Gravitational Modulation in Swirl–String Theory

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Abstract

Swirl–String Theory (SST) recasts matter as quantized vortex filaments in an inviscid background medium. Within this picture, gravitational attraction emerges from pressure deficits generated by swirling cores rather than spacetime curvature. This article develops a clear, testable notion of *gravitational modulation*: adjusting perceived gravity by altering circulation, alignment, or topology of swirl structures. We (i) summarize the SST constants and the softened "swirl Coulomb" potential, (ii) show how additive or opposing circulation strengthens or weakens attraction, (iii) describe anisotropy via alignment, phasing, and bulk rotation, and (iv) outline predicted electromagnetic co-signatures of topological changes. We close with feasibility bounds and near-term analog experiments.

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1 Introduction

Swirl–String Theory (SST) models elementary constituents as knotted or linked vortex filaments in a flat, incompressible medium. Mass and gravity, in this view, arise from the dynamics of the swirl rather than from curved spacetime. *Gravitational modulation* then means altering the effective strength, sign, or directionality of this attraction by changing swirl parameters (circulation, density, orientation) or topology. Here we collect the minimal equations, lay out control levers consistent with SST, and emphasize falsifiable predictions.

2 SST Fundamentals and the Vortex–Gravity Mechanism

2.1 Core structure and quantized circulation

Each particle is idealized as a vortex tube with core radius $r_c \sim 10^{-15}\,\mathrm{m}$ and tangential core speed $v_{\circlearrowleft} \approx 1.09 \times 10^6\,\mathrm{m\,s^{-1}}$. The surrounding fluid has very low mass density ρ_f, while the core stores a large mass-equivalent energy density ρ_{core}. Circulation is quantized:

$$\kappa \equiv 2\pi r_c\, v_{\circlearrowleft}, \tag{1}$$

and Kelvin's theorem keeps κ fixed for material loops. Composite structures add circulation (e.g., three sub-cores in a baryon-like tube $\Rightarrow \Gamma = 3\kappa$), deepening the associated pressure deficit and increasing effective rest mass.

2.2 Pressure deficit and emergent attraction

In steady, inviscid flow the Euler equation gives $\rho\,\mathbf{a} = -\nabla p$. Swirl creates a core pressure drop $\Delta p \simeq -\frac{1}{2}\rho_{\mathrm{core}} v_{\circlearrowleft}^2$, so

$$\mathbf{g}_{\mathrm{swirl}} \;\approx\; -\nabla\!\left(\frac{\Delta p}{\rho_{\mathrm{core}}}\right) \;=\; \nabla\!\left(\frac{v_{\circlearrowleft}^2}{2}\right), \tag{2}$$

directed toward the core. At distances $r \gg r_c$, the long-range behavior is captured by a softened potential

$$V_{\mathrm{SST}}(r) \simeq -\frac{\Lambda}{r^2 + r_c^2}, \qquad |\mathbf{a}_g| \approx \frac{2\Lambda}{r^3}, \tag{3}$$

with Λ set by core parameters $(\rho_{\mathrm{core}}, v_{\circlearrowleft}, r_c)$ and calibrated so that the emergent coupling matches G_N for ordinary conditions.

2.3 Clock effects from swirl

The same kinetic origin yields mild time dilation in deep pressure wells. To leading order, a local clock rate scales as

$$\frac{d\tau}{dt_\infty} \approx \sqrt{1 - \frac{v_{\circlearrowleft}^2}{c^2}}\,, \tag{4}$$

and increases in composite tubes where effective rim speeds grow with additive circulation. Although small for canonical $v_{\circlearrowleft} \ll c$, the direction is consistent: deeper wells $\Rightarrow$ slower internal clocks.

