Fundamental Constants as Emergent Parameters in MU-CFT

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Abstract

In the Mandrov Unified Coherent Field Theory (MU-CFT), fundamental constants are not primitive inputs but emergent parameters of a coherent space–time–observer system. This work develops a mathematical pathway from the MU-CFT action to effective, potentially scale-dependent quantities such as the cosmological constant Λ_{eff}, the gravitational coupling G_{eff}, the fine-structure constant α_{eff}, and effective particle masses. We derive the asymptotic behavior of Λ_∞ from the coherent static metric and outline how intersubjective coherence stabilizes the observed values within a branch. Observational predictions for small spatio-temporal variations of constants are also discussed.

Contents

1 Introduction

Fundamental constants in modern physics set interaction scales and boundary conditions for dynamics. In standard frameworks, they are treated as immutable inputs. MU-CFT reinterprets them as emergent outputs of a coherence-based interaction between geometry, fields, and the observer. This paper systematizes that interpretation, deriving explicit relations and highlighting how constants may vary across scales or quantum branches.

2 Background: MU-CFT Action and Fields

2.1 Kinematic variables and fields

We consider a Lorentzian metric $g_{\mu\nu}$ (signature $+---$) and an observer field $\mathcal{F}_s$ capturing subjective and intersubjective coherence. The realized physical branch corresponds to a coherent selection operator acting on a potentiality space.

2.2 MU-CFT action (schematic form)

We adopt the generic MU-CFT-consistent action:

$$\mathcal{S}[g, \mathcal{F}_s, \Psi] = \int d^4x \sqrt{-g} \Big(\mathcal{L}_{\text{grav}}[g] + \mathcal{L}_{\text{obs}}[\mathcal{F}_s, g] + \mathcal{L}_{\text{int}}[\mathcal{F}_s, \Psi, g] + \mathcal{L}_{\text{mat}}[\Psi, g] \Big), \tag{2.1}$$

where Ψ denotes matter fields. The gravitational sector contains the Einstein–Hilbert term and a coherence-dependent correction:

$$\mathcal{L}_{\text{grav}}[g] = \frac{1}{16\pi} R + \Phi_{\text{coh}}(\mathcal{F}_s)\, \Xi[g], \tag{2.2}$$

with R the Ricci scalar, $\Xi[g]$ a curvature invariant (possibly R^2-suppressed or $f(R)$-like), and Φ_{coh} a functional of $\mathcal{F}_s$. The observer sector $\mathcal{L}_{\text{obs}}$ encodes the dynamics of $\mathcal{F}_s$, while $\mathcal{L}_{\text{int}}$ modulates standard couplings through coherence.

2.3 Modified Einstein equations

Variation of (2.1) yields:

$$G_{\mu\nu} + C_{\mu\nu}[\mathcal{F}_s, g] = 8\pi\, T^{(\Psi)}_{\mu\nu} + T^{(\text{coh})}_{\mu\nu}[\mathcal{F}_s, g], \tag{2.3}$$

where $C_{\mu\nu}$ arises from the coherence–curvature coupling, and $T^{(\text{coh})}_{\mu\nu}$ is an effective stress tensor sourced by $\mathcal{F}_s$. In symmetric limits these reduce to a scale-dependent cosmological constant.

3 Mathematical Framework

3.1 Static, spherically symmetric ansatz

We adopt

$$\mathrm{d}s^2 = f(r)\,\mathrm{d}t^2 - \frac{\mathrm{d}r^2}{f(r)} - r^2(\mathrm{d}\theta^2 + \sin^2\theta\,\mathrm{d}\varphi^2), \tag{3.1}$$

with coherent metric function

$$f_{\mathrm{coh}}(r) = 1 - \frac{2Mr}{r^2+\epsilon^2} + \frac{\lambda}{6}\,r^2\big(1-e^{-\gamma r}\big), \tag{3.2}$$

where M is the mass parameter, $\epsilon > 0$ regularizes the center, and λ, γ are coherence parameters.

3.2 Einstein tensor and effective Λ

For (3.1) one finds:

$$G^t{}_t \;=\; G^r{}_r \;=\; \frac{f-1}{r^2} + \frac{f'}{r}, \qquad G^\theta{}_\theta \;=\; G^\varphi{}_\varphi \;=\; \frac{f''}{2} + \frac{f'}{r}. \tag{3.3}$$

Substituting (3.2) and taking $r \to \infty$ ($e^{-\gamma r} \to 0$, $1/r$ term vanishes):

$$G^\mu{}_\nu \;\to\; \frac{\lambda}{2}\,\delta^\mu_\nu \quad\Rightarrow\quad \boxed{\Lambda_\infty = -\frac{\lambda}{2}}. \tag{3.4}$$

A local identification is:

$$\Lambda^{(t)}_{\mathrm{eff}}(r) := -\,G^t{}_t(r), \qquad \Lambda^{(\theta)}_{\mathrm{eff}}(r) := -\,G^\theta{}_\theta(r), \tag{3.5}$$

which coincide with (3.4) at large r but generally differ at finite r.

