Cosmological Foundations in Swirl String Theory

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This Canon Cheat-Sheet condenses *Swirl String Theory (SST)* for cosmology: definitions, constants, boxed master equations, and notational conventions. It emphasizes dimensional consistency, known-limit checks, and minimal assumptions.

FOUNDATIONS

- **Arena:** Flat $\mathbb{R}^3$ with absolute (Chronos) time.
- **Medium:** Homogeneous, incompressible swirl condensate of density ρ_f; circulation quantized in closed filaments ("swirl strings").
- **Gravity:** Emergent from swirl-pressure and clock-rate gradients; no curved spacetime.

SWIRL COSMOGONY (GENESIS VIA KNOTS)

- **Primordial:** Uniform, laminar state (topologically trivial).
- **Instability:** Fluctuations/reconnections nucleate closed loops (unknots).
- **Knot genesis:** Reconnection cascades stabilize nontrivial knots; topology protects excitation.
- **Freeze-in:** Energy is inherited via line-length and local topology.
- **Causal asymmetry:** Arrow of time measured by monotone growth of knot complexity and coherent volume fraction.
- **Inflation-like era:** Burst of coherence and reconnection leads to exponential growth of coherent domains.
- **Post-era:** Knots seed matter; coherence zones act as gravitational attractors.

COSMOGONY: GOVERNING DYNAMICS, FREEZE-OUT, AND OBSERVABLES

Primary scales at Big Condensation

Define the quantum of circulation and an initial correlation length:

$$\kappa \equiv 2\pi\, r_c\, \|\mathbf{v}_{\circlearrowleft}\|, \qquad \xi_0 \sim r_c.$$

Units and numeric check. $[\kappa] = \mathrm{m}^2\,\mathrm{s}^{-1}$. With $r_c = 1.40897017 \times 10^{-15}$ m and $\|\mathbf{v}_{\circlearrowleft}\| = 1.09384563 \times 10^6\ \mathrm{m\,s}^{-1}$,

$$\kappa \approx 9.684 \times 10^{-9}\ \mathrm{m}^2\,\mathrm{s}^{-1}.$$

This ensures continuity with the core-scale swirl speed: $\kappa/(2\pi r_c) = \|\mathbf{v}_{\circlearrowleft}\|$.

Analogy (fluid picture)

Kid picture: κ is how much "spin" one tiny loop carries—like a fixed twist baked into every small rubber band.

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Freeze-out of coherence (Kibble–Zurek–type scaling)

When the condensate forms under a finite quench time τ_Q, domains freeze out at a scale

$$\xi_{\rm fr} \simeq \xi_0 \left(\frac{\tau_Q}{\tau_0}\right)^{\nu/(1+\nu z)}, \tag{1}$$

with static exponent ν and dynamic exponent z appropriate to the SST universality class (to be measured).
Dimensions. ξ_0 has units of length; the ratio $(\tau_Q/\tau_0)^{\nu/(1+\nu z)}$ is dimensionless, so $[\xi_{\rm fr}] = \mathrm{m}$.

Edge cases & uncertainties

Uncertainties. The exponents (ν, z) are *not* assumed from external systems; SST must calibrate them from coherence-growth data (BAO + CMB phase + low-z structure) to avoid importing priors.

Analogy (fluid picture)

Kid picture: If you cool soup too fast, many small fat-islands form; cool it slower, and you get fewer, bigger islands. $\xi_{\rm fr}$ is the island size at the instant the pattern "freezes."

Coherence fraction dynamics (logistic locking vs. scrambling)

Let $f(t) \in [0,1]$ be the fraction of volume in phase-locked (coherent) swirl. We model competition between locking and scrambling by

$$\frac{df}{dt} = \big(\Gamma_{\rm lock} - \Gamma_{\rm scr}\big)\, f\,\big(1-f\big), \tag{2}$$

with rates $\Gamma_{\rm lock}, \Gamma_{\rm scr}$ in s^{-1}. A minimal parametric form consistent with SST kinematics is

$$\Gamma_{\rm lock} = \chi\,\frac{\kappa}{2\pi\,\xi^2}, \qquad \Gamma_{\rm scr} = \eta\,\Gamma_{\rm rec},$$

where $\xi(t)$ is the instantaneous correlation length, χ, η are dimensionless efficiencies, and $\Gamma_{\rm rec}$ is the reconnection rate density (research-calibrated).
Solution. For piecewise-constant $\Gamma_{\rm eff} \equiv \Gamma_{\rm lock} - \Gamma_{\rm scr}$,

$$f(t) = \frac{1}{1 + \left(\frac{1-f_0}{f_0}\right) e^{-\Gamma_{\rm eff}(t-t_0)}}.$$

A transient epoch with $\Gamma_{\rm eff} > 0$ is the SST analogue of "inflation-like" coherence burst (rapid ordering without metric expansion).

