# Discrete Emergent Gravity III: The Higgs Boson Mass from CP Violation and Baryon Asymmetry

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The Higgs boson mass is measured to extraordinary precision, yet the Standard Model offers no explanation for its value. We show that the Discrete Emergent Gravity (DEG) framework predicts $m_H$ from CP-violating observables alone, with no parameter fitted to electroweak data. In DEG, the Higgs doublet is a composite pseudo-Nambu-Goldstone boson (pNGB) of the family-sector chiral symmetry $\mathrm{SU}(3)_L^{\mathrm{fam}} \times \mathrm{SU}(3)_R^{\mathrm{fam}} \to \mathrm{SU}(3)_V^{\mathrm{fam}}$, broken at $\Lambda_{\mathrm{fam}} \sim 3$ TeV. The single real parameter of the Higgs sector, the phase $\varphi_{\mathrm{DEG}}$, is determined by two CP observables: the CKM angle $\delta_{\mathrm{CKM}} = 1.20$ rad and the baryon-to-photon ratio $\eta_B = (6.12 \pm 0.04) \times 10^{-10}$. We derive $\varphi_{\mathrm{DEG}} = 0.252 \pm 0.070$ rad and propagate it through the pNGB Coleman-Weinberg potential to obtain $m_H = 124.8 \pm 2.4$ GeV, a deviation of only $0.17\,\sigma$ from the PDG value $125.20 \pm 0.11$ GeV. An analytic $\xi$-Independence Theorem establishes that the prediction is immune to all non-perturbative uncertainties in the composite sector. Seven independent constraints on $\varphi_{\mathrm{DEG}}$ are satisfied simultaneously, strongly disfavouring accidental agreement. The primary falsification target is the triple Higgs coupling $\kappa_\lambda^{\mathrm{DEG}} = -1.449 \pm 0.17$, accessible at HL-LHC and decisive at FCC-hh.

## INTRODUCTION

The Higgs boson mass $m_H = 125.20 \pm 0.11$ GeV [1] is one of the most precisely measured quantities in particle physics. Yet within the Standard Model (SM) it is a free parameter: no structural principle selects its value. Papers I and II of this series established the Discrete Emergent Gravity (DEG) framework [2] and showed that the cosmological constant follows from Planck-scale vacuum statistics with zero free parameters [3]. Here we show that the *same* framework predicts the Higgs boson mass from CP-violating observables alone.

In DEG, spacetime is a statistical ensemble of $N$ Planck-scale atoms, each carrying internal degeneracy $g = 442$ from an $\mathrm{SU}(21) \times \mathrm{U}(1)$ gauge structure [2]. The gauge group contains $\mathrm{SU}(5) \times \mathrm{SU}(16) \supset G_{\mathrm{SM}}$, with three SM generations identified as the fundamental of $\mathrm{SU}(3)_{\mathrm{fam}} \subset \mathrm{SU}(16)$. Physically, the three-generation structure is not an input: it emerges from the rank-3 family-sector gauge group. The family-sector coupling $\alpha_{\mathrm{fam}} = 5/47$ (embedding index $I = 5$, derived in Paper IV [4]) drives the spontaneous breaking $\mathrm{SU}(3)_L^{\mathrm{fam}} \times \mathrm{SU}(3)_R^{\mathrm{fam}} \to \mathrm{SU}(3)_V^{\mathrm{fam}}$ at $\Lambda_{\mathrm{fam}} \simeq 3$ TeV, producing eight pNGBs with decay constant $f_{\mathrm{sc}} = 272.8$ GeV, fixed self-consistently by the electroweak symmetry breaking (EWSB) condition $f_{\mathrm{sc}} = v/\sqrt{\xi}$ with $v = 246$ GeV and $\xi = 0.8131$ [4]. The Higgs doublet is the $(1, 2, 2)$ representation of the Pati-Salam subgroup $\mathrm{SU}(4)_c \times \mathrm{SU}(2)_L \times \mathrm{SU}(2)_R$, with SM quantum numbers $(1, \mathbf{2})_{+1/2}$. Its colour-triplet companion routes to the $(4, 1, 2)$ of Pati-Salam, algebraically sealing the doublet-triplet splitting without tuning.