3 Topology–Dependent Modulation

Because linking and chirality determine how pressure wells combine, gravity in SST is inherently topology sensitive. Aligned, like–handed structures *add* circulation and strengthen attraction; carefully phased or opposite–handed structures can partially *cancel* linking and weaken it. Achiral configurations (net helicity near zero) are predicted to couple weakly to the ambient swirl network, suggesting reduced attraction and, in special arrangements, effective repulsion. These ideas remain speculative but are natural within SST's topological bookkeeping.

4 Directional Control and Anisotropy

Three levers enable anisotropy.

- **Alignment and focusing:** Coaxial alignment concentrates attraction along the common axis (a weak "gravitational flashlight").
- **Phased oscillations:** Small coherent oscillations of multiple sources interfere, enhancing on-axis and canceling off-axis responses (phased-array logic at tiny amplitudes).
- **Bulk rotation:** Rapid rotation injects kinetic pressure that slightly reduces equatorial attraction relative to polar directions (SST cousin of frame dragging).

Define an effective $G(\theta)$ relative to a chosen axis; in natural settings $G(\theta)$ is nearly isotropic, but engineered arrays could imprint a minute angular dependence.

5 Electromotive Co–Signatures of Topology Change

SST links swirl dynamics to electromotive effects: time–varying swirl density or changes in linking number act as sources of EMF. Topological transitions (creation, annihilation, reconnection) should emit discrete voltage impulses of fixed magnitude $\Delta\Phi = \pm\Phi_*$, set by universal constants and the handedness of the change. This prediction is a clean discriminator: gravity modulation via swirl that *lacks* the EM impulse would falsify the mechanism.

6 Feasibility and Near–Term Tests

Energetic thresholds are steep: macroscopic changes to g require enormous Λ_{eff} and quickly confront a maximum-force bound. Nevertheless, table-top analogs in superfluids or condensates can probe the qualitative levers: co-rotating vs. counter-rotating vortex interactions, engineered alignment, and searches for quantized EM impulses during vortex reconnections.

7 Conclusion

Within SST, "controlling gravity" reduces to controlling circulation and topology in an inviscid medium. Additive circulation strengthens attraction; opposing or achiral arrangements weaken it; alignment and phasing introduce directionality; and any topological switch should co-emit a quantized EM signal. The framework is energetically constrained yet experimentally falsifiable, with near-term probes available in fluid analog platforms.

Notes on sources. Constants and constructs (e.g. r_c, $v_{\circlearrowleft}$, ρ_f, ρ_{core}, Λ, maximum-force bounds) follow the SST canon and related notes on topological gravity and swirl–EM coupling.

A Appendix: SST gravity modulation: summary

In Swirl–String Theory (SST), gravity is not a fundamental geometric field but an emergent pressure well of the swirl medium. The local swirl energy density

$$\rho_E \;=\; \frac{1}{2}\,\rho_f\,\|\mathbf{v}_{\circlearrowleft}\|^2, \qquad \rho_m \;=\; \frac{\rho_E}{c^2} \tag{5}$$

acts as an effective source in a Newtonian/weak-field limit,

$$\nabla^2\Phi \;\approx\; 4\pi\,G_{\text{swirl}}\,\rho_m, \tag{6}$$

with G_{swirl} fixed by Canon so that $G_{\text{swirl}} \simeq G_N$ in ordinary regimes. Near a core, the swirl-induced pressure deficit

$$\Delta p \;\approx\; -\,\frac{1}{2}\,\rho_{\text{core}}\,\|\mathbf{v}_{\circlearrowleft}\|^2 \tag{7}$$

yields a "gravitational" acceleration

$$\mathbf{g}_{\text{SST}} \;=\; -\frac{1}{\rho_{\text{core}}}\,\nabla p \;\approx\; \nabla\!\left(\frac{\|\mathbf{v}_{\circlearrowleft}\|^2}{2}\right), \tag{8}$$

so that strengthening gravity corresponds to increasing ρ_E or steepening $\nabla\|\mathbf{v}_{\circlearrowleft}\|^2$, while weakening or inverting it corresponds to shallowing or overcompensating this pressure well (e.g. via opposite-chirality swirl).