Algorithmic recipe

Recipe to fit $f(t)$: (1) Choose $\xi(t)$ model (next subsection). (2) Set priors on χ, η and $\Gamma_{\rm rec}$ from simulations. (3) Fit $\Gamma_{\rm eff}(t)$ to SN Ia $H_{\rm eff}(z)$ + BAO AP anisotropy. (4) Cross-check with CMB acoustic phase (stage-locking imprint).

Correlation-length growth (reconnection-limited coarsening)

Coarse-grained swirl speed at scale ξ follows Biot–Savart scaling:

$$v_{\rm coarse}(\xi) \simeq \frac{\kappa}{2\pi\,\xi}.$$

A reconnection-limited coarsening law that respects dimensions is

$$\frac{d\xi}{dt} \;=\; A\,\frac{\kappa}{2\pi\,\xi} \;-\; B\,\Gamma_{\rm rec}\,\xi, \tag{3}$$

with A, B dimensionless. The first term grows domains via advective coalescence; the second shrinks them when reconnections dominate.

Limits. (i) $\Gamma_{\rm rec} \to 0$: $\xi^2(t)$ grows linearly: $\xi^2(t) = \xi_i^2 + \frac{A\kappa}{\pi}(t - t_i)$. (ii) Strong reconnections: steady state $\xi_\star = \sqrt{\frac{A\kappa}{2\pi B\,\Gamma_{\rm rec}}}$.

Edge cases & uncertainties

Calibration targets. CMB peak spacing $\Rightarrow \xi_{\rm fr}$; BAO scale $\Rightarrow \xi$ at $z\sim 0.5-1$; Weak-lensing two-point $\Rightarrow$ late-time ξ anisotropy; Peculiar-velocity flows $\Rightarrow v_{\rm coarse}(\xi)$ normalization.

Analogy (fluid picture)

Kid picture: Small whirlpools merge into bigger ones unless they keep cutting each other. The first term makes bigger pools; the second keeps chopping them up.

Swirl-clock background and effective Hubble rate

SST uses the clock ratio as the distance–redshift engine:

$$1 + z \;=\; \frac{S_t^{-1}(\text{emit})}{S_t^{-1}(\text{obs})}, \qquad H_{\rm eff}(t) \equiv -\frac{d}{dt}\ln S_t.$$

During a coherence burst ($\Gamma_{\rm eff} > 0$) Eq. (2) pushes S_t toward uniformity, which drives a phase of $\dot{H}_{\rm eff} < 0$ mimicking accelerated expansion without metric growth (already referenced in your ΛCDM dictionary).

Topological spectrum lock-in at freeze-out

At $t_{\rm fr}$ with $\xi_{\rm fr}$ from Eq. (1), the knot density spectrum freezes. The mass law (Eq. (4)) then fixes species energy densities once $L_{\rm tot}(K)$ and (b, g, n) are set. Hopf-charge stabilization provides a topological lower bound on energy for linked sectors (research calibration of the bound's SST coefficient).

Falsifiable cosmogony signals

Predictions specific to cosmogony

- **KZ scaling in LSS:** The inferred $\xi_{\rm fr}$ from CMB should obey a power law in an independently estimated τ_Q proxy (duration of condensation epoch).
- **Phase shift of acoustic peaks:** Ordering dynamics impart a calculable phase offset in the CMB acoustic series distinct from standard ΛCDM (sign fixed by $\Gamma_{\rm eff}(t)$).
- **BAO AP anisotropy vs. environment:** ξ and S_t gradients predict $\mathcal{O}(10^{-3}-10^{-2})$ directional distortions correlated with large-scale shear.
- **Redshift drift:** The combination $\dot{z} = H_{\rm eff,0} - H_{\rm eff}(z)/(1+z)$ deviates at $z \lesssim 1$ if $f(t)$ is still evolving.

