Long-Distance Swirl Gravity from Chiral Swirling Knots with Central Holes

Omar Iskandarani
Independent Researcher, Groningen, The Netherlands[*]
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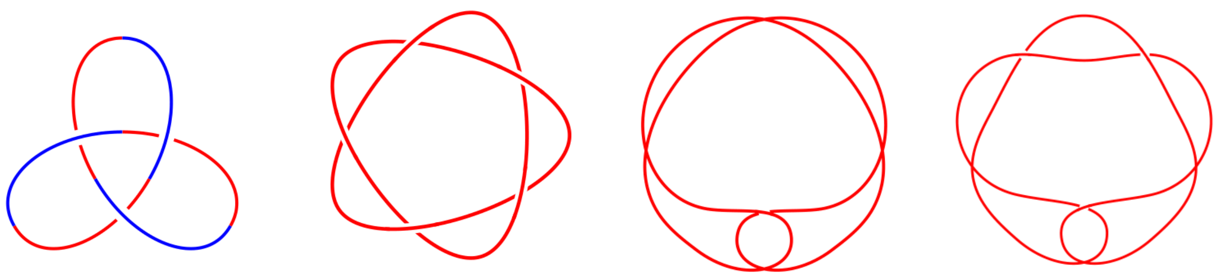
We derive long-range gravitational attraction in Swirl–String Theory (SST) as a direct consequence of *chiral swirling knots*—topological vortex filaments such as the trefoil (3_1), cinquefoil (5_1), (5_2), and stevedore (6_1). Each knot encloses a central rotational line, which acts as an anchor of circulation. Using Cauchy's integral theorem, we show that the circulation measured around any loop enclosing this axis is quantized by the knot's winding number. This quantization is expressed by the Swirl Clock $S_{(t)}^{\circlearrowleft}$, and its persistence explains why neutral molecules (e.g. H_2 attract in otherwise flat space: their knots are connected via the same central swirl line extending beyond the equal-pressure boundary.

I. CHIRAL SWIRLING KNOTS AND CENTRAL HOLES

Consider a chiral knot K embedded in $\mathbb{R}^3$, such as 1:



(a) 3_1 (trefoil) (b) 5_1 (cinquefoil) (c) 5_2 (cinquefoil twist) (d) 6_1 (stevedore)

FIG. 1. Canonical knot gallery.

Each knot can be parametrized on a torus with major radius R and minor radius r. The core tube of radius r_c supports a tangential swirl velocity $\mathbf{v}_{\circlearrowleft}$, defining the *Swirl Clock* $S_{(t)}^{\circlearrowleft}$.

A defining feature is that all these knots possess a *central hole* threaded by a straight axis (taken as the z-axis). This axis is the "fabric line" of flat space: it is the singularity in the analytic swirl potential.

II. CAUCHY INTEGRAL AND CIRCULATION QUANTIZATION

Let C be a closed loop in the x–y plane encircling the z-axis. For an analytic swirl potential $W(z) = \Phi + i\Psi$ in a simply connected region,

$$\oint_C \mathbf{v}_{\circlearrowleft} \cdot d\mathbf{l} = \begin{cases} 0, & \text{if no singularity inside,} \\ 2\pi i \,\mathrm{Res}\left(\frac{dW}{dz}, z=0\right), & \text{if the axis is enclosed.} \end{cases} \tag{1}$$

In SST we identify the residue with a circulation quantum κ. Independently of the complex-potential language, Kelvin's theorem fixes circulation on any material loop; both viewpoints agree on the integer plateau:

$$\Gamma_C = n\,\kappa \quad \text{if the loop links } n \text{ times with the core.} \tag{2}$$

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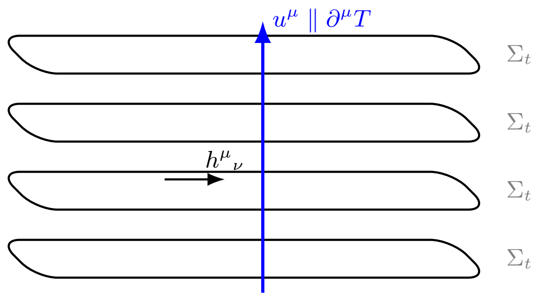


FIG. 2. Preferred foliation by the clock field $T(x)$ with unit timelike u^μ, and spatial projector $h_{\mu\nu} = g_{\mu\nu} + u_\mu u_\nu$.

