Rotating–Frame Unification in the SST Canon: From Swirl Density to Swirl–EMF, and a Canonical Derivation of the Coupling $\mathbf{G}_{swirl}$

Omar Iskandarani
*Independent Researcher, Groningen, The Netherlands**
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We derive, from the Swirl–String Theory (SST) Canon, a rotating-frame unification in which centrifugal and gravitational (swirl) effects merge into a single source term modifying Faraday's law in matter. The key objects are the swirl (vortex-line) areal density $\boldsymbol{\varrho}_{\circlearrowleft}$ and a swirl-induced electromotive source $\mathbf{b}_{\circlearrowleft}$ in the curl equation for $\mathbf{E}$. We prove the canonical relation:

$$\nabla \times \mathbf{E} = -\partial_t \mathbf{B} - \mathbf{b}_{\circlearrowleft}, \qquad \mathbf{b}_{\circlearrowleft} = \mathcal{G}_{\circlearrowleft}\, \partial_t \boldsymbol{\varrho}_{\circlearrowleft}$$

where $\mathcal{G}_{\circlearrowleft}$ is a material/topological transduction constant. Using SST electron logic, circulation quantization, and a flux-pumping pillbox argument, we show that $\mathcal{G}_{\circlearrowleft}$ is quantized in Weber units and, under minimal assumptions, is set by a single-flux normalization $\mathcal{G}_{\circlearrowleft} \simeq \Phi_\star$, with $\Phi_\star$ a flux quantum (*a priori* h/e; in superconductors $h/2e$) [**? ? ? ?**]. We provide a rotating-frame derivation, dimensional checks, and experimental predictions (EMF spikes at vortex nucleation during plate compression; integrated EMF $\simeq \Phi_\star \Delta N$).

I. CANONICAL OBJECTS AND ROTATING FOLIATION

SST adopts absolute time t and Euclidean space on leaves Σ_t, with a preferred congruence u^μ orthogonal to Σ_t. The Canon's chronos–Kelvin invariant enforces conservation of circulation at fixed topology,

$$\frac{D}{Dt}\Big(R^2\omega\Big) = 0 \quad \Longrightarrow \quad \Gamma \equiv \oint_{\mathcal{C}} \mathbf{v} \cdot d\boldsymbol{\ell} \;=\; N\,\kappa, \qquad N \in \mathbb{Z}, \tag{1}$$

where κ is the circulation quantum. Coarse graining over an area $A \subset \Sigma_t$ defines the *swirl (vortex-line) areal density vector*

$$\boldsymbol{\varrho}_{\circlearrowleft}(\mathbf{x},t) \;\equiv\; n_v(\mathbf{x},t)\,\hat{\mathbf{n}} \;=\; \frac{1}{A}\sum_{\ell\in A} \hat{\mathbf{t}}_\ell, \qquad [\boldsymbol{\varrho}] = \mathrm{m}^{-2}, \tag{2}$$

whose flux counts vortex lines through A:

$$\Phi_{\circlearrowleft}(t;A) = \int_A \boldsymbol{\varrho}_{\circlearrowleft} \cdot d\mathbf{A} = N(A,t). \tag{3}$$

a. Rotating frame merger. In a frame rotating with angular velocity $\boldsymbol{\Omega}$, the standard decomposition of absolute vorticity $\boldsymbol{\zeta}_a = \boldsymbol{\zeta}_r + 2\boldsymbol{\Omega}$ and the effective gravity $\mathbf{g}_{eff} = \mathbf{g} - \boldsymbol{\Omega} \times (\boldsymbol{\Omega} \times \mathbf{r})$ imply that centrifugal and gravitational contributions enter through *one* potential. In SST, this translates to a long-range *swirl gravity* channel: time-varying $\boldsymbol{\varrho}_{\circlearrowleft}$ couples to electromotive response via a single effective source $\mathbf{b}_{\circlearrowleft}$, i.e. the "centrifugal + gravity" merger manifests as

$$\nabla \times \mathbf{E} = -\,\partial_t \mathbf{B} - \mathbf{b}_{\circlearrowleft}, \qquad \mathbf{b}_{\circlearrowleft} = (\text{long-range response to } \partial_t \boldsymbol{\varrho}_{\circlearrowleft}). \tag{4}$$