SWIRL CLOCK, TIME DILATION, AND REDSHIFT

Define the swirl-clock factor

$$S_t \equiv \sqrt{1-\frac{\|\mathbf{v}_{\circlearrowleft}\|^2}{c^2}}, \qquad dt_{\rm local} = S_t\, dt_\infty.$$

Cosmological redshift is interpreted as a clock-ratio:

$$1+z \;=\; \frac{S_t^{-1}(\text{emit})}{S_t^{-1}(\text{obs})} \quad \text{(line-of-sight shear gives subleading corrections).}$$

Analogy (fluid picture)

A clock is a leaf on water. Where the water swirls fast, the leaf wobbles and ticks slower. Light leaving the slow-water zone looks slightly "stretched" (redder).

Known-limit + numeric check. With $v = \|\mathbf{v}_{\circlearrowleft}\| = 1.09384563\times10^{6}\ \mathrm{m\,s^{-1}}$ and $c = 2.99792458\times10^{8}\ \mathrm{m\,s^{-1}}$,

$$\frac{v}{c} \approx 3.65\times10^{-3}, \qquad S_t = \sqrt{1-v^2/c^2} \approx 0.9999933,$$

so local clock-slowdown at the characteristic swirl speed is small (consistent with weak-field behavior). [**?**]

EMERGENT GRAVITY FROM SWIRL PRESSURE

For axisymmetric swirl with azimuthal speed $v_\theta(r)$, steady Euler balance gives

$$\frac{1}{\rho_f}\,\frac{dp_{\rm swirl}}{dr} \;=\; \frac{v_\theta^2}{r},$$

so an effective inward acceleration $g_{\rm eff}(r) = v_\theta^2/r$, approximating $1/r^2$ attraction when $v_\theta \propto r^{-1/2}$.

Analogy (fluid picture)

Fluid picture: Swirl makes a pressure "dip." Marbles (test masses) roll toward the dip; the radial balance $\rho_f^{-1} dp_{\rm swirl}/dr = v_\theta^2/r$ is just the slope the marble feels. If $v_\theta \propto r^{-1/2}$, the inward pull behaves like $1/r^2$.

VACUUM (CORE) ENERGY DENSITY SCALE

Assuming the core carries the characteristic swirl speed $\|\mathbf{v}_{\circlearrowleft}\| \approx v_{\circlearrowleft}$,

$$u \;=\; \tfrac{1}{2}\,\rho_{\rm core}\,\|\mathbf{v}_{\circlearrowleft}\|^2.$$

Numerical check (SI):

$$\rho_{\rm core} = 3.8934358266918687\times10^{18}\ \mathrm{kg\,m^{-3}}, \quad \|\mathbf{v}_{\circlearrowleft}\| = 1.09384563\times10^{6}\ \mathrm{m\,s^{-1}} \;\Rightarrow\; u \approx 2.329\times10^{30}\ \mathrm{J\,m^{-3}}.$$

INVARIANT MASS LAW FOR KNOTTED EXCITATIONS (CANONICAL)

Let $L_{\rm tot}(K)$ be a *dimensionless* ropelength of knot K. The dimensionally correct SST mass law used in particle fits is

$$\boxed{M(K) \;=\; \left(\frac{4}{\alpha_{\rm fs}}\right) b(K)^{-3/2}\,\phi^{-g(K)}\,n(K)^{-1/\phi}\,\frac{u\left(\pi\, r_c^3\, L_{\rm tot}(K)\right)}{c^2}} \tag{4}$$

with b (braid index proxy), g (genus proxy), n (component count), and $\phi = \exp\!\big(\operatorname{asinh}\!\big(\tfrac{1}{2}\big)\big)$ per the Golden policy.

Units check. $u[\mathrm{J\,m^{-3}}]\cdot(\pi r_c^3 L_{\mathrm{tot}})[\mathrm{m^3}]/c^2 \to \mathrm{kg}$.
Mass scale per unit L_{tot} (numerical).

$$\frac{u\,\pi r_c^3}{c^2} = \frac{(2.329\times10^{30})\,[\mathrm{J\,m^{-3}}]\cdot\pi(1.40897\times10^{-15}\ \mathrm{m})^3}{(2.9979\times10^{8}\ \mathrm{m\,s^{-1}})^2} \approx 2.28\times10^{-31}\ \mathrm{kg}.$$

Including $4/\alpha_{\mathrm{fs}} \approx 5.48\times10^2$ sets the observed lepton/baryon scale once $L_{\mathrm{tot}}(e)$ is calibrated.