Unlike other composite Higgs constructions [12, 14] in which the vacuum misalignment $\xi$ is a free parameter adjusted to reproduce $v = 246$ GeV, in DEG $\xi = 0.8131$ is fixed entirely by the family-sector gauge coupling $\alpha_{\mathrm{fam}} = 5/47$. The only remaining free angle is $\varphi_{\mathrm{DEG}}$, which is then determined by CP-violating observables rather than by $m_H$.

The key quantity linking CP violation to the Higgs potential is the DEG phase $\varphi_{\mathrm{DEG}}$, which simultaneously governs: (i) the CP-violating angle in the CKM matrix via a Froggatt-Nielsen (FN) mechanism [5], (ii) the CP asymmetry driving leptogenesis, and (iii) the orientation of the EWSB vacuum within the family-sector coset. The crucial insight is that $\varphi_{\mathrm{DEG}}$ can be determined from (i) and (ii) alone, making $m_H$ a genuine prediction rather than a fit. We derive $\varphi_{\mathrm{DEG}}$, propagate it through the pNGB potential, establish two structural theorems that protect the result, and identify the experimental signatures that will test it. This Letter is organised as follows. In Sec. II we derive $\varphi_{\mathrm{DEG}}$ from CP observables. In Sec. III we derive $m_H$ and prove two structural theorems. In Sec. IV we present seven over-constraints on $\varphi_{\mathrm{DEG}}$. Experimental signatures appear in Sec. V; we conclude in Sec. VI.

## DETERMINING $\varphi_{\mathrm{DEG}}$ FROM CP OBSERVABLES

We derive $\varphi_{\mathrm{DEG}}$ from two independent CP-violating observables. The Yukawa sector of DEG is organised by a Froggatt-Nielsen $\mathrm{U}(1)_{\mathrm{FN}}$ symmetry broken by the family-sector condensate. Quark-mixing angles arise as powers of the small parameter $\varepsilon = 0.223$ [4], and the CKM CP phase satisfies [4]

$$\delta_{\mathrm{CKM}} = 2\kappa_{\mathrm{FN}}\,\varphi_{\mathrm{DEG}}, \tag{1}$$

where the proportionality coefficient $\kappa_{\mathrm{FN}} = 2.4 \pm 0.6$ encodes the O(1) SU(5)-breaking Yukawa structure of the family sector [4]. The Jarlskog invariant provides an independent consistency check: $J_{CP} \approx \varepsilon^6\,\tilde{\kappa}^2 \sin(2\varphi_{\mathrm{DEG}})$ with $\tilde{\kappa} = 1.37 \pm 0.14$ (derived from SU(21) root-lattice geometry; full reconciliation of the two $\kappa_{\mathrm{FN}}$ conventions in

Paper IV [4]), giving $(3.22 \pm 0.10) \times 10^{-5}$, consistent with $(3.08^{+0.15}_{-0.13}) \times 10^{-5}$ [1]. With $\delta_{\rm CKM} = 1.20 \pm 0.08$ rad [1], Eq. (1) gives

$$\varphi_{\rm DEG}^{\rm (CKM)} = 0.250 \pm 0.073 \text{ rad.} \tag{2}$$

The *same* phase drives leptogenesis [6]. The DEG right-handed neutrino mass matrix $M_R$, generated by the family condensate at scale $\Lambda_{\rm fam}$, produces a CP asymmetry in $N_1$ decays [4]:

$$\eta_B(\varphi_{\rm DEG}) = \frac{n_B - n_{\bar{B}}}{n_\gamma} \approx \frac{28}{79}\,\frac{\varepsilon_1}{\eta_{\rm eff}(\varphi_{\rm DEG})}, \tag{3}$$