II. CONSTITUTIVE CLOSURE IN MATTER (LOCAL TIER)

At laboratory scales we assume two local, linear constitutive maps:

$$\mathbf{D} = \varepsilon\,\mathbf{E}, \qquad \mathbf{B} = \mu\,\mathbf{H}, \tag{5}$$

$$\boldsymbol{\varrho}_{\circlearrowleft} = \chi_H\,\mathbf{H}, \qquad [\chi_H] = \mathrm{m}^{-1} A^{-1}, \tag{6}$$

where χ_H is a *swirl susceptibility*: stronger $\mathbf{H}$ aligns/admits more vortex lines per area in the medium. This is the right-hand (magnetic/swirl) mirror of Ohm's law on the left (electric/conduction) side,

$$\mathbf{j} = \sigma\,\mathbf{E}, \qquad [\sigma] = \mathrm{S}\,m^{-1}. \tag{7}$$

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III. PILLBOX THEOREM AND THE MIXED TOPOLOGICAL COUPLING

Integrate **??** over a surface $S \subset \Sigma_t$ with boundary ∂S and time interval $[t_i, t_f]$:

$$\int_{t_i}^{t_f} \oint_{\partial S} \mathbf{E} \cdot d\boldsymbol{\ell}\, dt = -\,\Delta\Phi_B(S) \;-\; \int_{t_i}^{t_f} \int_S \mathbf{b}_{\circlearrowleft} \cdot d\mathbf{A}\, dt. \tag{8}$$

If the magnetic flux is held fixed ($\Delta\Phi_B = 0$), the *time-integrated EMF* equals minus the spacetime integral of $\mathbf{b}_{\circlearrowleft}$.

Now, by definition **??** the rate of change of swirl flux counts vortex nucleations/escapes through S:

$$\frac{d}{dt}\int_S \boldsymbol{\varrho}_{\circlearrowleft} \cdot d\mathbf{A} \;=\; \dot{N}(S,t). \tag{9}$$

Postulate the *mixed topological coupling* (EFT level)

$$\boxed{\mathbf{b}_{\circlearrowleft} \;=\; \mathcal{G}_{\circlearrowleft}\, \partial_t \boldsymbol{\varrho}_{\circlearrowleft}}, \qquad [\mathcal{G}_{\circlearrowleft}] = \mathrm{V}\,s = \mathrm{W}b, \tag{10}$$

which is the unique linear, local-in-time map that (i) respects units ($\mathrm{V\,m^{-2}}$ on both sides of **??**), (ii) vanishes in steady states, and (iii) couples only to *topological* changes (nucleations/reconnections) via **??**.

Inserting **??** into **??** and using **??** gives the *flux-pumping quantization*:

$$\boxed{\int_{t_i}^{t_f} \oint_{\partial S} \mathbf{E} \cdot d\boldsymbol{\ell}\, dt \;=\; -\,\mathcal{G}_{\circlearrowleft}\, \Delta N(S)}, \qquad \Delta N(S) = \int_{t_i}^{t_f} \dot{N}(S,t)\, dt \in \mathbb{Z}. \tag{11}$$

Thus each net vortex line added/removed through S produces a *quantized EMF-time impulse* set by $\mathcal{G}_{\circlearrowleft}$.

IV. ELECTRON LOGIC: CANONICAL NORMALIZATION OF $\mathcal{G}$

SST models the electron in its propagation phase as a toroidal ring $\mathcal{R}$ with tangential speed fixed by the Canon,

$$\|\mathbf{v}_{\circlearrowleft}\| \equiv C_e \approx 1.09384563 \times 10^6\ \mathrm{m}\,s^{-1}, \qquad r_c \approx 1.40897 \times 10^{-15}\ \mathrm{m}, \tag{12}$$

and core cross-section $A_c = \pi r_c^2$. When $\mathcal{R}$ knots ($\mathcal{T}$) or unknots, the swirl topology changes by $\Delta N = \pm 1$. The ring guides electromagnetic phase around its core; a minimal and natural normalization is to require that *one topological event* corresponds to *one flux impulse* of size $\Phi_\star$:

$$\int_{t_i}^{t_f} \oint_{\partial S_c} \mathbf{E} \cdot d\boldsymbol{\ell}\, dt \overset{!}{=} \Phi_\star\, \Delta N, \qquad S_c \sim \text{core disk}. \tag{13}$$

Comparing with **??** fixes

$$\boxed{\mathcal{G}_{\circlearrowleft} = \Phi_\star}, \tag{14}$$

i.e. the swirl–EMF transduction constant equals a *flux quantum.* For single-charged rings the Aharonov–Bohm quantum suggests $\Phi_\star = h/e$ [**?**]; for Cooper-paired media, $\Phi_\star = h/2e$ [**?**]. Which constant is realized is a *material/topology* question; either choice preserves **??** and yields a falsifiable prediction.

a. Dimensional and energetic consistency. Equation **??** gives $[\mathcal{G}_{\circlearrowleft}] = \mathrm{V}\,s$ as required by **??**. Energetically, the EM work per event is $W = \int dt \oint \mathbf{E} \cdot d\boldsymbol{\ell}\, I_{\mathrm{loop}}(t)$. For weak backaction ($I_{loop}$ set by readout), **??** predicts an *impulse* independent of drive details—an SST counterpart of flux quantization.

