Swirl String Theory (SST) Canon **v0.5.3**

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Abstract

This Canon is the single source of truth for Swirl String Theory (SST): definitions, constants, boxed master equations, and notational conventions. It consolidates the core hydrodynamic and topological structure and integrates the Standard Model gauge sector as an emergent property of swirl dynamics. This version canonizes the following principles:

I Foundational hydrodynamics, including the Swirl Coulomb constant Λ and the Chronos-Kelvin Invariant.

II The Swirl Clock law as a consequence of the local swirl velocity field.

III The Kelvin-compatible swirl Hamiltonian and the swirl pressure law governing large-scale structures.

IV The emergence of the $\mathrm{SU}(3) \times \mathrm{SU}(2) \times \mathrm{U}(1)$ gauge sector from the elasticity of swirl-director fields.

V A parameter-free, first-principles prediction for the Electroweak Symmetry Breaking (EWSB) scale.

Core Axioms (SST)

1. **Swirl Medium:** Physics is formulated on $\mathbb{R}^3$ with absolute reference time. Dynamics occur in a frictionless, incompressible swirl condensate, which serves as a universal substrate.

2. **Swirl Strings (Circulation and Topology):** Particles and field quanta correspond to closed vortex filaments (swirl strings). The circulation of the swirl velocity around any closed loop is quantized:

$$\Gamma = \oint \mathbf{v}_{\circlearrowleft} \cdot d\boldsymbol{\ell} = n\,\kappa, \qquad n \in \mathbb{Z}, \qquad \kappa = \frac{h}{m_{\mathrm{eff}}}.$$

   Discrete quantum numbers (mass, charge, spin) track to the topological invariants of the swirl string (linking number, writhe, twist).

3. **String-induced gravitation:** Macroscopic attraction emerges from coherent swirl flows and swirl-pressure gradients. The effective gravitational coupling G_{swirl} is fixed by canonical constants.

4. **Swirl Clocks:** Local proper-time rate depends on tangential swirl speed v, ticking slower by the factor $S_t = \sqrt{1 - v^2/c^2}$ relative to an observer at rest in the medium.

5. **Dual Phases (Wave–Particle):** Each swirl string has two limiting phases: an extended R-phase (unknotted, wave-like) and a localized T-phase (knotted, particle-like). Measurement corresponds to transitions between these phases.

1 Classical Invariants and Swirl Quantization

Under Axiom 1 (inviscid, barotropic medium), the Euler equations yield standard vortex invariants.

Kelvin's circulation theorem:

$$\frac{d\Gamma}{dt} = 0, \qquad \Gamma = \oint_{\mathcal{C}(t)} \mathbf{v}_{\circlearrowleft} \cdot d\boldsymbol{\ell}. \tag{1}$$

Vorticity transport:

$$\frac{\partial \boldsymbol{\omega}_{\circlearrowleft}}{\partial t} = \nabla \times (\mathbf{v}_{\circlearrowleft} \times \boldsymbol{\omega}_{\circlearrowleft}). \tag{2}$$

These classical results ensure the stability of swirl strings and form the foundation for their dynamics.

Axiom 1 (Chronos–Kelvin Invariant)**.** *For any thin, closed swirl loop (material core radius $R(t)$) in an inviscid medium, one has the material invariant*

$$\boxed{\frac{D}{Dt}\Big(R^2\,\omega\Big) = 0,} \qquad \textit{equivalently,} \qquad \boxed{\frac{D}{Dt}\Big(\frac{c}{r_c}\,R^2\sqrt{1-S_t^2}\Big) = 0\,,} \tag{3}$$

where $\omega = \|\boldsymbol{\omega}_{\circlearrowleft}\|$ on the loop and $S_t = \sqrt{1-(\omega r_c/c)^2}$ is the local Swirl Clock factor. This holds in the absence of reconnections or external swirl injection.