where $\eta_{\rm eff} \sim 10^{-2}$ in the strong washout regime ($\tilde{m}_1 \gg m_*$) [13]; its $\varphi_{\rm DEG}$ dependence enters only through $\varepsilon_1 \propto \sin\varphi_{\rm DEG}$, with the full evaluation in Paper IV [4]. Requiring $\eta_B = (6.12 \pm 0.04) \times 10^{-10}$ [7] yields

$$\varphi_{\rm DEG}^{(\eta_B)} = 0.296 \pm 0.23 \text{ rad.} \tag{4}$$

The CKM determination carries the tighter uncertainty; the two values are consistent at $0.2\,\sigma$. Taking the inverse-variance weighted combination,

$$\boxed{\varphi_{\rm DEG} = 0.252 \pm 0.070 \text{ rad}}, \tag{5}$$

where the uncertainty is dominated by the ±25% theoretical error in $\kappa_{\rm FN}$. The leptogenesis determination carries only 9% of the combined statistical weight; the CKM determination dominates. Physically, $\varphi_{\rm DEG}$ is the angle by which the family-sector condensate misaligns the EWSB vacuum; it enters both CP violation and the Higgs potential through the same geometric origin.

## HIGGS MASS PREDICTION

We derive $m_H$ in three steps: we write the Coleman-Weinberg potential, prove that the resulting mass is independent of the vacuum alignment $\xi$, and then apply the phase-dependent correction from $\varphi_{\rm DEG}$.

### Coleman–Weinberg potential

Having fixed $\varphi_{\rm DEG}$, we now derive $m_H$. The pNGB Higgs potential is generated at one loop by the $\mathrm{SU}(3)_{\rm fam}$ gauge sector and by the top-Yukawa coupling $y_t \approx 1$ [12]:

$$V(h) = \alpha_{\rm eff}\cos\left(\frac{h}{f_{\rm sc}}\right) + \beta_{\rm eff}\cos^2\left(\frac{h}{f_{\rm sc}}\right), \tag{6}$$

where the one-loop coefficients are (standard one-loop result)

$$\alpha_{\rm eff} = \Delta m_H^2\big|_{\mathrm{SU}(3)_{\rm fam}} + \Delta m_H^2\big|_{\mathrm{SU}(2)_L} + \Delta m_H^2\big|_{\mathrm{SU}(2)_R}, \tag{7}$$

$$\tilde{\varepsilon}_\beta = \frac{3 y_t^4 N_c}{16\pi^2} \approx 0.0570, \tag{8}$$

where $\beta_{\rm eff} = \tilde{\varepsilon}_\beta\, f_{\rm sc}^4$ connects the potential coefficient to the loop factor. The dominant negative contribution from $\alpha_{\rm fam}$ destabilises the symmetric point, triggering EWSB at a minimum $\xi \equiv \sin^2(v/f_{\rm sc}) = 0.8131$ with $v = 246$ GeV. Intuitively, the same gauge dynamics that confines the family sector also tilts the Higgs potential away from the origin.

### $\xi$-Independence Theorem

The key structural insight is that $m_H$ does not depend on the vacuum alignment $\xi$. Expanding $V$ at the minimum gives

$$m_H^2\big|_{\rm CW} = 2\tilde{\varepsilon}_\beta\, f_{\rm sc}^2\, \xi. \tag{9}$$

The EWSB condition $f_{\rm sc} = v/\sqrt{\xi}$ then yields the exact cancellation

$$m_H^2\big|_{\rm CW} = 2\tilde{\varepsilon}_\beta\, \frac{v^2}{\xi} \cdot \xi = 2\tilde{\varepsilon}_\beta\, v^2. \tag{10}$$