For a roughly uniform energy density ρ_E in a spherical region of radius R, the induced surface acceleration is

$$g(R) \;\approx\; \frac{4\pi G_N}{3c^2}\,\rho_E\,R, \tag{9}$$

so the energy density required to generate or cancel a target increment g_0 is

$$\rho_E \;\approx\; \frac{3c^2\,g_0}{4\pi G_N\,R}. \tag{10}$$

Even for $g_0 \sim 0.01\,g$ and $R \sim 1$ m, Eq. (10) gives $\rho_E \sim 10^{25}\,\mathrm{J/m^3}$ ($\rho_m \sim 10^8\,\mathrm{kg/m^3}$), i.e. white-dwarf-scale densities. This encodes the core Canon conclusion: *any macroscopic gravity modulation in SST requires astrophysical energy densities in the swirl medium* and is therefore extremely constrained.

Directional and topological effects enter as mild corrections. If internal swirl defines a symmetry axis, the effective coupling can be written

$$G_{\text{eff}}(\theta) \;=\; G_{\text{swirl}}\,f(\theta), \qquad f(\theta) \;=\; 1+\delta f(\theta), \quad |\delta f(\theta)| \ll 1, \tag{11}$$

with $f(\theta)$ encoding how much linking circulation Γ_{link} is shared along angle θ relative to the swirl axis. Topological "shielding" or cancellation corresponds schematically to

$$\Gamma_{\text{link}} \neq 0 \;\Rightarrow\; \Phi(r) \sim -\frac{\Lambda}{r^2+r_c^2}, \qquad \Gamma_{\text{link}} \approx 0 \;\Rightarrow\; \Phi(r) \approx 0 \quad (r \gg r_c), \tag{12}$$

i.e. arranging swirl so that external loops see vanishing net linking (no long-range attraction). Such configurations are highly energetic and metastable, bounded above by the canonical maximum gravitational force $F_{\text{gr}}^{\max}$.

Finally, any genuine SST gravity modulation via topology change is *not* silent: the modified Faraday law

$$\nabla\times\mathbf{E} \;=\; -\frac{\partial\mathbf{B}}{\partial t} \;-\; \mathbf{b}_{\circlearrowleft}, \qquad \mathbf{b}_{\circlearrowleft} \;=\; G_{\circlearrowleft}\,\frac{\partial\boldsymbol{\rho}_{\circlearrowleft}}{\partial t} \tag{13}$$

implies, upon loop integration,

$$\oint \mathbf{E} \cdot d\boldsymbol{\ell} \;=\; -\,\frac{d\Phi_B}{dt} \;-\; \frac{d\Phi_{\circlearrowleft}}{dt}, \tag{14}$$

and a discrete topology change in the swirl field yields a quantized jump

$$\Delta\Phi_{\circlearrowleft} \;=\; \pm\,\Phi_*. \tag{15}$$

Canon implication: **any nontrivial SST gravity control via swirl topology must be accompanied by a quantized electromotive impulse $\pm\Phi_*$.** Absence of such EM signatures rules out claimed gravity modulation within the SST framework.

B Appendix: Swirl-Based Gravitational Coupling from $F_{\max}$ and r_c

In Swirl–String Theory (SST), the electron-scale swirl core is characterised by a tangential swirl speed $\mathbf{v}_{\circlearrowleft}$, a core radius r_c, and a maximal swirl tension (force) scale $F_{\max}$. These quantities are fixed from non-gravitational physics (electron scales, hydrogen spectroscopy, and high-field constraints) and are related by the canonical identities

$$F_{\max} = \frac{e^2}{16\pi\varepsilon_0 r_c^2} = \frac{\mathbf{v}_{\circlearrowleft}\,\hbar}{2r_c^2} = \pi r_c^2 \rho_E\, \mathbf{v}_{\circlearrowleft}^2, \tag{16}$$

where e is the elementary charge, ε_0 the vacuum permittivity, and ρ_E the swirl energy density in the electron core. Equation (16) is understood here as an empirically calibrated identity, not a fundamental postulate: the right-hand expressions agree numerically for the chosen SST constants.

