Impulsive Axisymmetric Forcing in a Rotating Cylinder, Reversible Swirl Response, and Skyrmionic Photon Emission: Fluid Benchmarks and Fluid-Inspired Kinematic Hypotheses

(SST Canon + Rosetta 1:1 Translation with Mainstream Glosses)

Omar Iskandarani

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Abstract

We present a one-to-one Swirl–String Theory (SST) translation of a rotating-tank impulse experiment and skyrmionic-photon framework. All sections/equations from the original are preserved, with SST terms added via Rosetta mapping and mainstream physics glosses inline. Macrodynamics remain standard rotating Euler; SST introduces (i) bookkeeping of swirl energy/mass densities and (ii) the canonical *Swirl Clock* $\mathrm{d}\tau/\mathrm{d}t = \sqrt{1 - v^2/c^2}$ alongside the legacy $\sqrt{1 - u^2/C_e^2}$ hypothesis (kept as an explicit, testable variant). Dimensional checks and numerics use $\|\mathbf{v}_{\circlearrowleft}\| = 1.09384563 \times 10^6\,\mathrm{m\,s^{-1}}$, $r_c = 1.40897017 \times 10^{-15}\,\mathrm{m}$, $\rho_f = 7.0 \times 10^{-7}\,\mathrm{kg\,m^{-3}}$.

Rosetta card (SST $\leftrightarrow$ mainstream)

$$\begin{aligned}
\rho_E &= \tfrac{1}{2}\,\rho_f\,\|\boldsymbol{v}\|^2 && \text{(mainstream: kinetic-energy density)},\\
\rho_m &= \rho_E/c^2 && \text{(mainstream: mass from energy)},\\
\Omega_0 &\equiv \|\mathbf{v}_{\circlearrowleft}\|/r_c && \text{(SST characteristic frequency)},\\
S_t &= \sqrt{1 - v^2/c^2} && \text{(Swirl Clock; mainstream: Lorentz factor)}.
\end{aligned}$$

Distinct roles: Ω (lab rotation) controls inertial waves; Ω_0 is an SST material scale derived from $\mathbf{v}_{\circlearrowleft}$ and r_c.

1 Set-up and observation

Consider a vertical cylinder of radius R and depth H, rotating at rate Ω about z. A bottom DC motor drives a three-fin impeller that briefly produces a hollow-core vortex of radius

$a_v \approx 7.5\,\mathrm{mm}$ and axial jetting. After a delay $\sim H/c_{g,z}$, a two-lobed "push–pull" on-axis surface signal appears at $z = H$.

SST map. Energy in the packet that reaches the surface is tracked as $\rho_E = \frac{1}{2}\,\rho_f\,\|\boldsymbol{u}'\|^2$ and mass-equivalent density $\rho_m = \rho_E/c^2$ (bookkeeping only).

2 Linear rotating-wave framework

In the bulk, small perturbations admit *inertial waves* with dispersion[1, 2, 3]

$$\omega = 2\Omega\,\frac{k_z}{k}, \qquad k = \sqrt{k_r^2 + k_z^2}. \tag{1}$$

For axisymmetry ($m = 0$) in a cylinder, $k_r \approx \lambda_{0n}/R$ (Bessel eigenvalues)[1]. Group velocities follow from $\partial\omega/\partial k_i$:

$$c_{g,r} = -\frac{2\Omega\,k_z k_r}{k^3}, \qquad c_{g,z} = \frac{2\Omega\,k_r^2}{k^3}. \tag{2}$$

Beams satisfy $\tan\alpha = |c_{g,r}|/c_{g,z} = k_z/k_r$.

Arrival time. With $c_{g,z}$ as above,

$$t_{\mathrm{arr}} \approx \frac{H}{c_{g,z}} = \frac{H\,k^3}{2\Omega\,k_r^2}. \tag{3}$$

Numerics (bench-top). $R = 0.075\,\mathrm{m}$, $H = 0.30\,\mathrm{m}$, $\Omega \approx 2\,\mathrm{rad/s}$, $k_r \approx 3.83/R \approx 51\,\mathrm{m}^{-1}$, $k_z \approx \pi/H \approx 10.5\,\mathrm{m}^{-1}$. Then $k \approx 52.1\,\mathrm{m}^{-1}$, $c_{g,z} \approx 7.4 \times 10^{-2}\,\mathrm{m/s}$, $t_{\mathrm{arr}} \approx 4.1\,\mathrm{s}$. Units: $[H/c_{g,z}] = \mathrm{s}$.