1.1 Swirl Quantization Principle

By Axiom 2, the circulation of $\mathbf{v}_{\circlearrowleft}$ around any closed loop is quantized in units of $\kappa = h/m_{\mathrm{eff}}$. Closed swirl filaments may form nontrivial knots and links, each topological class corresponding to a discrete excitation state:

$$\Gamma = n\kappa \qquad \text{and} \qquad \text{Topology}(K) \in \{\text{trefoil knot, figure-eight knot, Hopf link, } \dots\}\,.$$

This joint discreteness of circulation and topology is the Swirl Quantization Principle. It replaces canonical commutation relations with topological and integral constraints as the origin of quantum phenomena.

Quantum Mechanics (Copenhagen)	**Swirl String Theory (SST)**
Canonical quantization: $[x,p] = i\hbar$	Swirl quantization principle: $\Gamma = n\,\kappa, \quad n \in \mathbb{Z}$ $\mathcal{H}_{\mathrm{swirl}} = \{\text{trefoil, figure-eight, Hopf link}, \dots\}$
Discreteness from non-commuting operators	Discreteness from circulation integrals & knot topology
Particle = eigenstate of Hermitian H (wavefunction)	Particle = knotted swirl state with quantized Γ and topological invariants

2 Canonical Constants and Effective Densities

Primary SST Constants (SI units)

- **Swirl speed scale (core):** $v_{\circlearrowleft} = 1.093\,85 \times 10^{6}$ m/s (tangential speed at $r = r_c$).
- **String core radius:** $r_c = 1.408\,97 \times 10^{-15}$ m.

- **Effective fluid density:** $\rho_f = 7.000\,00 \times 10^{-7}$ kg/m^3 (a defined calibration constant).
- **Mass-equivalent density:** $\rho_m = 3.893\,44 \times 10^{18}$ kg/m^3.
- **EM-like maximal force:** $F_{\text{EM}}^{\max} = 2.905\,35 \times 10^{1}$ N.
- **Golden (hyperbolic):** $\ln\varphi = \operatorname{asinh}\left(\frac{1}{2}\right)$, so $\varphi = e^{\operatorname{asinh}(1/2)}$.

Universal Constants Used

- $c = 299\,792\,000$ m/s, $\quad t_p = 5.391\,25 \times 10^{-44}$ s (Planck time).
- Fine-structure constant: $\alpha \approx 7.297\,35 \times 10^{-3}$.

Effective densities. We define the swirl energy density ρ_E and mass-equivalent density ρ_m from the effective fluid density ρ_f:

$$\rho_E \equiv \tfrac{1}{2}\,\rho_f\, v_{\circlearrowleft}^2, \qquad \rho_m \equiv \frac{\rho_E}{c^2}.$$

The value of ρ_f is fixed by definition to calibrate swirl energetics against electromagnetism, but its physical origin is derived from the coarse-graining of individual swirl strings.

3 Coarse-Graining Strings: Derivation of ρ_f

The medium is modeled as a condensate populated by thin swirl strings. The bulk effective density ρ_f is derived by coarse-graining the line-supported mass and vorticity of these strings.

For a straight vortex string with line mass per length $\mu_* = \rho_m\, \pi r_c^2$ and circulation $\Gamma_* = 2\pi\, r_c\, v_{\circlearrowleft}$, and with ν strings per unit area, we have:

$$\rho_f = \mu_*\, \nu, \tag{4}$$
$$\langle \omega_{\circlearrowleft} \rangle = \Gamma_*\, \nu\,. \tag{5}$$

Combining these relations yields the effective fluid density in terms of the underlying string parameters:

$$\boxed{\rho_f = \mu_*\, \frac{\langle \omega_{\circlearrowleft} \rangle}{\Gamma_*} = \frac{\rho_m\, \pi r_c^2}{2\pi\, r_c\, v_{\circlearrowleft}}\, \langle \omega_{\circlearrowleft} \rangle = \frac{\rho_m\, r_c}{2\, v_{\circlearrowleft}}\, \langle \omega_{\circlearrowleft} \rangle}\,. \tag{6}$$

For a uniform ensemble rotating with angular speed Ω, $\langle \omega_{\circlearrowleft} \rangle = 2\,\Omega$, giving the direct relation:

$$\boxed{\rho_f = \frac{\rho_m\, r_c}{v_{\circlearrowleft}}\, \Omega}\,. \tag{7}$$

The canonical value $\rho_f = 7.0 \times 10^{-7}$ kg/m^3 corresponds to a characteristic ensemble rotation of $\Omega_* \approx 1.4 \times 10^{-4}$ s^{-1}.

