A Geometric Origin of the Higgs Mass and Electroweak Mixing Angle from Substrate Condensation Topology

Vijay Shankar Sharma

Independent Researcher, Gurugram, National Capital Region, India

ORCID: 0009-0001-9622-6121 · vss@vijayshankarsharma.com · DOI: 10.5281/zenodo.21280511

2026

The author declares no conflict of interest and no funding was received for this research.

Abstract

In the Standard Model, the masses of the W, Z, and Higgs bosons and the weak mixing angle are not predicted: the two gauge couplings, the vacuum expectation value, and the Higgs self-coupling are free parameters fixed by measurement, and the Higgs mass itself was unknown until its discovery at CERN in 2012. This paper proposes a geometric origin for these quantities from the condensation topology of a universal physical substrate, the Spaticle field, using one condensation free-energy functional and the proton mass scale. The neutral Z resonance follows from the core-stay topology of the condensation as $m\_Z\_vss = \pi^4 m_p = 91.396$ GeV/c². The charged W resonance follows independently from the retained three-core mass scale $M = m_p/3$ and the $n = 4$ reconfiguration space, whose $n^2 = 16$ coherent amplitudes enter quadratically, giving $m\_W\_vss = 256M = 80.066$ GeV/c². The weak mixing quantity is evaluated only after both masses are fixed, from their squared ratio, giving $\sin^2\theta\_W\_vss = 1 - 256^2/(9\pi^8) = 0.23257$. The observed Higgs state, termed here the H-class state, is identified as a radial resonance of the same substrate condensation, and not as the quantum of a separate fundamental field: the normalized radial coupling $\lambda\_H\_vss = R_0/\pi^2 = 0.12903$ and the radial scale $v\_vss = 6E\_unit/\alpha\_vss = 245.565$ GeV give $m\_H\_vss = v\_vss\sqrt{2\lambda\_H\_vss} = 124.75$ GeV/c². The Z, W, and H-class masses agree with the measured values to 0.23, 0.38, and 0.36 percent respectively, with no fitted parameter, and no mass is used as an input to another. The same functional also predicts two configuration resonances, the Shankar resonances, at $m\_Shankar(2+2)\ c^2 = 776.5$ MeV and $m\_Shankar(4+0)\ c^2 = 1403.7$ MeV. Falsifiable predictions are specified, including the value of the Higgs self-coupling accessible through Higgs-pair production.

Keywords: Higgs boson mass, W boson, Z boson, weak mixing angle, Higgs self-coupling, condensation topology, physical substrate

1. Introduction

In the Standard Model, the W and Z boson masses arise from electroweak symmetry breaking through the Higgs mechanism [2,3]. At tree level, $m_W = gv/2$ and $m_Z = \sqrt{g^2 + g'^2}\,v/2$, where g and g′ are the SU(2) and U(1) gauge couplings and v is the vacuum expectation value, and the weak mixing angle is defined by the ratio of the two gauge couplings. The Higgs boson mass is $m_H = v\sqrt{2\lambda}$, where λ is the Higgs self-coupling. The theory places no constraint on the numerical values of g, g′, v, or λ; each is fixed by measurement [1]. The discovery of a scalar resonance near 125 GeV by the ATLAS and CMS collaborations in 2012 [4,5] fixed λ empirically but offered no account of why it takes the value it does.

This paper proposes that these quantities follow from the condensation topology of a universal physical substrate proposed in prior work [6], using the same condensation free-energy functional that fixes the reduced Planck constant [10] and the three-core structure responsible for the mechanical origin of electric charge [13]. The calculation is organised so that no quantity is obtained by circular substitution. A derivation that uses the weak mixing angle to obtain the W mass and then presents the resulting mass ratio as a prediction of the angle is algebraically circular. A derivation of a scalar mass from already measured heavy-particle masses does not establish an independent origin for that state. Each quantity is therefore assigned here to one specific condensation mechanism, and each mechanism uses only inputs fixed before that step.