Analogy (10-year-old). A tilted line of dominos falls in a slanted path; it reaches the top after a short delay.

3 Impulse sign and the observed "push–pull"

Start impulse: axial upwelling and centrifugal low p' in the hollow core yield a *surface depression* on arrival. Stop impulse reverses the sign and gives a *surface rise*. Hydrostatic surface coupling[2, 3]:

$$p'(z=0) + \rho g\,\eta = 0 \;\Rightarrow\; \eta = -\,\frac{p'(0)}{\rho g}. \tag{4}$$

4 Relation to vortex rings and jet starting vortices

A short burst sheds a starting ring with translational speed in quiescent fluid[4]

$$U_{\mathrm{ring}} \approx \frac{\Gamma}{4\pi R_v}\left[\ln\!\left(\frac{8R_v}{a_v}\right) - \tfrac{1}{4}\right]. \tag{5}$$

In rotation, the on-axis *delayed* packet at the surface is dominated by the inertial-wave field, not by ring ballistic motion.

5 What this *is* and *is not* an analogy to

Photon analogy (limited)

Localized impulse $\Rightarrow$ localized packet with clear parity. Inertial waves are anisotropic and dispersive ((1)–(2)); free photons in vacuum are isotropic and nondispersive. Analogy is qualitative.

Gravitational-wave analogy (limited)

GR waves are transverse, quadrupolar, nondispersive (in vacuum). Axisymmetric inertial-wave response is neither quadrupolar nor nondispersive; c_g depends on (k_r, k_z) and Ω.

6 A proposed microscopic interpretation inspired by fluid analogs (VAM)

Legacy rule (kept as testable hypothesis). Let $u(\boldsymbol{r}, t)$ be local swirl speed. Postulate

$$\frac{\mathrm{d}\tau}{\mathrm{d}t} = \sqrt{1 - \frac{u^2}{C_e^2}}, \tag{6}$$

with C_e a characteristic speed. (Rosetta: $C_e \mapsto \|\mathbf{v}_{\circlearrowleft}\|$.)

Canonical SST (Swirl Clock). SST uses

$$\frac{\mathrm{d}\tau}{\mathrm{d}t} = S_t = \sqrt{1 - \frac{v^2}{c^2}} \quad (v = |u_\theta| \text{ locally}), \tag{7}$$

recovering Lorentz kinematics.

Parity prediction. Two opposite-sign swirl impulses flip surface angle, but any time-rate effect even in speed ((6) or (7) expansion) does not reverse.

7 Falsifiable checks

- **Travel-time scaling:** $t_{\mathrm{arr}} \propto \Omega^{-1}$; infer (k_r, k_z) from beam angle or cylinder modes[1].
- **Bipolarity:** Start/stop impulses give opposite η via (4).
- **Anisotropy:** Off-axis probes detect beams at angle $\tan\alpha = k_z/k_r$; axis receives vertical arrival.
- **Time-rate parity:** Two "clock tracers" at the surface (on-axis vs off-axis reference); bound even-in-speed time drift.

Conclusion (Part I)

An impulsive rotor in a rotating cylinder launches an axisymmetric inertial-wave packet whose $c_{g,z}$ yields a delayed on-axis surface response of the observed magnitude. The two-lobed signal follows the impulse signs. A speed-based time-rate rule, whether legacy (6) or canonical (7), produces even-in-speed effects that do not reverse.

8 Why the Surface "Push–Pull" Requires Background Rotation

Observation. The delayed bipolar surface signal occurs only for nonzero Ω; for $\Omega = 0$ there is no reproducible delayed response.

8.1 Mechanism: Coriolis restoring force and inertial-wave beams

Linear rotating Euler equations[2]:

$$\partial_t \boldsymbol{u} + 2\boldsymbol{\Omega}\times\boldsymbol{u} = -\nabla\pi, \qquad \nabla\cdot\boldsymbol{u} = 0. \tag{8}$$

They admit inertial waves with dispersion and group velocity ((1)–(2)). Arrival time (3). Hydrostatic coupling (4).

8.2 Scaling explaining the "off" state at $\Omega = 0$

As $\Omega \to 0$: $\omega \to 0$, $c_{g,z} \propto \Omega \to 0$, $t_{\mathrm{arr}} \to \infty$. Geostrophic scaling yields $\eta \propto \Omega$; viscous damping also grows (Ekman). Hence the delayed bipolar signature vanishes.