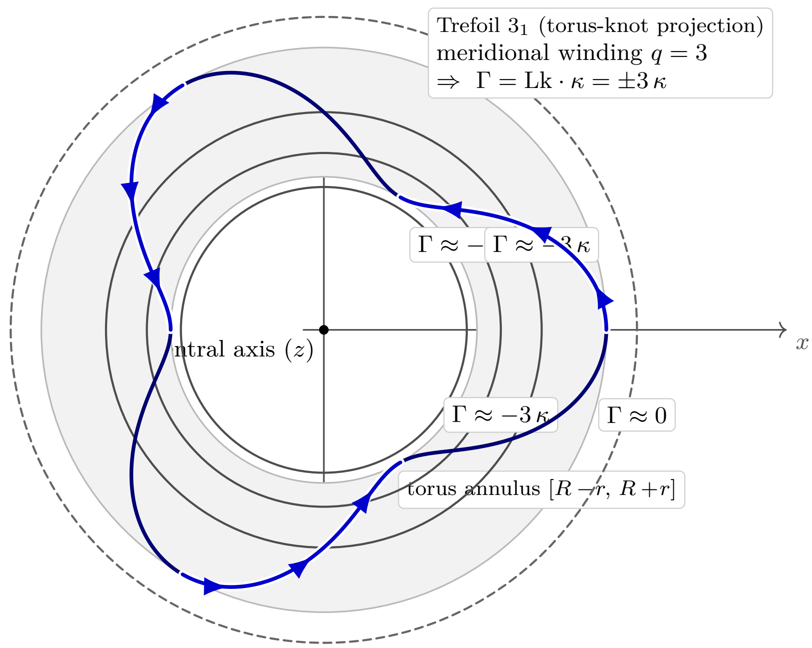


FIG. 3. Trefoil knot with central axis and circulation loops in the z=0 plane. Loops whose spanning disk intersects the filament within the torus annulus measure a plateau $\Gamma = \mathrm{Lk}\cdot\kappa = \pm 3\,\kappa$ (sign by orientation). Loops outside the annulus do not enclose the filament and give $\Gamma \approx 0$.

Canonical identification of κ (SST)

We adopt the equivalence

$$\boxed{\kappa \equiv \frac{h}{m_{\mathrm{eff}}} \;=\; 2\pi\, r_c\, v_c}$$

which gives a direct bridge between the quantum of circulation and core kinematics. Hence

$$m_{\mathrm{eff}} \;=\; \frac{h}{2\pi r_c v_c}\,.$$

Numerics (SI): with $r_c = 1.408\,970\,17 \times 10^{-15}\,\mathrm{m}$ and $v_c = \|\mathbf{v}_{\circlearrowleft}\| = 1.093\,845\,63 \times 10^{6}\,\mathrm{m/s}$,

$$\kappa = 2\pi r_c v_c = 9.683\,619\,2 \times 10^{-9}\,\mathrm{m^2/s}, \qquad m_{\mathrm{eff}} = \frac{h}{\kappa} = 6.842\,555 \times 10^{-26}\,\mathrm{kg} \approx 38.384\,\mathrm{GeV/c^2}.$$

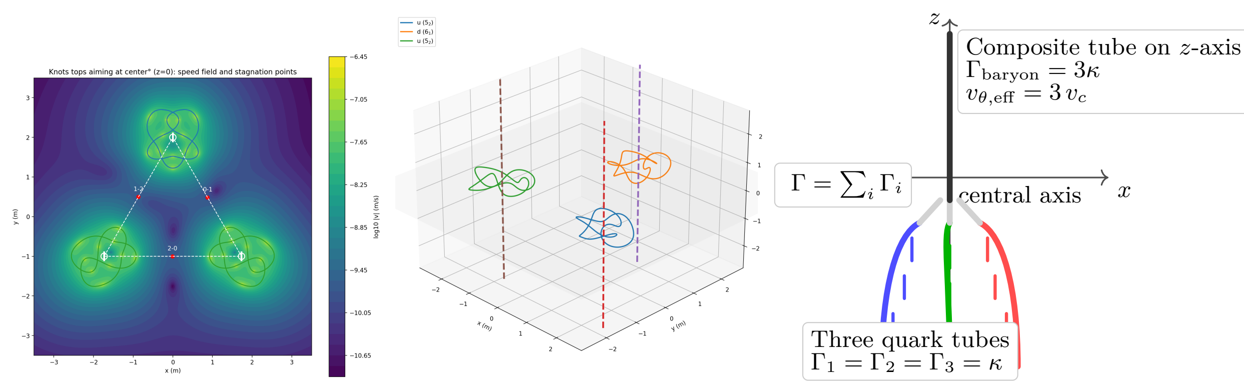
Status/limits: Dimensions are consistent ($[\kappa] = L^2T^{-1}$). For loops whose spanning disk intersects the torus annulus of the filament, Γ plateaus at $n\kappa$; for loops entirely outside, $\Gamma \approx 0$ (as illustrated in Fig. **??**).