The paper is organised as follows. Section 2 reviews the status of these quantities in standard physics. Section 3 introduces the substrate framework and addresses the historical objection that any physical medium filling space resembles the luminiferous aether. Section 4 sets out the condensation functional and the physical energy scale. Sections 5 and 6 derive the neutral Z and charged W resonances. Section 7 obtains the weak mixing quantity from their mass ratio. Section 8 derives the H-class state as a radial resonance. Section 9 derives the two Shankar resonances of the four-unit configuration spectrum. Section 10 collects the numerical results and the dependency structure. Section 11 addresses anticipated objections, Section 12 specifies falsifiable predictions, and Section 13 concludes.

2. The Higgs Mass and Weak Mixing in Standard Physics

The electroweak boson masses are among the most precisely measured quantities in particle physics. The Z mass, determined from the Z-pole line shape at LEP, is $m_Z = 91.1876 \pm 0.0021$ GeV/c^2 [17,1]. The world-average W mass is $m_W = 80.3692 \pm 0.0133$ GeV/c^2, and the Higgs boson mass is $m_H = 125.20 \pm 0.11$ GeV/c^2 [1]. The vacuum expectation value obtained from the Fermi constant is $v = 246.22$ GeV [1].

Within the Standard Model these numbers are consistent with one another once the gauge couplings and the self-coupling are fitted, but none of them is derived. The ratio of the W and Z masses is fixed by the ratio of g′ to g, which is itself an empirical input. The Higgs self-coupling inferred from the measured mass and vacuum expectation value, $\lambda = m_H^2/(2v^2) \approx 0.1293$, has no theoretical origin within the model; it is also the least directly tested parameter of the Higgs sector, constrained so far only weakly through searches for Higgs-pair production [15,16]. A framework that fixes these values from an independent physical structure, with no parameter adjusted to the electroweak data, therefore addresses a genuine open question.

3. The Physical Substrate and Relation to the Michelson-Morley Experiment

The mechanism proposed in this paper is derived from a physical substrate framework proposed in prior work [6], in which the universe is proposed to possess a universal physical matter substrate, termed the Spaticle field, with equilibrium density $\rho_s = 7.3 \times 10^{-27}$ kg/m³. Any proposal invoking a physical medium filling space invites an immediate and reasonable historical comparison to the luminiferous aether, decisively excluded by the Michelson-Morley experiment and its many high-precision successors [7,8]. This comparison deserves a direct response.

The luminiferous aether, as originally conceived, was a medium at rest relative to a preferred, absolute reference frame, through which the Earth and all material bodies moved; light was expected to propagate at a fixed speed relative to this frame, producing a detectable directional variation in the measured speed of light as the Earth's motion through the aether changed with the seasons [7]. The null result of the Michelson-Morley experiment, and of every subsequent interferometric test at ever-increasing precision [8], rules out exactly this structure: a medium establishing a preferred rest frame detectable through directional light-speed anisotropy.

The substrate proposed in [6] does not have this structure. It is not a medium through which matter and light move as through a separate background; it is the medium from which matter, electromagnetic radiation, and gravitational interaction are themselves proposed to arise as organised excitations and condensations. An observer, a measuring apparatus, and the interaction being studied are all organised states of the same substrate, so there is no configuration in which an observer moves through the substrate in the sense required for the Michelson-Morley experiment to detect a directional anisotropy. The aether required a preferred frame in which it was at rest; the substrate proposed here has no such frame, because everything capable of performing a measurement is already made of it.

3.1 Independent Cross-Validation of the Substrate Framework

The same substrate makes multiple independent quantitative predictions, each evaluated against observations in unrelated areas of physics. These include a single-substrate resolution of the cosmological constant problem, reconciling the quantum field theory vacuum energy prediction with the observed value without fine-tuning [6]; a non-circular consistency derivation of the speed of light from independently established electromagnetic and condensation-geometry quantities, agreeing with the measured value to 0.0003 percent [9]; and a geometric derivation of the reduced Planck constant from the substrate condensation geometry, consistent with the CODATA value to 0.0007 percent [10]. The condensation functional and its equilibrium radius R_0 used in Sections 4 to 8 are the same ones fixed in that derivation, on grounds unconnected to the electroweak sector. They are not constructions introduced to fit the boson masses.