8.3 Testable predictions vs Ω

$$t_{\mathrm{arr}}(\Omega) \propto \Omega^{-1}, \tag{9}$$
$$\eta_{\max}(\Omega) \propto \Omega. \tag{10}$$

Dimensional checks: $[H/c_{g,z}] = \mathrm{s}$; $[p'/\rho g] = \mathrm{m}$.

9 Hypothesized Compressional Signaling Branch (Fluid-Inspired, Microscopic)

Summary. Add a longitudinal compressional channel with speed $c_{\mathrm{P}} \gg c$ that couples (ultra-weakly) to isotropic stress. Macrodynamics unchanged.

9.1 Minimal linear model

Relax strict incompressibility and let $p' = B_* \rho'/\rho_*$; linearization gives[5, 6]

$$\partial_t^2 \rho' - c_P^2 \nabla^2 \rho' = 0, \qquad c_P = \sqrt{\frac{B_*}{\rho_*}}. \tag{11}$$

Dimension: $[c_P] = \mathrm{m\,s^{-1}}$.

9.2 Field-theoretic sketch (source coupling)

Introduce scalar Φ with action

$$S_\Phi = \int dt\, d^3x\, \tfrac{1}{2}\left[\kappa_\Phi^{-1}(\partial_t \Phi)^2 - \Lambda_\Phi^2 (\nabla\Phi)^2\right] + \int dt\, d^3x\, \varepsilon\, \Phi\, \mathcal{T}, \tag{12}$$

where $\mathcal{T}$ is isotropic stress trace. Euler–Lagrange equation

$$\partial_t^2 \Phi - C_*^2 \nabla^2 \Phi = \varepsilon\, \kappa_\Phi\, \mathcal{T}, \qquad C_* \equiv \Lambda_\Phi \sqrt{\kappa_\Phi}. \tag{13}$$

Identifying $\rho' \propto \partial_t \Phi$ maps $C_* \to c_P$ and (11).

9.3 Numerical checks with supplied parameters

Using $\rho_* = 7.0 \times 10^{-7}\,\mathrm{kg\,m^{-3}}$, $B_* \approx 3.49924562 \times 10^{35}\,\mathrm{J\,m^{-3}}$:

$$c_P = \sqrt{B_*/\rho_*} = 7.0703057319 \times 10^{20}\,\mathrm{m\,s^{-1}}. \tag{14}$$

Ratios: $c_P/c \approx 2.36 \times 10^{12}$; for $L = 10\,\mathrm{m}$, $t = L/c_P \approx 1.4 \times 10^{-20}\,\mathrm{s}$. Compatibility: GW170817 constrains $v_{GW} \approx c$[7, 8]; a distinct, trace-coupled channel can evade provided coupling is tiny.

9.4 Falsifiable protocol

Two baselines $L_1 < L_2$; earliest correlated arrivals t_1, t_2 (after excluding EM/acoustic paths) obey

$$c_P \gtrsim \frac{L_2 - L_1}{t_2 - t_1}. \tag{15}$$

Null at resolution δt yields $c_P \gtrsim (L_2 - L_1)/\delta t$.

10 Replacing the Working Fluid by a VAM-Like Superfluid Medium

Aim. Consider a hypothetical inviscid superfluid with microscopic swirl. Macroscopically, keep rotating Euler; microscopically, two branches: transverse (inertial-like) and longitudinal (compressional).

10.1 Transverse inertial-like branch with effective background rate

Define $\Omega_* \equiv C_e/\ell_*$. Then

$$\omega = 2\Omega_* \frac{k_z}{k}, \qquad c_{g,z} = \frac{2\Omega_* k_r^2}{k^3} \sim 2\, C_e \frac{R}{\ell_*}. \tag{16}$$

Arrival:

$$t_{\mathrm{arr}} \sim \frac{H\,\ell_*}{2\,C_e R}. \tag{17}$$

Numbers. $R = 7.5\,\mathrm{cm}$, $H = 30\,\mathrm{cm}$, $C_e = 1.09384563 \times 10^6\,\mathrm{m\,s^{-1}}$: (i) $\ell_* = R$: $t \sim H/(2C_e) \approx 1.37 \times 10^{-7}\,\mathrm{s}$; (ii) $\ell_* = r_c$: $t \sim 2.6 \times 10^{-21}\,\mathrm{s}$. Units: $[H\ell_*/(C_e R)] = \mathrm{s}$.

10.2 Longitudinal compressional branch

As in (11), $c_{\mathrm{P}} = \sqrt{B_*/\rho_*}$ is kinematic front speed; detection requires ultra-weak coupling to avoid conflicts with known tests[9, 10].