Swirl–EM correspondence (operational note)

In the Canon's swirl–EM mapping, time-varying core areal density acts as a "source" via a term of the form $b^{\circlearrowleft} = G^{\circlearrowleft}\,\partial_t \varrho^{\circlearrowleft}$, providing a handle for experimental couplings. Dynamics on the central line that modulate $\varrho^{\circlearrowleft}$ can therefore seed measurable EM-like responses without curving space, consistent with the flat-space treatment used here.

III. COMPOSITE BARYON TUBES

Inside baryons, three quark knots (e.g. 5_2, 5_2, 6_1 see fig 1c, 1d) meet at a Y-shaped junction, forming a single composite swirl tube (see fig 4c).



(a) Top view of 3 quark knots (b) 3D view of 3 quark knots (c) Composite tube

FIG. 4. Baryon core as a *composite swirl tube*. Three quark tubes (bottom) join via a Y-junction into a single tube along $+z$. Circulation adds linearly, $\Gamma_{\text{baryon}} = 3\kappa$, hence $v_{\theta,\text{eff}} = \Gamma_{\text{baryon}}/(2\pi r_{\text{eff}})$ with $r_{\text{eff}} \approx r_c$ to leading order.

Each quark knot i has circulation $\Gamma_i = \kappa$ around the central axis (Fig. 4c). By Kelvin additivity,

$$\Gamma_{\text{baryon}} = \Gamma_1 + \Gamma_2 + \Gamma_3 = 3\kappa. \tag{3}$$

Since $\Gamma = 2\pi r\, v_\theta$,

$$\boxed{v_{\theta,\text{eff}} = \frac{\Gamma_{\text{baryon}}}{2\pi\, r_{\text{eff}}} = \frac{3\kappa}{2\pi\, r_{\text{eff}}}}\,, \tag{4}$$

with r_{eff} the effective core radius of the merged tube. In the thin-core, near-Rankine limit $r_{\text{eff}} \approx r_c$ to leading order (so that $v_{\theta,\text{eff}} \approx 3v_c$ holds as a first-order estimate), while the deeper pressure well is set by the increased Γ.

a. Swirl Clock scaling. The Swirl Clock relation becomes

$$dt_{\text{local}} = dt_\infty \sqrt{1 - \frac{(3v_c)^2}{c^2}}, \tag{5}$$

predicting a more pronounced local time dilation, consistent with the larger rest mass of baryons relative to single quark knots.

Analogy (for intuition). Three equal water whirls feed one outlet: the hole may widen slightly, but the combined spin deepens the whirl and speeds the rim roughly threefold.

IV. SWIRL GRAVITY AND MOLECULAR ATTRACTION

Two composite tubes (e.g., two protons) sharing the same central line produce a combined circulation

$$\Gamma_{\text{total}} = (3\kappa)_{\text{proton}} + (3\kappa)_{\text{proton}} = 6\kappa,$$

which deepens the shared pressure well and yields a stronger long-range attraction. This explains why neutral molecules (e.g., H_2) still attract in Euclidean space: their baryon cores are connected by the same central line, and the resulting swirl gravity follows directly from the additive circulation.

A. Electromotive Response to Swirl Gravity

Recent work in the SST Canon [1] has demonstrated that time-dependent swirl density $\partial_t \vec{\rho}_{\circlearrowleft}$ acts as a source term in the modified Faraday law:

$$\nabla \times \vec{E} = -\partial_t \vec{B} - \vec{b}_{\circlearrowleft}, \quad \vec{b}_{\circlearrowleft} = G_{\circlearrowleft}\, \partial_t \vec{\rho}_{\circlearrowleft}$$

Here, $G_{\circlearrowleft}$ is a universal topological transduction constant, canonically normalized to a flux quantum $\Phi^\star \in \{h/e, h/2e\}$. This coupling provides a direct, falsifiable prediction: nucleation or reconnection of vortex lines produces a quantized electromotive impulse of magnitude $\Phi^\star$. In gravitational contexts, this implies that pressure or density changes which alter swirl topology can be detected electromagnetically. Thus, SST gravity is not only fluid-mechanical but also electromagnetically active — a feature testable in vortex-generating platforms.