V. ROTATING FRAME: CENTRIFUGAL + GRAVITY ⇒ b

Let the container rotate at $\boldsymbol{\Omega}$ while the plate area shrinks from A_0 to A. With swirl flux frozen (disconnected electrodes), flux conservation **??** implies

$$\boldsymbol{\varrho}_{\circlearrowleft}(A) = \frac{N\,\hat{\mathbf{n}}}{A}, \quad a(A) \sim n_v^{-1/2} = \sqrt{\frac{A}{N}}, \tag{15}$$

and nucleation when $a \lesssim \alpha r_c$. The rate $\partial_t \boldsymbol{\varrho}_{\circlearrowleft}$ is nonzero during nucleation bursts, and by **??** produces a nonzero $\mathbf{b}_{\circlearrowleft}$. In the rotating foliation, the absolute vorticity merger ensures that centrifugal forcing does not appear as a separate source: its effect is absorbed into the *long-range* channel represented by $\mathbf{b}_{\circlearrowleft}$. Combining these, we obtain the *two-tier symmetry*:

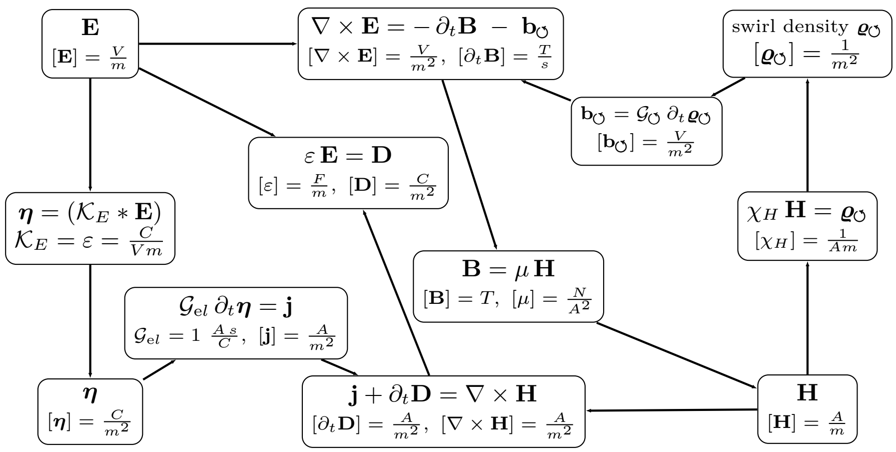
Local tier (mirror):

$$\boxed{\mathbf{j} = \sigma \mathbf{E} \quad \leftrightarrow \quad \boldsymbol{\varrho}_{\circlearrowleft} = \chi_H \mathbf{H}}.$$

Long-range tier (unification):

$$\boxed{\partial_t \boldsymbol{\varrho}_{\circlearrowleft} \xrightarrow[\mathcal{G}_{\circlearrowleft}]{} \mathbf{b}_{\circlearrowleft}, \quad \text{centrifugal + gravity merged}}.$$

VI. COMPLETE DIAGRAM (WITH UNITS AND THE LONG-RANGE LINK)



- $\mathbf{b}_{\circlearrowleft} = \mathcal{G}_{\circlearrowleft}\, \partial_t \boldsymbol{\varrho}_{\circlearrowleft}$: swirl–EMF source, with units $[\mathbf{b}_{\circlearrowleft}]$.
- $\boldsymbol{\varrho}_{\circlearrowleft}$: swirl density, with units $[\boldsymbol{\varrho}_{\circlearrowleft}]$.
- Swirl–gravity mediation: $\mathcal{G}_{\circlearrowleft} = \Phi_\star$.
- $\boldsymbol{\eta}$: conduction accumulation, with units $[\boldsymbol{\eta}]$.
- $\mathcal{K}_E$: a constitutive kernel (electric side), mapping the field $\mathbf{E}$ into an areal charge accumulation $\boldsymbol{\eta}$. In the simplest (local, isotropic) form:

  $$\boldsymbol{\eta} = \varepsilon\, \mathbf{E}$$

  but written as $(\mathcal{K}_E * \mathbf{E})$, it allows for spatial/temporal nonlocal response (like a susceptibility kernel).
- χ_H: a swirl susceptibility (magnetic side), mapping the field $\mathbf{H}$ into the swirl density $\boldsymbol{\varrho}_{\circlearrowleft}$:

  $$\boldsymbol{\varrho}_{\circlearrowleft} = \chi_H\, \mathbf{H}$$

  Units: $[\chi_H] = \mathrm{m}^{-1}\mathrm{A}^{-1}$. It plays the same role as an electric or magnetic susceptibility, but in the SST Canon it measures how strongly $\mathbf{H}$ seeds swirl line density.

VII. FROM THE CANON TO A VALUE FOR $\mathcal{G}$

Equation **??** sets the *scale* of $\mathcal{G}_{\circlearrowleft}$; SST "electron logic" refines it:

a. (i) Topological normalization. The ring $\mathcal{R}$ carries an integer winding N; knotting/unknotting changes $N \to N \pm 1$. A single event thus generates an EMF-time impulse $\Phi_\star$ by **??**–**??**.

b. (ii) Energetic matching. The ring's effective energy change for $\Delta N = \pm 1$ is

$$\Delta E \simeq (\epsilon_0 A_c + \beta)\,\Delta L + \alpha C(\mathcal{T}) + \gamma \mathcal{H}(\mathcal{T}), \tag{16}$$

with Canon bulk term ϵ_0 and line/helicity/contact coefficients (as in the SST Lagrangian). A resonant photon of $\hbar\omega_0 \approx \Delta E$ mediates the transition. The EMF impulse $\Phi_\star$ does *no net* work without a readout current; thus energetic matching does not fix $\Phi_\star$—it fixes *rates* (Rabi), while **??** fixes the *topological size*. This separation is natural in a mixed topological term.

c. (iii) Choice of $\Phi_\star$. For single-charge matter waves, the Aharonov–Bohm flux quantum h/e is the canonical choice [**?**]; in superconducting media, $h/2e$ applies [**?**]. Measuring EMF-time impulses during controlled vortex nucleation discriminates these cases.

VIII. PREDICTIONS & EXPERIMENTAL PROGRAM

- **Plate compression (levitated PG/electret stack).** With electrodes disconnected (frozen charge), shrink the effective plate area so that the swirl flux cannot escape. Monitor a pickup loop around the active region. Prediction:

$$\int dt\,\mathrm{EMF}(t) \;=\; \Phi_\star\,\Delta N, \quad \Delta N \in \mathbb{Z},$$

  with bursts coincident with vortex nucleation (when $a \lesssim \alpha r_c$).
- **Rotating frame.** Repeat while ramping Ω. The threshold area $A_\star(\Omega)$ for first nucleation obeys $N/A_\star \simeq 2\Omega/\kappa$ (Feynman relation), and EMF-time impulse remains quantized by $\Phi_\star$.
- **Pump–probe control.** A resonant optical pump at ω_0 modulates the nucleation rate $\propto |\partial_t \boldsymbol{\varrho}|$; the *integrated* EMF per event remains $\Phi_\star$ (topologically protected), while the *temporal* profile tracks the pump.

IX. BOXED SUMMARY (SST CANON ⇒ DIAGRAM)

$$\boxed{\begin{array}{c}
\text{(Kelvin/Canon)} \quad \Gamma = \oint \mathbf{v}\cdot d\boldsymbol{\ell} = N\kappa, \quad \Phi_{\circlearrowleft} = \int_A \boldsymbol{\varrho}\cdot d\mathbf{A} = N \\
\text{(local mirror)} \quad \mathbf{j} = \sigma\mathbf{E} \;\leftrightarrow\; \boldsymbol{\varrho} = \chi_H \mathbf{H} \\
\text{(long-range unification)} \quad \nabla\times\mathbf{E} = -\partial_t\mathbf{B} - \mathbf{b}_{\circlearrowleft}, \quad \mathbf{b}_{\circlearrowleft} = \mathcal{G}_{\circlearrowleft}\,\partial_t\boldsymbol{\varrho} \\
\text{(electron normalization)} \quad \mathcal{G}_{\circlearrowleft} = \Phi_\star \in \{h/e,\ h/2e\}, \quad \int dt \oint \mathbf{E}\cdot d\boldsymbol{\ell} = -\,\Phi_\star\,\Delta N
\end{array}}$$

a. Dimensional checks. $[\boldsymbol{\varrho}] = \mathrm{m}^{-2}$, $[\partial_t\boldsymbol{\varrho}] = \mathrm{m}^{-2}s^{-1}$; $[\mathcal{G}_{\circlearrowleft}] = \mathrm{V}\,s$ so $[\mathbf{b}_{\circlearrowleft}] = \mathrm{V}\,m^{-2}$ matches $[\partial_t\mathbf{B}] = \mathrm{T}\,s^{-1} = \mathrm{V}\,m^{-2}$; all local maps in **??** use standard SI.