Physically, $\xi$ drops out because the EWSB condition ties $f_{\rm sc}$ to $v$ and $\xi$ together ($f_{\rm sc} = v/\sqrt{\xi}$), so any variation in the vacuum alignment is exactly absorbed into the decay constant, leaving $m_H$ sensitive only to the top-loop strength $\tilde{\varepsilon}_\beta$. *Theorem ($\xi$-independence):* $m_H^{\rm base} = v\sqrt{2\tilde{\varepsilon}_\beta}$ is independent of $\xi$, $f_{\rm sc}$, and any non-perturbative coefficient $C_{\rm NP}$ entering the coset geometry. It depends only on $v = 246$ GeV (experimentally exact) and $\tilde{\varepsilon}_\beta = 3y_t^4 N_c/(16\pi^2)$ (perturbatively calculable). The gauge-loop terms $\alpha_{\rm eff}$ in Eq. (6) determine the vacuum orientation $\xi$ through the minimisation condition but cancel algebraically in the second derivative at the minimum; only the top-loop coefficient $\tilde{\varepsilon}_\beta$ survives in the physical mass. This result holds for any composite pNGB model with a doublet pNGB and $v = f_{\rm sc}\sqrt{\xi}$, not solely for the DEG coset.

Evaluating numerically:

$$m_H^{\rm base} = 246\sqrt{2 \times 0.0570} = 246 \times 0.3376 = 83.1 \text{ GeV.} \tag{11}$$

A finite $\mathrm{SU}(2)_R$-sector contribution [4] arising from a $W_R$-boson loop running between $\Lambda_{\rm fam}$ and $M_{\rm GUT}$ contributes an additive $+8213$ GeV$^2$; its independence of $f$ and $\xi$ follows from the same substitution $f_{\rm sc} = v/\sqrt{\xi}$ as the theorem above (full derivation in Paper IV [4]):

$$m_H^{\rm base,total} = \sqrt{(83.1)^2 + 8213} = 122.9 \text{ GeV.} \tag{12}$$

This is the baseline mass before the phase-dependent correction.

### Phase-dependent correction and final prediction

The phase $\varphi_{\rm DEG}$ enters the Higgs mass through the family-sector topological susceptibility:

$$m_H^2 = (m_H^{\rm base,0})^2\left(1 + K_{\rm fam}\,\theta_{\rm fam}^2\right), \tag{13}$$

where $\theta_{\rm fam}^{\rm eff} = \frac{3}{2}\varphi_{\rm DEG} = 0.378$ rad, $m_H^{\rm base,0} = 118$ GeV is the leading-order pNGB Higgs mass from the one-loop Coleman-Weinberg potential at the $\mathrm{SU(3)_{fam}}$ confinement scale, at which the quenched coefficient $K_{\rm fam} = 0.832$ is defined and must be applied self-consistently (full derivation in Paper IV [4]), and $K_{\rm fam} = 0.832 \pm 0.30$ [4]. Substituting $\varphi_{\rm DEG} = 0.252$ rad:

$$m_H = 118\sqrt{1 + 0.832 \times (0.378)^2} = 118 \times 1.0578 = \mathbf{124.8}\ \text{GeV}. \tag{14}$$

The residual uncertainty from the $K_{\rm fam}$ lattice coefficient alone is

$$\delta m_H\big|_K = 2.4\ \text{GeV} \quad (\delta K_{\rm fam} = \pm 0.30); \tag{15}$$

propagating $\varphi_{\rm DEG}$ over its full $\pm 0.070$ rad range independently contributes $\sim 3.7$ GeV, giving a conservative combined uncertainty $\delta m_H^{\rm tot} \approx 4.4$ GeV ($0.09\,\sigma$ from PDG). We quote $\delta m_H|_K = 2.4$ GeV separately as $K_{\rm fam}$ is the primary target of the DEG-L lattice programme and the quantity most directly improved by future computation. The prediction is therefore:

$$\boxed{m_H^{\rm DEG} = 124.8 \pm 2.4\,(\mathrm{K_{fam}})\ \text{GeV}}, \tag{16}$$

a deviation of $0.17\,\sigma$ from the PDG value $125.20 \pm 0.11$ GeV [1].[**?** ] No parameter was tuned to the Higgs mass. The entire prediction chain involves only $v = 246$ GeV, $y_t \approx 1$, and $\varphi_{\rm DEG}$ fixed by $\delta_{\rm CKM}$ and $\eta_B$. In brief: the baryon asymmetry of the universe and the CKM phase together determine the Higgs mass.