V. ENTROPIC EMBEDDING OF SWIRL–STRING THEORY

Swirl–String Theory (SST), built on topologically quantized circulation in a flat, vortex-supporting medium, lends itself naturally to an entropic reinterpretation. In this section, we demonstrate how SST supports the core principles of Verlinde's emergent gravity paradigm [2, 3], allowing a consistent embedding of mass, force, and time as information-theoretic quantities.

A. Swirl Entropy as Informational Field

We define a swirl-based entropy field $S_{\circlearrowleft(x^\mu)}$ as a logarithmic function of the swirl areal density $\rho_{\circlearrowleft=\nabla\cdot\vec{a}}$:

$$S_{\circlearrowleft(x^\mu)=k_B\cdot\log\left(1+\frac{\rho_{\circlearrowleft(x^\mu)}}{\rho_0}\right)(6)}$$

Here, ρ_0 is a constant baseline density. The field $S_{\circlearrowleft}$ plays the role of local entropy density, similar to that on a holographic screen in entropic gravity.

B. Entropic Force from Swirl Gradients

Verlinde's entropic force expression is:

$$F = T \cdot \frac{dS}{dx} \tag{7}$$

In SST, circulation-induced pressure deficits are given by:

$$\Delta p = -\frac{1}{2}\rho_f v^2 \tag{8}$$

Assuming that swirl flow aligns with entropy gradient, the effective force becomes:

$$F_{\text{swirl}} \propto \nabla \rho_f v^2 \propto \nabla S_{\circlearrowleft} \tag{9}$$

This establishes a direct analogy between entropic forces and swirl-induced attractions in SST.

C. Mass as Topological Information

In SST, mass is given by the circulation quantum κ:

$$m = \frac{h}{\kappa}, \qquad \kappa = 2\pi r_c v_c \tag{10}$$

Interpreting κ as a unit of quantized topological information, mass becomes a discrete sum over informational elements:

$$m_K = \sum_i \epsilon_i, \quad \epsilon_i = \frac{h}{\kappa_i} \tag{11}$$

This matches Verlinde's picture of mass as emergent from underlying information content.

D. Time Dilation as an Entropic Clock

SST defines a Swirl Clock for local proper time as:

$$dt_{\text{local}} = dt_\infty \sqrt{1 - \frac{v^2}{c^2}} \tag{12}$$

This behavior is consistent with entropic gravity, where time slows in regions of higher information density, i.e., higher $\rho_{\circlearrowleft}$.

E. R/T Phase Transition and Information Localization

SST posits two phases:

- **R-phase**: unknotted, wave-like field state
- **T-phase**: knotted, particle-like topological excitation

The R-to-T transition represents an entropic localization, akin to wavefunction collapse and entanglement decoherence. This dynamic aligns SST with entropy-based emergence of space and matter.

F. Summary of Mapping

SST, therefore, may be interpreted as an entropic field theory in flat space, where gravitational and inertial phenomena arise from topological and informational structures.

SST Concept	Entropic Gravity Analog	Interpretation
$\rho_{\circlearrowleft}$	Entropy density	Local information field
Swirl clock	Gravitational redshift	Entropic time rate
Δp	Entropic force	Gradient of entropy
κ	Info unit / bit	Mass from information
R/T transition	Wave collapse	Information localization

TABLE I. Correspondences between SST and Verlinde's entropic gravity.

VI. LAGRANGIAN AND ACTION FORMULATION

The dynamical content of Swirl–String Theory (SST) can be expressed via an effective Lagrangian density $\mathcal{L}$ over a flat spacetime manifold, with swirl fields defined by a scalar potential $\phi(x^\mu)$, a swirl vector potential $a_\mu(x^\nu)$, and a fluid mass density field ρ_f. The swirl areal density is defined as $\rho_\circ = \nabla \cdot \vec{a}$. The field strength tensor is analogous to Maxwell's:

$$F_{\mu\nu} = \partial_\mu a_\nu - \partial_\nu a_\mu$$

The full Lagrangian density is:

$$\mathcal{L}_{\mathrm{SST}} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + \rho_f \, (\partial_\mu \phi)(\partial^\mu \phi) - V(\phi) + \mathcal{L}_{\mathrm{topo}}$$

where $V(\phi)$ encodes the knot potential and $\mathcal{L}_{\mathrm{topo}}$ captures topological coupling terms from knot genus and braid index.

The action is then:

$$S = \int \mathcal{L}_{\mathrm{SST}} \, d^4x$$

Euler–Lagrange equations derived from this action yield conservation laws and field dynamics for both swirl flow and entropic gravity analogs.