3.2 Convergence With Existing Physics

The proposal that space possesses physical substance is a convergence with established physics, not a departure from it. General relativity describes space as possessing physical properties that curve, warp, and support gravitational-wave propagation. Loop quantum gravity reaches a related conclusion by an unrelated route, proposing that space is a discrete physical structure at the Planck scale [11]. Quantum field theory treats the vacuum as a medium whose ground-state energy cannot be removed, measured directly through the Casimir effect and the Lamb shift. The scalar resonance observed at CERN in 2012 [4,5] shows that the vacuum itself can be excited into a massive, localised state; within the present framework this state is a radial resonance of the substrate, derived quantitatively in Section 8. Four independent lines of established physics, using different mathematics and different starting assumptions, converge on the same statement: space has physical substance.

Einstein argued in his 1920 Leiden lecture, delivered five years after general relativity was complete, that according to the general theory of relativity space is endowed with physical qualities, and that space without such a medium would permit no propagation of light and no physical meaning for measuring rods or clocks [12]. He declined to assign this medium the properties of an ordinary substance because he had no measured quantity to give it. The substrate proposed here assigns the medium a specific, independently constrained equilibrium density, which converts an unquantified physical medium into a falsifiable one.

3.3 Why the Michelson-Morley Null Result Does Not Apply Here

The Michelson-Morley result excludes a medium with an absolute rest frame against which motion can be detected. The substrate proposed here has no such property, and there is a deeper reason the null result carries no weight against it: light and matter are both organised excitations of the same substrate. Every instrument capable of testing for motion relative to the substrate, including the interferometer, the light path, and the reference standard, is constituted from the substrate under test, so the measuring apparatus and the quantity being measured deform together. The null result is the only result the framework permits, and the framework preserves full Lorentz covariance: a substrate with no preferred frame and Lorentz-compatible local dynamics is fully consistent with special relativity.

4. The Condensation Functional and the Physical Scale

The stable matter condensation is described by a radial free-energy functional in the dimensionless radius R, the sum of localisation, confining, linear-sharing, and topological terms [10]:

$$E(R) = A/R^2 + BR^2 + CR + D/R \qquad (1)$$

with $A = 1/2$, $B = 0.56308$, $C = -1/3$, and $D = 1$. The coefficient $A = 1/2$ is the localisation normalisation, $D = 1$ is the complete topological winding contribution, so that $D = 2A$, and $C = -1/3$ represents the three-way sharing of the retained three-core structure [13]. The equilibrium follows from $E'(R_0) = 0$, where $E'(R) = -2A/R^3 + 2BR + C - D/R^2$, giving

$$R_0 = 1.27348221 \qquad (2)$$

The curvature of the functional at this minimum, $E''(R_0) = 6A/R_0^4 + 2B + 2D/R_0^3 \approx 3.2352$, measures the raw radial stiffness of the condensation. It is distinct from the normalised radial coupling used in Section 8.

The condensation is converted to physical energy through the energy unit

$$E\_unit = m_p c^2/\pi = 298.661 \text{ MeV} \qquad (3)$$

The four-unit condensation settles into a persistent 3+1 configuration, in which a retained three-core carries the proton mass and one balancing unit is detached [13]. The on-site mass scale of the retained three-core is

$$M = m_p/3 = 312.757\ \mathrm{MeV}/c^2 \qquad (4)$$

The four-unit system also fixes the transition-space count n = 4, and hence $n^2 = 16$ coherent reconfiguration amplitudes. The substrate fine-structure quantity entering the radial scale in Section 8 is evaluated as α_vss = 1/137.036655. Together, R_0, E_unit, M, n, and α_vss are the only inputs to Sections 5 to 8, and none of them involves a boson mass or a mixing angle.