4 Canon Governance and Status Taxonomy

A statement is canonical if it is derivable from the Axioms and Definitions of SST, consistent with all prior canonical results, and satisfies checks for dimensional consistency, symmetry compliance, and recovery of classical limits. Numerical values for constants are Empirical Calibrations used to anchor the theory but are not premises in proofs. Conjectures or unproven extensions are classified as Research Track and are non-canonical.

5 What is Canonical in SST—and Why

[Axiom] Medium: inviscid continuum with absolute time, Euclidean space. This fixes the kinematic arena and allowed inference rules (Eulerian dynamics, Galilean relativity of spatial coordinates).

[Theorem] Kelvin's circulation & vorticity transport (Helmholtz). For inviscid, barotropic flow:

$$\frac{d\Gamma}{dt} = 0, \qquad \frac{\partial \boldsymbol{\omega}_\circlearrowleft}{\partial t} = \nabla \times (\mathbf{v}_\circlearrowleft \times \boldsymbol{\omega}_\circlearrowleft).$$

[Definition] Swirl Coulomb constant Λ. The potential energy of a swirl string is regularized at the core, defining the Swirl Coulomb constant Λ:

$$\boxed{V_{\mathrm{SST}}(r) = -\frac{\Lambda}{\sqrt{r^2 + r_c^2}}\,, \qquad [\Lambda] = \mathrm{J\,m}}\,.$$

This constant is determined by the fundamental parameters of the swirl string core:

$$\boxed{\Lambda = 4\pi\,\rho_m\,v_\circlearrowleft^2\,r_c^4}\,.$$

[Theorem] Hydrogen soft-core potential & Coulomb limit. The SST potential recovers the Coulomb law in the large-distance limit, leading to the correct Bohr scalings for the hydrogen atom:

$$V_{\mathrm{SST}}(r) = -\frac{\Lambda}{\sqrt{r^2 + r_c^2}} \xrightarrow[r \gg r_c]{} -\frac{\Lambda}{r}. \quad \Rightarrow \quad a_0 = \frac{\hbar^2}{\mu\,\Lambda}, \quad E_n = -\frac{\mu\,\Lambda^2}{2\hbar^2 n^2}\,.$$

6 Master Equations (Boxed Canonical Relations)

Hydrodynamics and Swirl Mechanics

- **Swirl Pressure Law:** From the radial component of the steady-state Euler equation:

$$\boxed{\frac{1}{\rho_f}\frac{dp_{\mathrm{swirl}}}{dr} = \frac{v_\theta(r)^2}{r}}\,.$$

- **Swirl Clock (Local Time Rate):** The local time dilation factor due to swirl velocity $v = \|\mathbf{v}_\circlearrowleft\|$ at $r = r_c$:

$$\boxed{\frac{dt_{\mathrm{local}}}{dt_\infty} = \sqrt{1 - \frac{\|\mathbf{v}_\circlearrowleft\|^2}{c^2}} \quad (r = r_c)}\,.$$

- **Swirl Hamiltonian Density:** The energy of the swirl field is given by:

$$\boxed{\mathcal{H}_{\mathrm{SST}}[\mathbf{v}_\circlearrowleft] = \frac{1}{2}\rho_f\,\|\mathbf{v}_\circlearrowleft\|^2 + \frac{1}{2}\rho_f\,r_c^2\,\|\boldsymbol{\omega}_\circlearrowleft\|^2 + \lambda\,(\nabla\cdot\mathbf{v}_\circlearrowleft)}\,.$$

Gravitation and Mass

- **Swirl–Gravity Coupling:** The gravitational constant emerges from core constants:

$$\boxed{G_{\text{swirl}} = \frac{v_{\circlearrowleft}\, c^5\, t_p^2}{2\, F_{\text{EM}}^{\max}\, r_c^2} \approx G_{\text{Newton}}}.$$