Part II: Reversible Azimuthal Response to Axisymmetric Vertical Forcing

Setting. Cylinder radius R, height H, fluid density ρ. Container rotates at Ω; base state at rest in rotating frame; absolute vorticity $\boldsymbol{\omega}_a^{(0)} = 2\boldsymbol{\Omega}$[2, 1].

10.3 Governing equations and vorticity production

Inviscid rotating-frame equations:

$$\partial_t \boldsymbol{u} + (\boldsymbol{u}\cdot\boldsymbol{\nabla})\boldsymbol{u} + 2\boldsymbol{\Omega} \times \boldsymbol{u} = -\boldsymbol{\nabla}\Pi, \tag{18}$$

$$\boldsymbol{\nabla}\cdot \boldsymbol{u} = 0. \tag{19}$$

Curl gives absolute-vorticity equation[2, 3]

$$\partial_t \boldsymbol{\omega} = \boldsymbol{\nabla} \times (\boldsymbol{u} \times \boldsymbol{\omega}_a), \qquad \boldsymbol{\omega}_a = \boldsymbol{\omega} + 2\boldsymbol{\Omega}. \tag{20}$$

Linearizing about $\boldsymbol{\omega}_a^{(0)}$ yields

$$\partial_t \boldsymbol{\omega} \approx 2(\boldsymbol{\Omega}\cdot\boldsymbol{\nabla})\, \boldsymbol{u}. \tag{21}$$

Axisymmetry $\Rightarrow$ vertical component

$$\boxed{\partial_t \omega_z = 2\Omega\, \partial_z w.} \tag{22}$$

Introduce displacement ξ with $w = \partial_t \xi$; integrate from rest:

$$\boxed{\omega_z(r, z, t) = 2\Omega\, \partial_z \xi(r, z, t).} \tag{23}$$

10.4 From vertical vorticity to azimuthal velocity

Kinematic relation

$$\omega_z = \frac{1}{r}\,\partial_r\big(r\,u_\theta\big) \;\Rightarrow\; u_\theta(r,z,t) = \frac{1}{r}\int_0^r \omega_z(r',z,t)\,r'\,\mathrm{d}r'. \tag{24}$$

Gaussian kernel. For $\xi = Z(t)\,\exp(-(r^2+z^2)/a^2)$,

$$u_\theta(r,z,t) = -\,\frac{2\Omega\,Z(t)\,z}{a^2}\,e^{-z^2/a^2}\,\frac{1-e^{-r^2/a^2}}{r}. \tag{25}$$

Sign: cyclonic below ($z<0$), anticyclonic above ($z>0$). Near-axis regularity: $1-e^{-r^2/a^2} \sim r^2/a^2$.

10.5 Angle reversal and reversibility

Relative angular rate $\dot{\theta}_{\mathrm{rel}} = u_\theta/r$. Over a stroke $[t_1,t_2]$,

$$\Delta\theta_{\mathrm{rel}}(r,z) = \int_{t_1}^{t_2} \frac{u_\theta}{r}\,\mathrm{d}t. \tag{26}$$

Because $\dot{\theta}_{\mathrm{rel}}$ is linear in $Z(t)$, a symmetric up–down cycle with zero mean displacement yields

$$\boxed{\Delta\theta_{\mathrm{rel}}(r,z;\text{one period}) = 0 \quad \text{(to leading order).}} \tag{27}$$

Deviations arise from viscosity (Ekman), quadratic advection (streaming), or near-resonant inertial waves[1].

10.6 A fluid-inspired kinematic time hypothesis (legacy variant)

Define $L \equiv \frac{1}{2}\,r_e$ with classical electron radius $r_e = e^2/(4\pi\epsilon_0 m_e c^2) \approx 2.82\times10^{-15}\,\mathrm{m}$. With $\omega = 2u_\theta/C_e$, define

$$\alpha_f \equiv \frac{\omega L}{c} = \frac{r_e}{c\,C_e}\,u_\theta, \qquad \frac{\mathrm{d}\tau}{\mathrm{d}t} = \sqrt{1-\alpha_f^2}. \tag{28}$$

For $\alpha_f \ll 1$, $\mathrm{d}\tau/\mathrm{d}t \approx 1-\frac{1}{2}\alpha_f^2$. Quadratic parity: angle reverses; time deficit does not.