5. The Neutral Z Resonance

The neutral resonance is identified with the core-stay configuration of the condensation, in which the balancing unit is retained within the core structure and no charged configuration forms. The mass scale of this configuration is fixed by the π-normalised condensation geometry:

$$m\_Z\_vss = \pi^4 m_p \qquad (5)$$

With m_p = 0.93827208816 GeV/c², this gives m_Z_vss = 91.396 GeV/c², against the measured value 91.1876 GeV/c² [1], a difference of 0.23 percent. The expression contains neither the W mass nor any mixing angle; the Z resonance is fixed before any electroweak mixing relation is introduced. Within the same normalisation, the electron mass derived from the detached balancing unit, m_e_vss = $m_p/(6\pi^5)$ [14], and the neutral resonance satisfy

$$m\_Z\_vss \times m\_e\_vss = m_p^2/(6\pi) \qquad (6)$$

linking the detached-unit scale and the core-stay scale without reference to the charged branch.

6. The Charged W Resonance

The charged branch begins from the retained three-core scale $M = m_p/3$ of equation (4). The four-unit transition space has n = 4 and therefore $n^2 = 16$ coherent reconfiguration amplitudes. The resonance energy is quadratic in this coherent mode-amplitude count, so the multiplicity factor entering the charged resonance is $(n^2)^2 = 16^2 = 256$. Because M is already a mass, this factor multiplies M directly:

$$m\_W\_vss = 256M = (256/3)m_p \qquad (7)$$

This gives m_W_vss = 80.066 GeV/c², against the measured world average 80.3692 GeV/c² [1], a difference of 0.38 percent. The derivation does not start from m_Z_vss cosθ_W and assumes no mixing angle. Its only inputs are the three-core mass scale and the coherent n = 4 reconfiguration count. The W and Z branches therefore reach their mass scales through different parts of the same condensation architecture: the neutral branch carries the π^4 core-stay factor, and the charged branch carries the quadratic coherent-mode factor acting on the three-core scale.

7. Weak Mixing as a Mass-Ratio Output

Once the two resonance masses are fixed independently, their ratio defines the electroweak mixing quantity of the substrate framework:

$$\cos^2\theta\_W\_vss = (m\_W\_vss/m\_Z\_vss)^2 \qquad (8)$$

$$\sin^2\theta\_W\_vss = 1 - (m\_W\_vss/m\_Z\_vss)^2 = 1 - 256^2/(9\pi^8) = 0.23257 \qquad (9)$$

Substituting equations (5) and (7) cancels the proton mass, so the mixing quantity depends only on the dimensionless ratio of the two independently generated resonance coefficients. It is an output of the mass architecture and is used as an input to neither mass.

8. The H-Class State as a Radial Resonance

The H-class state belongs to a separate dynamical branch of the same condensation. It is identified with the radial resonance of the Spaticle-field condensation about its equilibrium R_0, and its construction begins from the radial functional itself, not from the W and Z masses.

8.1 The Normalised Radial Coupling

The normalised radial coupling of the electroweak branch is constructed from the equilibrium geometry of equation (1):

$$\lambda\_H\_vss = 2AR_0/\pi^2 = R_0/\pi^2 = 0.12903 \qquad (10)$$

The factor 2A and the normalisation by π^2 convert the equilibrium radius into the coupling appropriate to the radial mode; this quantity is distinct from the raw curvature $E''(R_0)$ of Section 4. The Standard Model self-coupling inferred from the measured Higgs mass and vacuum expectation value is $\lambda = 0.1293$ [1], a difference of 0.19 percent.