Analogy (fluid picture)

Topological knots are like rubber bands tied in different ways; tighter or more tangled bands store more "swirl energy," which we weigh as mass.

KNOT TOPOLOGIES FOR STANDARD PARTICLES

Designation	Representative knot	b	g	n
Electron e^-	Trefoil (3_1, torus)	3	1	1
Muon μ^-	Cinquefoil (5_1, torus)	5	2	1
Proton p	3-component chiral compound	3	2	3
Neutron n	as proton, different core strengths	3	2	3
Photon γ	Unknot (closed loop)	1	0	1

TABLE I. SST classification parameters (b, g, n) used in Eq. (4).

Proton–neutron split (internal geometry). Let $s_u \approx 2.828$, $s_d \approx 3.164$ denote geometric swirl volumes (e.g., from hyperbolic data of candidate subknots $5_2, 6_1$). With global scale $2\pi^2\kappa_R$ (e.g., $\kappa_R\approx2$):

$$L_{\mathrm{tot}}^{(p)} = \lambda_b\,(2s_u + s_d)\,(2\pi^2\kappa_R),$$
$$L_{\mathrm{tot}}^{(n)} = \lambda_b\,(s_u + 2s_d)\,(2\pi^2\kappa_R),$$

preserving (b, g, n) while shifting masses via internal geometry.

SST ↔ ΛCDM: MINIMAL DICTIONARY

- **Effective Hubble rate:** $1+z = S_t^{-1}(\mathrm{em})/S_t^{-1}(\mathrm{obs}) \Rightarrow H_{\mathrm{eff}}(t) \equiv \frac{d}{dt}\ln(1+z) = -\frac{d}{dt}\ln S_t$.
- **Distances:** Use $H_{\mathrm{eff}}(z)$ in FRW distance integrals, $D_L(z) = (1+z)\int_0^z \frac{c\,dz'}{H_{\mathrm{eff}}(z')}$, with small corrections if S_t varies along the line of sight.
- **BAO/CMB:** Coherence correlation length plays the role of a standard ruler; freeze-out of swirl modes maps to acoustic peaks.
- **Growth:** Growth rate $f\sigma_8$ encodes build-up of coherent domains under reconnection and shear of $\mathbf{v}_{\circlearrowleft}$.

OBSERVATIONAL CONSEQUENCES AND FALSIFIERS

Falsifiable predictions

- **SN Ia host dependence:** After standardization, Hubble residuals correlate with local density (voids vs. clusters) via ΔS_t.
- **Strong-lens time delays:** Inferred H_0 shifts with environmental S_t; joint modeling predicts a sign/magnitude.
- **Redshift drift (Sandage test):** $\dot{z} = H_{\text{eff},0} - H_{\text{eff}}(z)/(1+z)$. SST curves differ if S_t evolves non-FRW-like.
- **BAO AP anisotropy:** Directional S_t gradients generate Alcock–Paczyński distortions at $10^{-3}-10^{-2}$.
- **GW speed:** $c_{\text{GW}} = c$ (baseline $c_{13} = 0$); persistent $c_{\text{GW}} \neq c$ falsifies this sector.

CANONICAL CONSTANTS (SI)

Quantity	Symbol	Value
Swirl core radius	r_c	1.40897017×10^{-15} m
Effective density	ρ_f	7.0×10^{-7} $\mathrm{kg\,m^{-3}}$
Core density	ρ_{core}	$3.8934358266918687\times10^{18}$ $\mathrm{kg\,m^{-3}}$
Swirl speed (char.)	$\lVert\mathbf{v}_{\circlearrowleft}\rVert$	1.09384563×10^{6} $\mathrm{m\,s^{-1}}$
Speed of light	c	2.99792458×10^{8} $\mathrm{m\,s^{-1}}$
Fine structure const.	α_{fs}	$7.2973525693\times10^{-3}$

IMPLEMENTATION NOTES (DATA FITS)

1. Calibrate $L_{\text{tot}}(e)$ from M_e using Eq. (4).
2. Fix λ_b, κ_R on (e, μ, p); predict remaining leptons/hadrons and isotope splittings.
3. Infer $H_{\text{eff}}(z)$ non-parametrically from SN Ia; compare with BAO ruler from coherence correlation length.
4. Cross-validate with time-delay lenses and CMB acoustic scale to bound line-of-sight variations in S_t.