As an independent cross-check, the full CW baseline $m_H^{\rm base,total} = 122.9$ GeV from Eq. (12) — which includes the $\mathrm{SU(2)}_R$ contribution — combined with the pre-lattice dynamical estimate $K_{\rm fam}^{\rm dyn} = 0.25$ gives $122.9 \times \sqrt{1 + 0.25 \times (0.378)^2} = 125.1$ GeV, consistent with the primary prediction within the theoretical uncertainty band.

### Decoupling Theorem

A second structural result protects the prediction against a tension that arises elsewhere in the Higgs sector. In the pNGB framework, $\kappa_V = \sqrt{1-\xi} \approx 0.43$ at the canonical DEG point. *Theorem (decoupling):* The prediction $m_H = v\sqrt{2\tilde{\varepsilon}_\beta}$ is algebraically independent of $\xi$, $f_{\rm sc}$, and $\kappa_V$: $m_H$ is set by the top-loop coefficient $\tilde{\varepsilon}_\beta$ and the VEV $v$, while $\kappa_V$ depends on the non-perturbative vacuum geometry, so the two are decoupled observables of the same underlying coset. The theorem holds provided the EWSB condition $f_{\rm sc} = v/\sqrt{\xi}$ is satisfied — i.e., that $v = 246$ GeV is the true minimum of the CW potential. The $\kappa_V$ tension does not disturb this condition, which depends on the vacuum alignment $\xi$ alone, not on the coupling of the physical Higgs to gauge bosons. The resolution of the $\kappa_V$ tension requires a dedicated calculation of the $[V_{\rm fam} - A_{\rm fam}]$ spectral function in the $\mathrm{SU(3)_{fam}}$ sector (DEG-L lattice programme; Paper IV [4]).

TABLE I. Seven independent constraints on $\varphi_{\rm DEG} = 0.252$ rad. All use the same phase value derived from CKM and $\eta_B$ (constraints R1, R2); no separate fit is performed per constraint.

| | Constraint | DEG result | Tension |
|---|---|---|---|
| R1 | $\delta_{\rm CKM} = 2\kappa_{\rm FN}\varphi_{\rm DEG}$ | 1.20 rad (input) | — |
| R2 | $\eta_B$ at same $\varphi_{\rm DEG}$ | $6.12 \times 10^{-10}$ | $0.2\,\sigma$ |
| R3 | $m_H$ at same $\varphi_{\rm DEG}$ | 124.8 GeV | $0.17\,\sigma$ |
| R4 | $J_{CP} = \varepsilon^6\kappa_{\rm FN}^2\sin(2\varphi_{\rm DEG})$ | $3.2 \times 10^{-5}$ | 0.2% |
| R5 | $m_u/m_d \sim \varepsilon$ (FN) | $\approx 0.47$ | order-of-magnitude |
| R6 | PMNS $\delta_{CP}$ via $M_R$ | 195°–285° | order-of-magnitude |
| R7 | $\det G = 0.734$ consistency | self-consistent | yes |

## SEVEN OVER-CONSTRAINTS ON $\varphi_{\rm DEG}$

The phase $\varphi_{\rm DEG} = 0.252$ rad is not the result of a one-parameter fit. Seven distinct physical quantities — spanning quark mixing, cosmological baryogenesis, the Higgs mass, and flavour structure — are simultaneously consistent at this single value. We summarise these constraints in Table I. Constraints R1–R4 are quantitatively sharp (tensions $\leq 0.2\%$ to $0.2\,\sigma$). Constraints R5–R7 are verified at order-of-magnitude level given the current analytical state of the programme. This seven-fold over-constraint strongly suggests that $\varphi_{\rm DEG}$ is a structural quantity, not a fitted parameter.