In the gravitational sector of SST, the effective Newton constant is encoded in a swirl–gravity coupling that, at the level of natural units and dimensional analysis, takes the form

$$G = \frac{\mathbf{v}_{\circlearrowleft}\, c^5 T_{\mathrm{micro}}^2}{2F_{\max} r_c^2}, \tag{17}$$

where c is the speed of light and T_{micro} is a microscopic time scale associated with the short-distance structure of the swirl field ("swirl-clock" or correlation time). All of the dependence on the electron-scale structure enters through $(\mathbf{v}_{\circlearrowleft}, F_{\max}, r_c)$; the remaining freedom sits in the choice of T_{micro}.

B.1 Canonical representation and Coulomb form

Using the first equality in Eq. (16),

$$F_{\max} = \frac{e^2}{16\pi\varepsilon_0 r_c^2}, \tag{18}$$

we can eliminate $F_{\max}$ from Eq. (17) to obtain

$$G = \frac{\mathbf{v}_{\circlearrowleft} c^5 T_{\mathrm{micro}}^2}{2\big(e^2/(16\pi\varepsilon_0 r_c^2)\big) r_c^2} = \frac{8\pi\varepsilon_0\, \mathbf{v}_{\circlearrowleft} c^5 T_{\mathrm{micro}}^2}{e^2}. \tag{19}$$

For the special choice $T_{\mathrm{micro}} = t_p$, the usual Planck time $t_p^2 = \hbar G/c^5$, this identity reduces to a tautology; it is then best viewed as a constant-compression relation between $(G, e, \varepsilon_0, c, \hbar)$ and the SST constants $(\mathbf{v}_{\circlearrowleft}, F_{\max}, r_c)$.

Equation (19) is nevertheless useful: once $\mathbf{v}_{\circlearrowleft}$ and $F_{\max}$ have been fixed from non-gravitational data (via Eq. (16)), the *functional form* of G in terms of a single microscopic time T_{micro} is completely determined.

B.2 Cavity-induced toy gravitational constant

The single-mode Compton-scale cavity model used in the electron charge appendix (inspired by Ref. [14]) produces a toy effective charge

$$q = \frac{1}{2\pi}\sqrt{3\,\varepsilon_0\hbar c}, \qquad q^2 = \frac{3}{4\pi^2}\,\varepsilon_0\hbar c, \tag{20}$$

and an effective fine-structure constant

$$\alpha_{\rm eff} = \frac{q^2}{4\pi\varepsilon_0\hbar c} = \frac{3}{16\pi^3} \simeq 0.83\,\alpha, \tag{21}$$

with α the physical fine-structure constant.

If we formally replace $e \to q$ in Eq. (19), we obtain a *cavity-based* gravitational constant

$$G_{\rm cav} = \frac{8\pi\varepsilon_0\,\mathbf{v}_{\circlearrowleft} c^5 T_{\rm micro}^2}{q^2} = \frac{8\pi\varepsilon_0\,\mathbf{v}_{\circlearrowleft} c^5 T_{\rm micro}^2}{3\varepsilon_0\hbar c/(4\pi^2)} \tag{22}$$

$$= \frac{32\pi^3}{3}\,\frac{\mathbf{v}_{\circlearrowleft} c^4 T_{\rm micro}^2}{\hbar}. \tag{23}$$

For the particular choice $T_{\rm micro} = t_p$ and canonical SST constants, one finds numerically

$$G_{\rm cav} \approx 1.21\,G, \tag{24}$$

i.e. the same $\sim 20\%$ deviation that appears in $\alpha_{\rm eff}/\alpha$. The cavity model is thus consistent at the level of *constant scalings*, but does not yet produce the observed G without further structure.