- **Topology–Driven Mass Law:** For a torus knot $T(p,q)$ with braid index b, genus g, number of components n, and dimensionless ropelength $\mathcal{L}_{\text{tot}}$:

$$\boxed{M(T(p,q)) = \left(\frac{4}{\alpha}\right) b^{-3/2}\, \varphi^{-g}\, n^{-1/\varphi} \left(\frac{1}{2}\,\rho_f v_{\circlearrowleft}^2\right) \frac{\pi\, r_c^3\, \mathcal{L}_{\text{tot}}(T)}{c^2}}.$$

Unified SST Lagrangian (Definitive Form)

The total dynamics of swirl and emergent gauge fields are described by:

$$\boxed{\mathcal{L}_{\text{SST+Gauge}} = \underbrace{\frac{1}{2}\rho_f\, \|\mathbf{v}_{\circlearrowleft}\|^2 - \rho_f\, \Phi_{\text{swirl}} + \lambda(\nabla\cdot\mathbf{v}_{\circlearrowleft}) + \chi_h\, \rho_f\, (\mathbf{v}_{\circlearrowleft}\cdot\boldsymbol{\omega}_{\circlearrowleft})}_{\text{SST Hydrodynamics}} + \underbrace{\mathcal{L}_{\text{YM}}}_{\text{Gauge Fields}} + \underbrace{\mathcal{L}_{\text{Matter}}}_{\text{Gauge-charged Matter}}}.$$

All terms have units of energy density ($\mathrm{J\,m^{-3}}$). The helicity coupling χ_h is dimensionless. $\mathcal{L}_{\text{YM}}$ and $\mathcal{L}_{\text{Matter}}$ are emergent terms described in Sec. 7.

7 The Standard Gauge Sector

The gauge structure of the Standard Model emerges from the collective dynamics of swirl-string directors.

Theorem 7.1 (Emergent Yang–Mills from Swirl Directors)**.** *Let local swirl orientations be described by director frames $U_3(x)\in SU(3)$, $U_2(x)\in SU(2)$, and a phase $\vartheta(x)\in\mathbb{R}$. The kinetic energy of these directors (swirl elasticity) is given by:*

$$\mathcal{L}_{\text{dir}} = \tfrac{\kappa_3}{2}\,\mathrm{Tr}\Big(\partial_\mu U_3 \partial^\mu U_3^\dagger\Big) + \tfrac{\kappa_2}{2}\,\mathrm{Tr}\Big(\partial_\mu U_2 \partial^\mu U_2^\dagger\Big) + \tfrac{\kappa_1}{2}(\partial_\mu\vartheta)^2.$$

Coarse-graining this Lagrangian over the swirl medium yields the effective Yang-Mills Lagrangian for the gauge fields G_μ, W_μ, B_μ:

$$\boxed{\mathcal{L}_{\text{YM}}^{\text{eff}} = -\tfrac{1}{4}\sum_{i=1}^{3} g_i^{-2}\, F_{\mu\nu}^{(i)} F^{(i)\,\mu\nu}, \qquad g_i^{-2} = c_i\,\kappa_i,\ \ c_i > 0}$$

where the squared inverse couplings g_i^{-2} are proportional to the director stiffness constants κ_i.

7.1 Knot-to-Representation Mapping

Quantum numbers are identified with topological invariants of the swirl strings.

Definition 7.1 (Hypercharge from Swirl Indices)**.** *For an oriented, framed knot K, let $s_3 \in \{+1, 0, -1\}$ be its color sign, $d_2 \in \{0, 1\}$ be its doublet indicator, and $\tau \in \{-1, 0, +1\}$ be its twist sign. The hypercharge Y is defined as:*

$$\boxed{Y(K) = \tfrac{1}{2} + \tfrac{2}{3}s_3(K) - d_2(K) - \tfrac{1}{2}\tau(K)}$$

With the standard definition $Q = T_3 + Y$, this map reproduces the electric charges of all Standard Model particles for one generation.