8.2 The Electroweak Radial Scale

The energy scale of the radial branch follows from the condensation energy unit and the fine-structure quantity:

$$v\_vss = 6E\_unit/\alpha\_vss = 6m_pc^2/(\pi\alpha\_vss) = 245.565\ \text{GeV} \qquad (11)$$

The factor six is the same normalisation that connects the detached balancing unit to the condensation energy unit, and α_vss converts the sub-GeV condensation scale to the electroweak scale. The vacuum expectation value obtained from the Fermi constant is 246.22 GeV [1], a difference of 0.27 percent. No W mass, Z mass, mixing angle, or top-quark mass enters this step.

8.3 The H-Class Mass

With the radial coupling and radial scale fixed independently, the H-class mass follows from the radial-mode relation:

$$m\_H\_vss = v\_vss\sqrt{2\lambda\_H\_vss} = 6m_pc^2\sqrt{2R_0}/(\pi^2\alpha\_vss) = 124.75\ \text{GeV}/c^2 \qquad (12)$$

against the measured Higgs mass 125.20 GeV/c² [1], a difference of 0.36 percent. The derivation is radial from beginning to end. It does not interpolate between the masses of other heavy particles, does not require the top-quark mass, and does not use the W and Z results of Sections 5 and 6. The closed form depends on R_0 through $\sqrt{2R_0}$, which ties the state directly to oscillation about the condensation minimum; this is the physical reason for describing the observed state as a radial resonance of the one Spaticle field.

9. The Shankar Resonances of the Four-Unit Configuration Spectrum

The same four-unit functional that supplies the charged reconfiguration structure also fixes the energies of the three four-unit configurations [10]. The persistent 3+1 configuration has E(3+1) = 1.40 in model units, while the 2+2 and 4+0 configurations have E(2+2) = 4.00 and E(4+0) = 6.10. Their excitation gaps above the persistent state are therefore

$$\Delta E(2+2) = 2.60, \quad \Delta E(4+0) = 4.70 \tag{13}$$

Converting with the energy unit of equation (3) gives two predicted configuration resonances, termed here the Shankar resonances:

$$m\_Shankar(2+2)\, c^2 = 2.60E\_unit = 776.5\ \text{MeV} \tag{14}$$

$$m\_Shankar(4+0)\, c^2 = 4.70E\_unit = 1403.7\ \text{MeV} \tag{15}$$

These are configuration excitations of the four-unit condensation, not ingredients of the electroweak or H-class derivations; no quantity in Sections 5 to 8 uses them. They show that one condensation functional supports two distinct types of excitation: configuration changes within the four-unit sector, which give the Shankar resonances, and the radial mode about R_0, which gives the H-class state.

10. Numerical Results and Dependency Structure

Table 1 collects the results. Each derived quantity is listed with its relation, its value, the corresponding measured value where one exists, and its role in the dependency chain.

Quantity	Relation	Derived value	Measured value [1]	Difference	Role
M	$m_p/3$	312.757 MeV/c²	n/a	n/a	Three-core scale
m_Z_vss	$\pi^4 m_p$	91.396 GeV/c²	91.1876 GeV/c²	0.23%	Neutral resonance
m_W_vss	256M = (256/3)m_p	80.066 GeV/c²	80.3692 GeV/c²	0.38%	Charged resonance
sin²θ_W_vss	1 − (m_W_vss/m_Z_vss)²	0.23257	n/a	n/a	W/Z mass-ratio output
λ_H_vss	R_0/π^2	0.12903	0.1293	0.19%	Radial coupling
v_vss	6E_unit/α_vss	245.565 GeV	246.22 GeV	0.27%	Radial scale
m_H_vss	v_vss√(2λ_H_vss)	124.75 GeV/c²	125.20 GeV/c²	0.36%	H-class radial resonance
m_Shankar(2+2) c²	2.60E_unit	776.5 MeV	n/a	n/a	Configuration resonance

m_Shankar(4+0) c^2	4.70E_unit	1403.7 MeV	n/a	n/a	Configuration resonance

Table 1. Derived electroweak, H-class, and Shankar resonance quantities, measured values, and role of each quantity in the dependency chain.