B.3 Eliminating $\hbar$ in favour of SST quantities

Using the second and third expressions in Eq. (16), we may eliminate $\hbar$ from Eq. (23). From

$$F_{\rm max} = \frac{\mathbf{v}_{\circlearrowleft}\,\hbar}{2r_c^2} = \pi r_c^2 \rho_E\,\mathbf{v}_{\circlearrowleft}^2 \tag{25}$$

we obtain

$$\hbar = \frac{2F_{\rm max} r_c^2}{\mathbf{v}_{\circlearrowleft}} = 2\pi\rho_E\,\mathbf{v}_{\circlearrowleft}\,r_c^4. \tag{26}$$

Substituting the second form into Eq. (23) yields

$$G_{\rm cav} = \frac{32\pi^3}{3}\,\frac{\mathbf{v}_{\circlearrowleft} c^4 T_{\rm micro}^2}{2\pi\rho_E\,\mathbf{v}_{\circlearrowleft}\,r_c^4} = \frac{16\pi^2}{3}\,\frac{c^4 T_{\rm micro}^2}{\rho_E\,r_c^4}. \tag{27}$$

Thus the cavity-based gravitational constant can be written purely in terms of the swirl energy density ρ_E, core radius r_c, and the microscopic time $T_{\rm micro}$, with no explicit $\hbar$.

Equations (17), (19), (23), and (27) summarise the current status:

- Electron-scale physics (via $F_{\rm max}$, r_c, $\mathbf{v}_{\circlearrowleft}$) fixes the *form* of G in SST.
- A single microscopic time scale $T_{\rm micro}$, to be derived from the short-distance dynamics (e.g. circulation-loop UV cutoff), controls the overall magnitude.
- The Compton-scale cavity toy model is consistent at the level of constant scalings, but does not yet reproduce the observed G without an additional dynamical input.

C Appendix: Circulation-Loop Gas, UV Cutoff, and an SST Crossover Temperature

The circulation-loop gas considered in Ref. [15] provides a natural ultraviolet (UV) cutoff for classical Rayleigh–Jeans-type spectra: the highest admissible angular frequency is set by the smallest mechanically allowed loop scale. In SST, this is identified with the core scale of the swirl string,

$$\omega_{\max} = \frac{\mathbf{v}_{\circlearrowleft}}{r_c}, \tag{28}$$

so that no classical circulation mode can exceed the kinematic limit set by the swirl speed and core radius.

C.1 Loop-gas Rayleigh–Jeans energy density with cutoff

For a massless field in three spatial dimensions, the classical Rayleigh–Jeans energy density with a general UV cutoff function $f(\omega/\omega_{\max})$ can be written in the form

$$u_{\text{loop}}(T) = \frac{k_B T}{\pi^2 c^3}\, C_f\, \omega_{\max}^3, \tag{29}$$

where

$$C_f = \int_0^1 x^2 f(x)\,\mathrm{d}x, \tag{30}$$

and $f(x)$ encodes the precise way in which high-frequency modes are suppressed. For a sharp cutoff $f(x) = \Theta(1-x)$ one simply has

$$C_f^{(\text{sharp})} = \int_0^1 x^2\,\mathrm{d}x = \frac{1}{3}. \tag{31}$$

The dependence $u_{\text{loop}}(T) \propto k_B T\, \omega_{\max}^3$ is the standard Rayleigh–Jeans scaling with an explicit mechanical cutoff $\omega_{\max}$.

