect (MNT/END) framework. It is designed as a companion to the current core documents: *Axioms & Ontology*, *Math Lexicon*, *Structural Proofs*, *Global Validation*, and the *Unified White Paper / END Companion*. The goal here is modest but precise:

- isolate the part of the unified Lagrangian that feeds into the QED–like sector and $\alpha$,
- state clearly which parameters are treated as structural inputs (lattice / limit / pattern quantities) rather than retrofitted numbers,
- and provide a small SymPy script that any reviewer can run to reproduce the algebra and check how close a given parameter choice comes to the observed $\alpha \simeq 1/137$.

The point is to give a clean, auditable path from the MNT/END Lagrangian to a concrete quantity, in the same non–circular spirit as the *Structural Proofs* and *Global Validation* manuscripts.

## 1 Context and Relation to the Core Documents

The present note is not a replacement for any of the main texts. Instead, it is a worked example that sits on top of them:

- **Axioms & Ontology** defines the pre–geometric potential layer, frame stack, node lattice, progression limit $\Lambda_{\text{lim}}$, and EQEF/torsion structure.
- **Math Lexicon** introduces the unified effective Lagrangian $\mathcal{L}_{\text{eff}}$, gauge sector, constants lexicon (including Definitions of $c$, $\hbar_{\text{eff}}$, $G_{\text{eff}}$ and $\alpha(\mu)$), and dimensionless hierarchy ratios.
- **Structural Proofs** gives non–circular derivation templates for foundational constants, gauge couplings, $\alpha$–structure, lepton masses, and decay rates.
- **Global Validation** lists the concrete tests and alignment roadmap (GW, SM spectra, DM, cosmology, LV/CPT, etc.).
- The **END Companion / Unified White Paper** ties the whole architecture together and explains the "one graph / parameter lock" rule.

Here we simply take the gauge/scalar slice relevant for the fine–structure constant and turn it into an executable, review–friendly calculation.

## 2 Relevant Lagrangian Sector

Following the notation of the *Math Lexicon* and *Structural Proofs*, consider the scalar–plus–phase sector for a representative Higgs–like field $\Phi$ and a phase variable $\theta$ encoding node–coherence / pattern information:

$$\mathcal{L}_{\Phi,\theta} = \frac{1}{2}\,\partial_\mu\Phi\,\partial^\mu\Phi - V(\Phi) + \frac{1}{2}N_c\,\partial_\mu\theta\,\partial^\mu\theta - \frac{\gamma}{4}(\Box\Phi)^2 - \delta\,\sin^2(\Delta\theta)\,\partial_\mu\Phi\,\partial^\mu\Phi, \tag{1}$$

with

$$V(\Phi) = \frac{\lambda_h}{4}\,(\Phi^2 - v^2)^2, \qquad v \simeq 246\text{ GeV}. \tag{2}$$

Here

- $N_c$ is a dimensionless node–interaction parameter (also appearing in other sectors of the unified Lagrangian, consistent with the *one graph / parameter lock* rule),
- $\delta$ is a dimensionless coupling controlling how phase misalignment $\Delta\theta$ modulates the kinetic term of $\Phi$,
- $\gamma$ controls higher–derivative corrections and is not used directly in the $\alpha$ estimate below,
- and $\lambda_h$ is fixed by the Higgs mass in the usual way.

In the continuum gauge sector, the *Math Lexicon* defines a QED–like piece

$$\mathcal{L}_{\text{QED}} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \bar{\psi}\big(i\gamma^\mu D_\mu - m\big)\psi, \qquad D_\mu = \partial_\mu + ie(\mu)\,A_\mu, \tag{3}$$

and the fine–structure constant at scale $\mu$ as

$$\alpha(\mu) = \frac{e^2(\mu)}{4\pi\,\hbar_{\text{eff}}c}. \tag{4}$$

The MNT/END proposal is that for a specific pattern choice, expansion of the $\delta\sin^2(\Delta\theta)$ term in Eq. (1) produces an *effective* gauge–kinetic contribution that can be matched to the $F_{\mu\nu}F^{\mu\nu}$ term, yielding a structural relation between a *derived* electric charge $e$ and the microscopic parameters $(\delta, N_c, v, \ell_0, \delta\tau, \dots)$.

## 3 Heuristic Map to the Effective Charge

A simple, representative ansatz is:

$$\Delta\theta(x) = N_c\,A_\mu(x)\,x^\mu, \tag{5}$$

so that, for small fluctuations,

$$\sin^2\big(\Delta\theta(x)\big) = \big(\Delta\theta(x)\big)^2 - \frac{1}{3}\big(\Delta\theta(x)\big)^4 + \mathcal{O}\big(\Delta\theta^6\big). \tag{6}$$

Substituting into Eq. (1) and keeping the leading quadratic term gives an effective contribution

$$\mathcal{L}_{\text{eff}} \supset -\delta\,\big(\Delta\theta\big)^2\,\partial_\mu\Phi\,\partial^\mu\Phi \;\sim\; -\frac{\delta N_c^2}{2}\,A_\mu A^\mu\,x^2\,\partial_\nu\Phi\,\partial^\nu\Phi. \tag{7}$$

Up to integration by parts and field redefinitions, the $x^2A^2$ structure can be traded for a gauge–kinetic term $F_{\mu\nu}F^{\mu\nu}$, such that the *effective* electric charge obeys, schematically,

$$e_{\text{eff}}^2 \propto \delta N_c \, v_{\text{eff}}^2, \tag{8}$$

where $v_{\text{eff}}$ is an effective mass scale built from the Higgs VEV and conversion factors between natural units and SI (or the chosen unit system).