The calculation consists of four logically separated chains. First, the neutral core-stay topology gives $m\_Z\_vss = \pi^4 m_p$. Second, the charged four-unit reconfiguration gives $M = m_p/3$, $n^2 = 16$, and m_W_vss = 256M. Third, only after these two results exist is $\sin^2\theta\_W\_vss$ calculated from their squared mass ratio. Fourth, the radial equilibrium gives λ_H_vss, which combines with E_unit and α_vss to give v_vss and then m_H_vss. The mixing quantity is not an input to m_W_vss; m_W_vss is not an input to m_Z_vss; m_Z_vss is not an input to m_H_vss; and m_H_vss is not obtained from any combination of other particle masses. The framework can therefore be tested at several independent numerical points.

11. Discussion: Physical Interpretation and Anticipated Objections

11.1 Physical Interpretation

Within the proposed interpretation, one condensation framework yields three kinds of electroweak information: a neutral resonance scale, a charged resonance scale, and a radial resonance scale. The weak mixing quantity then appears as a relation between the independently established charged and neutral scales. The two vector masses arise from different dimensionless structures, π^4 for the neutral branch and 256/3 for the charged branch, and their ratio removes m_p to leave a purely dimensionless mixing expression. The H-class state carries a separate mathematical signature, depending on R_0, on the condensation normalisation m_p/π, and on α_vss.

11.2 "Are the coefficients chosen to reproduce the boson masses?"

No. The functional of equation (1) and its equilibrium R_0 are those fixed in the derivation of the reduced Planck constant [10], on grounds unrelated to the electroweak sector. The coefficients π^4, 256, and $2A/\pi^2$ follow from the core-stay topology, the coherent n = 4 mode count, and the radial normalisation respectively, and none contains an adjustable parameter. The separation of branches also makes the framework sensitive to error: changing the coherent-mode rule would alter the W mass and the mixing quantity but leave the H-class mass unchanged, while changing R_0 would alter the H-class mass but leave the factor 256 of the W branch intact.

11.3 "Is the H-class state the quantum of a separate fundamental field?"

No. The substrate is one field. Matter and interaction states are organised excitations and condensations of that field, and the observed scalar state is its radial resonance about the condensation minimum. The framework introduces no second fundamental scalar field to supply the W and Z masses; those masses follow from the neutral and charged condensation structures of Sections 5 and 6.

11.4 "Does this modify the confirmed electroweak phenomenology?"

No confirmed measurement is affected. The relations $m\_H = v\sqrt{(2\lambda)}$ and $\cos^2\theta\_W = (m\_W/m\_Z)^2$ are retained in form; the proposal supplies physical values for the quantities that the

Standard Model takes from measurement. Production cross-sections, decay widths, and precision electroweak observables are left as described by the Standard Model with the measured parameters [15,16,17].

12. Falsifiable Predictions

The condensation account of the electroweak and H-class sector makes the following falsifiable predictions.

Prediction 1. The Higgs self-coupling is fixed at $\lambda\_H\_vss = R_0/\pi^2 = 0.12903$. Measurements of Higgs-pair production at the High-Luminosity LHC are therefore predicted to find the trilinear self-coupling consistent with this value, within about one percent of the Standard Model expectation built from the measured mass and vacuum expectation value. A confirmed deviation of the trilinear self-coupling from this value, beyond the combined experimental uncertainty, would falsify the identification of the observed state as the radial resonance of the condensation.

Prediction 2. Because the observed scalar state is the radial resonance of one substrate field, no additional fundamental scalar field participates in electroweak mass generation. Searches for further heavy neutral or charged Higgs bosons of the kind required by extended Higgs sectors, such as two-Higgs-doublet models, are predicted to find none. A confirmed discovery of an additional fundamental Higgs-sector scalar would falsify this account.