ACKNOWLEDGEMENT OF CANONICAL CONSTANTS

Where numerical evaluation is desired, adopt the Canon values C_e, r_c, $\rho_{æ}^{\mathrm{core}}$, $\rho_{æ}$ provided in the SST Canon; these enter rate and threshold estimates (via $a \sim \sqrt{A/N}$ and r_c), but not the quantized *magnitude* $\Phi_\star$ of the EMF-time impulse.

ADDENDUM Q: DOUBLE–SAW-SHAPED COIL STACK REALIZATION

Q.1 Definition (Double–Saw-Shaped Coil)

On a stator with $S = 40$ slots and $p = 4$ poles, consider a short–pitched 3–phase winding with pitch $y = 2$ (step rule $+11/-9$). This yields a chording angle

$$\gamma = y\,\alpha_e = 36^\circ, \qquad \alpha_e = \tfrac{180^\circ p}{S} = 18^\circ,$$

so that

$$k_p^{(5)} = \cos\left(\tfrac{5\gamma}{2}\right) = 0.$$

The winding is implemented as two interleaved 3–phase saw shaped coil (“Double–Saw-Shaped”), with electrical displacement $\Delta_e = 30°$, giving

$$\mathcal{A}_\nu \;\propto\; 2\cos\left(\frac{\nu\Delta_e}{2}\right) k_w^{(\nu)}.$$

Hence

$$\mathcal{A}_1 \approx 1.93\, k_w^{(1)}, \qquad \mathcal{A}_5 = 0, \qquad \mathcal{A}_6 = 0, \qquad \mathcal{A}_7 \simeq -0.05,$$

i.e. fundamental reinforced, 5^{th} suppressed, 6^{th} canceled, 7^{th} reduced.

S40_double_star_best.png

FIG. 1. S40 double star best

Q.2 Stacking (Two Double–Saw-Shapeds)

Place two identical Double–Saw-Shaped coils axially stacked (gap h). Let their on–axis contributions be $B_T(z)$ and $B_B(z)$. Superposition allows the following canonical modes:

$$\begin{aligned}
\text{Mode A (additive):}&\quad B_{\text{tot}} \simeq B_T + B_B \quad \Rightarrow \quad \text{max fundamental.}\\
\text{Mode B (gradient):}&\quad \Delta p = \eta\,\frac{B_B^2 - B_T^2}{2\mu_0} \quad \Rightarrow \quad \text{effective gravity blocking.}\\
\text{Mode C (counter–rot.):}&\quad B_{\text{rot}} \to 0,\ \nabla B^2 \neq 0 \quad \Rightarrow \quad \text{standing pressure pattern.}\\
\text{Mode D (beat):}&\quad \varphi \neq 0 \;\Rightarrow\; \text{axially traveling envelope.}
\end{aligned}$$

Q.3 Canonical Equation (Swirl Pressure)

Within SST Canon, the swirl pressure on a foliation slice Σ_t is

$$p_{sw}(z) \;=\; \eta \,\frac{\langle B^2(z)\rangle}{2\mu_0},$$

so that a stacked asymmetry yields

$$F_z \;=\; \int_A \Delta p(z)\, dA = \eta\, \frac{B_B^2 - B_T^2}{2\mu_0}\, A.$$

Q.4 Experimental Pathway

1. Verify harmonic hygiene: $5^{th} = 0$, $6^{th} = 0$, $7^{th} \ll 1$.
2. Map $B(z)$ with Hall sensors for both stacks.
3. Tune B_B/B_T to measure Δp on a plate of area A.
4. Switch to Mode C (counter–rotate top stack) to confirm ∇B^2 persists with vanishing torque.

Q.5 Canonical Status

This configuration is canonical for coil–based RMF realization in SST:

- It implements the harmonic hygiene postulates (Addendum O).
- It realizes swirl pressure modulation in direct accordance with the pressure functional (Canon Core v0.3.3).
- It defines a benchmark experimental platform for *gravity–blocking* tests.

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