In the simplest natural–unit normalization (with $\hbar_{\text{eff}} = c = 1$) we can write

$$\alpha \equiv \frac{e_{\text{eff}}^2}{4\pi} \simeq \frac{\delta N_c \, v_{\text{eff}}^2}{4\pi}, \tag{9}$$

with all unit conversions and geometric factors folded into $v_{\text{eff}}$. The important point is structural: once $(\delta, N_c)$ and the mapping from $v$ to $v_{\text{eff}}$ are fixed by the global fit (or a small set of reference observables), Eq. (9) yields a definite prediction for $\alpha$ at a given scale.

# 4 SymPy Reproduction Script

To make this check fully transparent, we package the above reasoning into a small SymPy script. A reviewer can paste this into a Jupyter notebook and verify every step.

## Code Listing

**SymPy script (copy into Jupyter / Python):**

```
import sympy as sp

# Symbols
delta, N_c, v = sp.symbols('delta N_c v', positive=True, real=True)

# Effective v in natural units (GeV -> 1/fm)
v_eff = sp.symbols('v_eff', positive=True, real=True)

# Fine-structure constant template: alpha = (delta * N_c * v_eff^2) / (4 pi)
alpha_expr = (delta * N_c * v_eff**2) / (4 * sp.pi)

print("Symbolic alpha:", alpha_expr)

# Nominal parameter choices (illustrative; to be aligned with the global fit)
delta_val = 0.00115      # phase-damping strength
N_c_val   = 1.0e-6       # node-interaction constant
v_val     = 246.0        # GeV
hc_GeV_fm = 0.1973269804 # hbar c in GeV*fm

# Convert v to an effective dimensionless scale v_eff
v_eff_val = v_val / hc_GeV_fm

alpha_num = alpha_expr.subs({
    delta: delta_val,
```

```
    N_c:   N_c_val,
    v_eff: v_eff_val
}).evalf()

print("Numeric alpha (natural units) =", alpha_num)
print("1/alpha ~", 1.0 / alpha_num)

# Compare to CODATA value alpha ~ 1/137.035999
alpha_exp = 1.0 / 137.035999
dev_percent = abs(alpha_num - alpha_exp) / alpha_exp * 100
print("Percent deviation from experimental alpha ~", dev_percent, "%")
```

### What This Script Checks

The script does the following:

1. Declares the structural parameters $(\delta, N_c)$ and the effective scale $v_{\text{eff}}$.
2. Encodes the template relation $\alpha = (\delta N_c v_{\text{eff}}^2)/(4\pi)$.
3. Inserts an illustrative numerical choice $(\delta, N_c, v) = (0.00115, 10^{-6}, 246\ \text{GeV})$ and a standard conversion for $\hbar c$ to compute $v_{\text{eff}}$.
4. Computes the resulting $\alpha$ and compares it to the experimental value, reporting the relative deviation.

Because all of the steps are explicit, a reviewer can:

- adjust $(\delta, N_c)$ to values that are consistent with the global MNT/END fit;
- swap in an updated mapping from the lattice parameters to $v_{\text{eff}}$ if a more precise one is derived;
- or extend the script to include running, threshold effects, or correlations with other constants, using the machinery already spelled out in the *Structural Proofs* and *Global Validation* documents.

## 5 Non–Circularity and Usage

To stay aligned with the "proof–of–method" philosophy:

- $(\delta, N_c)$ and the conversion to $v_{\text{eff}}$ should ultimately be fixed *once* by a small set of reference observables (e.g. $c$, $\hbar_{\text{eff}}$, one or two mass scales) plus lattice / pattern constraints, not tuned separately for each constant.
- The present note is therefore best used as:
  - a worked example of how to go from the unified Lagrangian to a dimensionless constant,
  - a diagnostic tool for checking consistency of any proposed global parameter set,
  - and a reproducible template that external groups (CERN, ATLAS, DESI, LIGO, XENON, industry labs) can drop into their own symbolic/numerical stacks.

Once a global MNT/END parameter set is fixed (as outlined in the *Global Validation* roadmap), the same parameters that determine $\alpha$ in Eq. (9) also feed neutrino masses, gravitational scales, cosmology, and direct–detection signals. A successful global numerical fit would therefore count as a single, highly non–trivial test of the entire framework.