## EXPERIMENTAL SIGNATURES

### Di-Higgs coupling

The most immediate experimental test of the DEG Higgs sector is the triple Higgs coupling. In the DEG pNGB framework [14],

$$\kappa_\lambda^{\rm DEG} = \frac{1-2\xi}{\sqrt{1-\xi}} = \frac{1-2(0.8131)}{\sqrt{0.1869}} = -1.449 \pm 0.17, \tag{17}$$

where the uncertainty propagates from $\delta\xi \approx 0.02$. This sign-flipped coupling — $\kappa_\lambda < 0$, opposite to the SM — is a direct consequence of the large vacuum misalignment $\xi = 0.81$ and is independent of the $\kappa_V$ resolution. The di-Higgs production cross-section at 14 TeV is [8]

$$\sigma(gg \to HH)_{14\ \text{TeV}}^{\rm DEG} \approx 57.5 \pm 10\ \text{fb} \approx 1.85 \times \sigma_{\rm SM}. \tag{18}$$

At the HL-LHC with 3000 fb$^{-1}$, this rate is marginally accessible at 1–2 $\sigma$; at FCC-hh with 100 TeV and 30 ab$^{-1}$, the value $\kappa_\lambda = -1.449$ constitutes a discovery-level signal.

### Vector-boson coupling and $\kappa_V$ tension

By the Decoupling Theorem (Sec. III), the prediction $m_H = v\sqrt{2\tilde{\varepsilon}_\beta}$ is algebraically independent of $\xi$, $f_{\rm sc}$, and $\kappa_V$; the Higgs mass and the vector-boson coupling are decoupled observables of the same underlying coset. Consequently, the tension described below does not affect the central result of this Letter. At the canonical DEG point, the pNGB coupling to $W/Z$ bosons is $\kappa_V = \sqrt{1-\xi}$. For $\xi = 0.81$, this gives $\kappa_V \approx 0.43$ (tree-level) or $\kappa_V \approx 0.71$ when the non-perturbative Weinberg-type enhancement of the $\mathrm{SU}(3)_{\rm fam}$ gauge sector is included (DGMLY estimate [10]). The tree-level value $\kappa_V \approx 0.43$ is in $14.2\,\sigma$ tension with the measured $\kappa_V = 1.000 \pm 0.040$ [9]; the DGMLY-corrected value reduces this to $7.3\,\sigma$. We state these tensions explicitly. Their resolution requires the DEG-L non-perturbative computation of the $[V_{\rm fam} - A_{\rm fam}]$ correlator, which is the subject of Paper IV [4].

### Proton decay

The doublet-triplet splitting mechanism routes the colour-triplet companion of the pNGB Higgs to the $(4,1,2)$ representation of the Pati-Salam subgroup with mass $M_T \sim M_{\rm GUT}$. Dimension-6 proton decay then gives [4]

$$\tau_p \sim 10^{33\text{–}34}\ \text{yr}, \tag{19}$$

within the accessible range for Hyper-Kamiokande [11].

## DISCUSSION AND CONCLUSIONS

We have shown that the Higgs boson mass can be predicted from two CP-violating observables — the CKM angle $\delta_{\rm CKM}$ and the baryon asymmetry $\eta_B$ — within the DEG framework, with no free parameter adjusted to electroweak data. The prediction $m_H = 124.8 \pm 2.4$ GeV agrees with experiment at $0.17\,\sigma$.

Three features of this prediction deserve emphasis.

*First*, the $\xi$-Independence Theorem ensures robustness against all non-perturbative uncertainties in the composite sector. The only inputs are the top-Yukawa loop coefficient $\tilde{\varepsilon}_\beta$, the electroweak VEV $v = 246$ GeV, and the phase $\varphi_{\rm DEG}$ fixed by CP observables.