C.2 Planck energy density and crossover condition

The corresponding quantum (Planck) energy density for the same mode density is

$$u_{\text{Planck}}(T) = a_R T^4, \qquad a_R = \frac{\pi^2 k_B^4}{15\,\hbar^3 c^3}, \tag{32}$$

the usual radiation constant. A natural definition of an SST *crossover temperature* T_{SST} is the point at which the loop-gas Rayleigh–Jeans description and the Planck spectrum carry the same energy density:

$$u_{\text{loop}}(T_{\text{SST}}) = u_{\text{Planck}}(T_{\text{SST}}). \tag{33}$$

Equating the two expressions gives

$$\frac{k_B T_{\text{SST}}}{\pi^2 c^3}\, C_f\, \omega_{\max}^3 = \frac{\pi^2 k_B^4}{15\,\hbar^3 c^3}\, T_{\text{SST}}^4. \tag{34}$$

Cancel c^3 and one power of T_{SST}:

$$\frac{k_B C_f}{\pi^2}\, \omega_{\max}^3 = \frac{\pi^2 k_B^4}{15\,\hbar^3}\, T_{\text{SST}}^3, \tag{35}$$

so that

$$T_{\text{SST}}^3 = \frac{15\,\hbar^3}{\pi^4 k_B^3}\, C_f\, \omega_{\max}^3. \tag{36}$$

Taking the cube root,

$$T_{\text{SST}} = \left(\frac{15\,C_f}{\pi^4}\right)^{1/3} \frac{\hbar\,\omega_{\max}}{k_B}. \tag{37}$$

It is convenient to introduce the dimensionless factor

$$\xi \equiv \left(\frac{15\,C_f}{\pi^4}\right)^{1/3}, \tag{38}$$

which depends only on the shape of the UV cutoff. Then Eq. (37) becomes

$$T_{\text{SST}} = \xi\,\frac{\hbar\omega_{\max}}{k_B}. \tag{39}$$

For a sharp cutoff $C_f = 1/3$ this yields

$$\xi_{\text{sharp}} = \left(\frac{5}{\pi^4}\right)^{1/3} \approx 0.372. \tag{40}$$

C.3 SST specialisation and characteristic scales

In SST we identify the UV cutoff with the core frequency given by Eq. (28), $\omega_{\max} = \mathbf{v}_{\circlearrowleft}/r_c$, where $\mathbf{v}_{\circlearrowleft}$ and r_c are fixed by electron-scale structure. Inserting this into Eq. (39) gives

$$T_{\text{SST}} = \xi\,\frac{\hbar}{k_B}\,\frac{\mathbf{v}_{\circlearrowleft}}{r_c}. \tag{41}$$

With the canonical constants $\mathbf{v}_{\circlearrowleft} = 1.09384563 \times 10^6\,\text{m}\,\text{s}^{-1}$ and $r_c = 1.40897017 \times 10^{-15}\,\text{m}$, one finds $\omega_{\max} \approx 7.76 \times 10^{20}\,\text{s}^{-1}$ and

$$\frac{\hbar\omega_{\max}}{k_B} \simeq 5.9 \times 10^9\,\text{K}. \tag{42}$$

For a sharp cutoff ($C_f = 1/3$, $\xi \simeq 0.372$) this yields

$$T_{\text{SST}} \approx 2.2 \times 10^9\,\text{K}, \tag{43}$$

corresponding to an energy scale $k_B T_{\text{SST}} \approx 190\,\text{keV}$, i.e. an $\mathcal{O}(1)$ fraction of the electron rest energy $m_e c^2 \approx 511\,\text{keV}$.

One may also associate a characteristic correlation time,

$$\tau_{\text{SST}} \equiv \frac{\hbar}{k_B T_{\text{SST}}} = \frac{1}{\xi\,\omega_{\max}} = \frac{1}{\xi}\,\frac{r_c}{\mathbf{v}_{\circlearrowleft}}, \tag{44}$$

which is of the same order as the core orbit time $r_c/\mathbf{v}_{\circlearrowleft}$. This provides a natural microscopic time scale for use as T_{micro} in Eq. (17), once the SST gravitational field equations and loop-gas dynamics are combined.

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