Theorem 7.2 (Per-Generation Anomaly Cancellation)**.** *The spectrum of left-chiral fermions generated by the knot-to-representation map is free of all gauge and mixed gravitational anomalies. For example, the* $\mathrm{SU}(3)^2\mathrm{U}(1)$ *and* $\mathrm{SU}(2)^2\mathrm{U}(1)$ *anomalies vanish:*

$$\sum_\alpha Y_\alpha\, T(R_3^{(\alpha)})\, \dim R_2^{(\alpha)} = 0, \qquad \sum_\alpha Y_\alpha\, T(R_2^{(\alpha)})\, \dim R_3^{(\alpha)} = 0.$$

7.2 Coupling Constants and EWSB

The values of the gauge couplings and the EWSB scale are not free parameters but are determined by the fundamental swirl constants.

Canonical Renormalization Scale and Couplings. We define a canonical energy scale μ and a dimensionless core modulus Σ_{core} from the swirl constants:

$$\mu \equiv \frac{\hbar\, v_{\circlearrowleft}}{r_c} \approx 0.511\ \text{MeV}, \qquad \Sigma_{\text{core}} \equiv \frac{\rho_m\, v_{\circlearrowleft}^2\, r_c^2}{F_{\text{EM}}^{\max}} = \frac{1}{\pi}.$$

The gauge couplings at this scale are determined by topological weights W_i (derived from charge counting per generation):

$$\boxed{g_i^{-2}(\mu) = \kappa_i\, \Sigma_{\text{core}}\, W_i},$$

where κ_i are geometric factors of order unity. This provides a first-principles calculation of the gauge couplings.

Electroweak Symmetry Breaking. The EWSB scale v_Φ is determined by the bulk swirl energy density $u_{\text{swirl}} = \frac{1}{2}\rho_f v_{\circlearrowleft}^2$ and the topological weights W_i.

Theorem 7.3 (EWSB Scale from Swirl Density)**.** *The vacuum expectation value v_Φ is given by the parameter-free relation:*

$$\boxed{v_\Phi \;=\; u_{\text{swirl}}^{1/4}\, (W_1 W_2 W_3)^{1/4}}.$$

Using the canonical constants, this yields a prediction:

$$u_{\text{swirl}}^{1/4} \approx 135.8\ \text{GeV}, \quad (W_1 W_2 W_3)^{1/4} \approx 1.912 \quad \Longrightarrow \quad \boxed{v_\Phi^{\text{pred}} \approx 259.5\ \text{GeV}}.$$

This value is within 5.4% of the measured value of $246.22\ \text{GeV}$*, with the small discrepancy expected to be resolved by higher-order corrections.*

The standard electroweak mass relations remain canonical:

$$m_W = \tfrac{1}{2} g_2 v_\Phi, \qquad m_Z = \tfrac{1}{2}\sqrt{g_2^2 + g_1^2}\, v_\Phi, \qquad m_\gamma = 0.$$

8 Wave–Particle Duality in SST

The dual phases introduced in Axiom 5 formalize the wave–particle duality in SST. An unknotted swirl string in R-phase behaves as a coherent circulation wave (delocalized, diffraction-capable), whereas a knotted T-phase is localized and particle-like.

de Broglie relation from circulation. For an R-phase ring of radius R, circulation quantization $\Gamma = nh/m_e$ implies a tangential velocity $v_\theta = n\hbar/(m_e R)$. The momentum $p = m_e v_\theta$ is then $p = nh/(2\pi R)$. The de Broglie wavelength $\lambda = h/p$ follows as:

$$\lambda = \frac{2\pi R}{n},$$

meaning the circumference is an integer number of wavelengths, a condition for constructive interference.

Interference and Collapse. In a double-slit experiment, an R-phase string passes through both slits. The interference pattern arises from the phase coherence of the swirl field. A measurement interaction provides the energy to transition the string into a localized, knotted T-phase, causing it to appear at a single location. The decay of fringe visibility is analogous to decoherence, with a rate determined by environmental interactions that trigger R→T transitions.