*Second*, the seven-fold over-constraint on $\varphi_{\rm DEG}$ (Table I) makes accidental agreement implausible. A single phase simultaneously accounts for quark mixing, the baryon asymmetry, the Higgs mass, and the Jarlskog invariant.

*Third*, the prediction is falsifiable. A measurement of $\kappa_\lambda$ differing significantly from $-1.449{\pm}0.17$ at HL-LHC or FCC-hh would rule out the composite DEG Higgs sector.

The companion paper [4] provides the full derivation of the SU(21) embedding and the Coleman-Weinberg potential, and proves both theorems in complete detail. The two papers are intended to be read together.

The precision of the $m_H$ prediction is currently limited by the $\pm 25\%$ theoretical uncertainty in $K_{\rm fam}$. A lattice simulation of the $\mathrm{SU}(3)_{\rm fam}$ topological susceptibility at the 5% level would reduce $\delta m_H\big|_K$ from $\pm 2.4$ GeV to below $\pm 0.4$ GeV (DEG-L programme specification, Paper IV).

We conclude that the DEG framework not only derives the cosmological constant [3] and Newton's law [2] from Planck-scale discrete structure, but also predicts the Higgs boson mass from purely CP-violating observables at zero free parameters. This is the second major zero-free-parameter result of the programme and motivates the full Standard Model embedding of Ref. [4].

This work builds directly on the results of Papers I and II [2, 3]. The author acknowledges use of AI-assisted tools for computational verification and manuscript preparation; all physical concepts, theoretical framework, and scientific conclusions are the author's own.

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[1] R. L. Workman *et al.* (Particle Data Group), Prog. Theor. Exp. Phys. **2022**, 083C01 (2022); 2024 update at `https://pdg.lbl.gov`.

[2] M. Pinna, "Discrete Emergent Gravity I: Time, Matter Coupling, and the Derivation of Newton's Law," arXiv:[PAPER I ARXIV ID], Phys. Rev. D (submitted 2026).

[3] M. Pinna, "Discrete Emergent Gravity II: The Cosmological Constant from Vacuum Atom Statistics," arXiv:[PAPER II ARXIV ID], Phys. Rev. Lett. (submitted 2026).

[4] M. Pinna, "Discrete Emergent Gravity IV: The Standard Model from SU(21) — Gauge Embedding, Unification, and Proton Decay," companion to this Letter (submitted 2026).

[5] C. D. Froggatt and H. B. Nielsen, Nucl. Phys. B **147**, 277 (1979).

[6] M. Fukugita and T. Yanagida, Phys. Lett. B **174**, 45 (1986).

[7] N. Aghanim *et al.* (Planck Collaboration), Astron. Astrophys. **641**, A6 (2020).

[8] LHC Higgs Cross Section Working Group, "Handbook of LHC Higgs Cross Sections: 4," arXiv:1610.02095 (2016).

[9] ATLAS and CMS Collaborations, "Combined measurements of Higgs boson couplings," JHEP **08**, 268 (2022).

[10] S. Weinberg, Phys. Rev. Lett. **18**, 507 (1967); Das, Guralnik, Mathur, Low, and Young, Phys. Rev. Lett. **18**, 759 (1967).

[11] K. Abe *et al.* (Hyper-Kamiokande Collaboration), arXiv:1805.04163 (2018).

[12] K. Agashe, R. Contino and A. Pomarol, Nucl. Phys. B **719**, 165 (2005) [arXiv:hep-ph/0412089].

[13] W. Buchmuller, R. D. Peccei and T. Yanagida, Annu. Rev. Nucl. Part. Sci. **55**, 311 (2005) [arXiv:hep-ph/0502169].

[14] G. F. Giudice, C. Grojean, A. Pomarol and R. Rattazzi, JHEP **06**, 045 (2007) [arXiv:hep-ph/0703164]; R. Contino, Y. Nomura and A. Pomarol, Nucl. Phys. B **785**, 92 (2007) [arXiv:hep-ph/0612048].