3.3 Coefficient comparison heuristic

Comparing (3.2) with $f_{\mathrm{GR}} = 1 - 2M/r - (\Lambda/3)r^2$:

$$-\frac{\Lambda^{(\mathrm{coef})}_{\mathrm{eff}}(r)}{3} \;\equiv\; \frac{\lambda}{6}\left(1-e^{-\gamma r}\right) \quad\Rightarrow\quad \Lambda^{(\mathrm{coef})}_{\mathrm{eff}}(r) = -\frac{\lambda}{2}\left(1-e^{-\gamma r}\right). \tag{3.6}$$

This matches (3.4) asymptotically and clarifies the sign.

3.4 Toward G_{eff} and α_{eff}

Effective couplings are defined by linear response:

$$G_{\mathrm{eff}} \;\propto\; \chi_{\mathrm{coh}}[\mathcal{F}_s; g]\big|_{\text{weak field,}} \tag{3.7}$$

where χ_{coh} is the coherent susceptibility functional. The EM sector yields:

$$\alpha_{\mathrm{eff}} \;=\; \alpha\,\mathcal{A}[\mathcal{F}_s; g], \tag{3.8}$$

with $\mathcal{A} \to 1$ in the classical (low-coherence-contrast) limit.

4 Constants in Standard Physics

We recall how Λ, G, $\hbar$, α, m_e, and m_p appear in GR, QM, and the Standard Model, where their values are inputs with no deeper derivation.

5 Emergent Constants in MU-CFT

5.1 Cosmological constant

Eqs. (3.4)–(3.6) summarize the coherent reinterpretation.

5.2 Gravitational coupling

Eq. (3.7) defines G_{eff} from coherent response to localized sources.

5.3 Fine-structure constant

Eq. (3.8) expresses coherence-modulated electrodynamics; deviations could be probed via spectroscopy.

5.4 Effective particle masses

Stable coherent matter defines m^{coh}; branch dependence allows small environment-induced drifts.

5.5 Dark sector densities

Coherent curvature mimics dark energy; geometry-induced modifications emulate dark matter.

6 Anthropic Principle and Branch Dependence

Observed constants correspond to intersubjective coherence plateaus: ranges where physical records remain stable. Other branches may realize different plateaus.

7 Observational Predictions

- Mild redshift dependence of α_{eff} and m^{coh} at $z \lesssim 1$.

- Environmental variation near compact objects due to coherence gradients.
- Late-time approach to $\Lambda_\infty = -\lambda/2$ in cosmology.

8 Formal Summary Table

Constant	Dimension (SI)	Interpretation	Key relation
Λ	m^{-2}	In GR: vacuum curvature scale. In MU-CFT: coherent curvature emerging asymptotically.	$\Lambda_\infty = -\lambda/2$ (Eq. 3.4)
G	$\mathrm{m}^3\,\mathrm{kg}^{-1}\,\mathrm{s}^{-2}$	In GR: Newton's constant. In MU-CFT: coherent susceptibility of space–time to energy-momentum.	$G_{\text{eff}} \propto \chi_{\text{coh}}[\mathcal{F}_s; g]\big\vert_{\text{weak field}}$ (Eq. 3.7)
α	dimensionless	In QED: electromagnetic coupling constant. In MU-CFT: coherence-modulated effective vertex.	$\alpha_{\text{eff}} = \alpha\,\mathcal{A}[\mathcal{F}_s; g]$ (Eq. 3.8)
m_e	kg	In SM: electron rest mass. In MU-CFT: stable coherent matter state.	m_e^{coh} (def.)
m_p	kg	In SM: proton rest mass. In MU-CFT: stable coherent baryon state.	m_p^{coh} (def.)

Table 1: Fundamental constants and their MU-CFT interpretations. The last column provides the corresponding MU-CFT relation or definition.

9 Discussion

MU-CFT unifies disparate tunings: constants are branch-stable outputs of coherence, not axioms. Unlike scalar-field or modified gravity models, MU-CFT ties variations to observer-field dynamics and intersubjective stability.

10 Conclusion

Fundamental constants emerge as coherent parameters. The framework explains their apparent fine-tuning and suggests small, testable variations across scales, while recovering standard values on the coherence plateau.

11 Outlook

Future work will: (i) refine Φ_{coh} and $\mathcal{A}$; (ii) derive $G_{\text{eff}}(x)$ in cosmological backgrounds; (iii) confront predictions with spectroscopy, lensing, and gravitational waves.

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A Derivations for the Static Coherent Metric

Using (3.1), the Einstein components are (3.3). Substituting (3.2) and expanding at large r gives (3.4). The coefficient heuristic (3.6) matches the asymptotics and clarifies the sign relation between λ and the GR Λ.