Prediction 3. The weak mixing quantity carries no parameter of its own. Any independent derivation of the W and Z resonances from the same condensation structure is predicted to reproduce $\sin^2\theta\_W\_vss = 1 - 256^2/(9\pi^8)$ exactly, and a condensation structure giving a different mass ratio would falsify the present assignment of the neutral and charged branches.

13. Conclusions

We have proposed a geometric origin for the W, Z, and Higgs boson masses and the electroweak mixing quantity from the condensation topology of a universal physical substrate. The neutral core-stay branch gives $m\_Z\_vss = \pi^4 m_P = 91.396$ GeV/c². The charged $n = 4$ reconfiguration uses $M = m_P/3$ and $(n^2)^2 = 256$ to give $m\_W\_vss = 80.066$ GeV/c². The mixing quantity follows from their mass ratio as $\sin^2\theta\_W\_vss = 0.23257$. Independently of this chain, the radial branch gives $\lambda\_H\_vss = R_0/\pi^2 = 0.12903$ and $v\_vss = 245.565$ GeV, which yield $m\_H\_vss = 124.75$ GeV/c². The four-unit configuration spectrum of the same functional gives the two Shankar resonances at 776.5 MeV and 1403.7 MeV.

The three masses agree with measurement to 0.23, 0.38, and 0.36 percent with no fitted parameter, and no mass is used as an input to another. Within this interpretation, the observed Higgs state is the radial resonance of the one Spaticle field, and the W and Z states arise from its distinct neutral and charged condensation structures.

References

[1] Navas, S., et al. (Particle Data Group) (2024). Review of Particle Physics. Physical Review D, 110, 030001.

[2] Higgs, P.W. (1964). Broken symmetries and the masses of gauge bosons. Physical Review Letters, 13(16), 508–509.

[3] Weinberg, S. (1967). A model of leptons. Physical Review Letters, 19(21), 1264–1266.

[4] ATLAS Collaboration (2012). Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC. Physics Letters B, 716(1), 1–29.

[5] CMS Collaboration (2012). Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC. Physics Letters B, 716(1), 30–61.

[6] Sharma, V.S. (2026). A Single-Substrate Interpretation of the Cosmological Constant Problem. Zenodo. doi:10.5281/zenodo.21280358

[7] Michelson, A.A. and Morley, E.W. (1887). On the relative motion of the Earth and the luminiferous ether. American Journal of Science, 34(203), 333–345.

[8] Müller, H., Herrmann, S., Braxmaier, C., Schiller, S., and Peters, A. (2003). Modern Michelson-Morley experiment using cryogenic optical resonators. Physical Review Letters, 91, 020401.

[9] Sharma, V.S. (2026). A Physical and Mechanical Explanation of the Speed of Light: Why All Photons and Gravitational Waves Travel at c. Zenodo. doi:10.5281/zenodo.21292900

[10] Sharma, V.S. (2026). A Geometric Origin of the Reduced Planck Constant from Substrate Condensation Geometry. Zenodo. doi:10.5281/zenodo.21280494

[11] Rovelli, C. (2004). Quantum Gravity. Cambridge University Press, Cambridge.

[12] Einstein, A. (1920). Äther und Relativitätstheorie. Address delivered at the University of Leiden, 5 May 1920. Springer, Berlin.

[13] Sharma, V.S. (2026). A Physical Origin of Electric Charge. Zenodo. doi:10.5281/zenodo.21303147

[14] Sharma, V.S. (2026). Why the Electron Is So Much Smaller Than the Proton, and Why It Orbits So Far Away. Zenodo. doi:10.5281/zenodo.21303192

[15] ATLAS Collaboration (2022). A detailed map of Higgs boson interactions by the ATLAS experiment ten years after the discovery. Nature, 607, 52–59.

[16] CMS Collaboration (2022). A portrait of the Higgs boson by the CMS experiment ten years after the discovery. Nature, 607, 60–68.

[17] ALEPH, DELPHI, L3, OPAL, and SLD Collaborations (2006). Precision electroweak measurements on the Z resonance. Physics Reports, 427(5–6), 257–454.