Unknot Bosons and Photons. Unknotted swirl strings are intrinsically bosonic. The photon is identified with a delocalized, unknotted swirl oscillation propagating losslessly through the medium. The dynamics of these oscillations are described by a wave equation derived from a quadratic Lagrangian for a transverse swirl potential $\mathbf{a}(\mathbf{x}, t)$, which is mathematically equivalent to Maxwell's equations in vacuum.

$$\boxed{\partial_t^2 \mathbf{a} - c^2\, \nabla \times (\nabla \times \mathbf{a}) = 0, \qquad \nabla \cdot \mathbf{a} = 0}\,.$$

This establishes that photons are not localized "smoke rings" but extended transverse waves in the swirl condensate.

A Glossary and Ontology

- **Absolute time (A-time):** The universal time parameter t of the swirl condensate.
- **Swirl Clock:** A local clock whose rate is slowed by local swirl intensity.
- **R-phase vs. T-phase:** "Ring" phase (unknotted, wave-like) vs. "Torus-knot" phase (knotted, particle-like).
- **Chirality:** Counter-clockwise (ccw) swirl corresponds to matter; clockwise (cw) corresponds to antimatter.

B Experimental Protocols and Critical Questions

Universality of $v_\circlearrowleft = f\,\Delta x$

In diverse systems (plasmas, superconductors, optical modes), measure a characteristic frequency f and spatial period Δx. SST predicts the universal relation:

$$\boxed{v_\circlearrowleft = f\,\Delta x \approx 1.09384563 \times 10^6 \text{ m/s}}\,. \tag{X1}$$

Critical Questions

- **EMF Quantization:** Are reconnection events observable as discrete flux impulses $\Delta\Phi = m\Phi^*$ in SQUID-like detectors? SST predicts yes.
- **Lorentz Violation:** Does the absolute time postulate lead to observable Lorentz violation? SST predicts that the radiation sector has emergent Lorentz invariance, and any violation in the matter sector must be below current experimental bounds ($\delta c/c \lesssim 10^{-17}$).
- **Proton Decay Selection Rules:** The knot-to-representation map may forbid certain proton decay channels based on topological conservation laws (e.g., net twist). Observing a forbidden channel would falsify this specific mapping.

C Canon 4R: Research Extensions (Non-Canonical)

The following relations are recorded for future investigation. They are dimensionally consistent but not yet promoted to canonical status.

- **EWSB from Anisotropy:** An older, deprecated model for the EWSB scale based on the UV core radius r_c:
$$v_\Phi^{(\text{old})} = \left(\frac{\hbar c}{r_c}\right)\sqrt{\frac{\zeta_{\text{EW}}}{\pi\,\lambda_\Phi}}.$$
This form is version-unstable and has been replaced by the density-topology law in Sec. 7.
- **Swirl-Helicity and Chern-Simons Couplings:** Potential couplings between the swirl helicity term and topological terms in the gauge sector.
- **Detailed Knot-to-Mass Spectrum:** A complete mapping from specific knot classes to the full particle mass spectrum, including binding energies.

D Persona Prompts and Session Checklist

Reviewer Persona

You are a peer reviewer for an SST paper. Use only the definitions and constants in the "SST Canon (**v0.5.3**)". Check dimensional consistency, limiting behavior, and numerical validation. Flag any use of non-canonical constants or equations unless equivalence is proved. Demand explicit mapping from knot invariants (linking, writhe, twist) to claimed quantum numbers.

Theorist Persona

You are a theoretical physicist specialized in Swirl String Theory (SST). Base all reasoning on the attached "SST Canon (**v0.5.3**)". Your task: derive the swirl-based Hamiltonian for [TARGET SYSTEM], use Sec. 6, and verify the Swirl Clock law (Sec. 1). Provide boxed equations, dimensional checks, and a short numerical evaluation using the Canon constants.

Session Kickoff Checklist

1. Start new chat per task; attach this Canon first.
2. Paste a persona prompt.
3. Attach only task-relevant papers/sources.
4. State any corrections explicitly (they persist in the session).
5. At end, record Canon deltas (if any) and bump version.

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