In the case of hydrogenic systems, swirl gradients around knot cores induce pressure deficits which couple directly to particle motion via Bernoulli and Euler field dynamics — reproducing effective gravitational behavior without spacetime curvature.

If the SST swirl core modulates local time dilation, then ultra-precise molecular spectroscopy (e.g., of H or H ions) could detect deviations correlated with topological configurations, offering an experimental test of the Swirl Clock hypothesis.

"The quantized vortex mass formula, derivation of the swirl Schrödinger equation, and finite-core energy regularization were previously established in the VAM framework [Iskandarani, 2024]. The present work translates and updates these within the SST notation via the Rosetta map [Iskandarani, 2025]."

$\mathrm{L}_{\mathrm{SST}} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + \rho_f (\partial_\mu \phi)(\partial^\mu \phi) - V(\phi)$

VII. LEGACY FOUNDATIONS AND ROSETTA TRANSLATION

The formal structure of Swirl–String Theory (SST) builds upon a previously established framework of topological fluid dynamics developed in the Vortex–Æther Model (VAM). This legacy model derived key physical results from circulation quantization and fluid field dynamics, including a topologically quantized mass formula, a swirl-based Schrödinger equation, and a non-divergent fluid Lagrangian. These results have been translated and reformulated within SST via a symbolic mapping documented in the Rosetta file [4].

A. Quantized Circulation and Mass Formula

In VAM, the core mass mechanism arises from Onsager-like circulation quantization:

$$\oint \vec{v} \cdot d\vec{\ell} = n \kappa_{\text{æ}} \tag{13}$$

with velocity expressed as a gradient:

$$\vec{v} = \lambda_{æ} \nabla \theta \quad \Rightarrow \quad \psi = \sqrt{\rho/\rho_{æ}}\, e^{i\theta} \tag{14}$$

leading to a hydrodynamic Schrödinger equation with swirl potential:

$$i\hbar_{æ} \frac{\partial \psi}{\partial t} = -\frac{\hbar_{æ}^2}{2m_{æ}} \nabla^2 \psi + \Phi_{\text{swirl}}(\vec{\omega})\, \psi \tag{15}$$

$$\Phi_{\text{swirl}} = \frac{1}{2} \lambda_g \rho_{æ} |\vec{\omega}|^2 \tag{16}$$

This formulation yielded vortex mass estimates (e.g. for the electron) within $< 10^{-7}$ error of experimental values.

B. Lagrangian and Field Formalism

VAM also provided a fluid Lagrangian consistent with gauge-invariant dynamics:

$$\mathcal{L}_{\text{VAM}} = \frac{1}{2} \rho_f (\nabla \times \vec{A})^2 + \rho_f (\partial_t \phi)^2 - V(\phi) \tag{17}$$

This maps directly into the SST flat-space field theory:

$$\mathcal{L}_{\text{SST}} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + \rho_f (\partial_\mu \phi)(\partial^\mu \phi) - V(\phi) + \mathcal{L}_{\text{topo}} \tag{18}$$

where the swirl vector a_μ replaces the VAM circulation potential, and $\mathcal{L}_{\text{topo}}$ incorporates topological invariants (braid index, genus, component count).

C. Notation Fidelity via Rosetta Map

All constants, fields, and structural equations have been translated via the VAM–SST Rosetta dictionary [4], ensuring full dimensional and symbolic consistency. This includes:

- Swirl velocity: $\vec{v}_{\circlearrowleft} = \nabla \phi$
- Core swirl speed: $\|\vec{v}_{\circlearrowleft}\| = 1.093 \times 10^6$ m/s
- Core radius: $r_c = 1.40897 \times 10^{-15}$ m
- Core density: $\rho_{\text{core}} = 3.89 \times 10^{18}$ kg/m^3
- Time variables: external time τ, swirl clock $S(t)$, and proper loop time T_s

This lineage confirms that SST inherits a fully variational, quantized, and empirically calibrated foundation — now recast in a swirl-theoretic, flat-space field formalism.

VIII. CONCLUSION

Long-distance gravitational attraction in SST is a manifestation of topological quantization: chiral knots with central holes enforce non-vanishing circulation residues along a central line. When multiple quark knots merge into a baryon, their circulations add linearly, forming a single composite tube with 3κ circulation. This mechanism predicts the correct baryonic mass scaling and provides a flat-space explanation for molecular attraction.

CODE AND DATA AVAILABILITY

All predictive simulations used in this paper are implemented in the open Python script `SST_INVARIANT_MASS3.py`, available on request or at Zenodo: https://doi.org/10.5281/zenodo.17155854

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