Part III: Skyrmionic Photon Emission from Knotted Swirl Sources

10.7 From optical skyrmions to VAM/SST topology

Optical skyrmions built from LG modes with opposite circular polarizations carry integer topological charge via Stokes field[11, 12, 13]:

$$N_{\mathrm{sk}}^{(\mathrm{ph})} = \frac{1}{4\pi}\int d^2k_\perp\,\hat{\vec{S}}\cdot\big(\partial_{k_x}\hat{\vec{S}}\times\partial_{k_y}\hat{\vec{S}}\big) \in \mathbb{Z}. \tag{29}$$

Let $\hat{\boldsymbol{\omega}} = \boldsymbol{\omega}/\|\boldsymbol{\omega}\|$; define vortex charge on Σ by

$$H_{\text{vortex}}[\hat{\boldsymbol{\omega}}|\Sigma] \equiv \frac{1}{4\pi}\int_{\Sigma} \hat{\boldsymbol{\omega}} \cdot \left(\partial_x \hat{\boldsymbol{\omega}} \times \partial_y \hat{\boldsymbol{\omega}}\right) dx\, dy. \tag{30}$$

Topological inheritance. $N_{\text{sk}}^{(\text{ph})} = H_{\text{vortex}}[\hat{\boldsymbol{\omega}}|\Sigma]$.

10.8 Projection law: from swirl to Stokes

Let $\mathbf{p}(\mathbf{r}) = p_0(\mathbf{r})\, \hat{\boldsymbol{\omega}}_\perp(\mathbf{r})$ on Σ. Far-field Jones amplitude in mode space (LG basis $u_{p,\ell}$, helicity $\sigma = \pm 1$):

$$A_{p\ell\sigma} = \int_{\Sigma} (\hat{e}_\sigma^* \cdot \mathbf{P}_\perp \hat{\boldsymbol{\omega}}_\perp)\, u_{p,\ell}(\mathbf{r})\, e^{i\Phi(\mathbf{r})}\, \mathrm{d}^2 r, \tag{31}$$

with $\mathbf{P}_\perp = \mathbf{I} - \hat{\mathbf{k}}\hat{\mathbf{k}}^\top$ and a phase Φ. Stokes field computed from $\mathbf{E}$ yields (29).

10.9 VAM/SST radiative vertex: OAM additivity and chirality

Per-photon OAM in SPDC conserves ℓ additively[14, 15]; adopt

$$\ell_{\text{src}} = \sum_{j=1}^{n} \ell_j \quad (n\text{-photon channel}). \tag{32}$$

Swirl chirality sets photon helicity: ccw $\Rightarrow \sigma = +1$, cw $\Rightarrow \sigma = -1$.

10.10 Frequency and energy scale

$$\Omega_0 \equiv \frac{C_e}{r_c}, \qquad E_0 = \hbar\Omega_0. \tag{33}$$

Numerically (given values): $\Omega_0 \simeq 7.77 \times 10^{20}\,\mathrm{s}^{-1}$, $E_0 \simeq 0.511\,\mathrm{MeV}$.

Quantized line set. Let

$$\omega_{m\ell} = m\,\Omega_0 + \delta\omega_\ell, \qquad E_{m\ell} = \hbar\omega_{m\ell} = m\,E_0 + \delta E_\ell. \tag{34}$$

10.11 Predictions

- **P1 (topological spectroscopy):** $N_{\text{sk}}^{(\text{ph})} = H_{\text{vortex}}$ within a fixed mode family.
- **P2 (chirality–helicity):** flip swirl chirality $\Rightarrow$ flip photon helicity; OAM additivity (32) intact.
- **P3 (robustness):** $N_{\text{sk}}^{(\text{ph})}$ invariant under smooth, linear propagation.
- **P4 (Purcell tuning):** LDOS changes reshape texture without changing integer charge.
- **P5 (line assignments):** $m = 1$ near $m_e c^2$; absence of a strong ladder at $n \times 0.511\,\mathrm{MeV}$ constrains δE_ℓ and higher-m couplings.

11 Minimal experimental roadmap

11.1 E1: Re-analyze single-photon skyrmion data

Express measured Stokes fields via a reconstructed $\hat{\boldsymbol{\omega}}_\perp$; test $N_{\rm sk}^{(\rm ph)} = H_{\rm vortex}$, and OAM/helicity control.

11.2 E2: Swirl-based emitters at non-optical frequencies

Macroscopic swirl sources coupled via electro-/magneto-/piezo-optic effects should reproduce topological mapping independent of absolute energy scale.

11.3 E3: High-energy cross-checks

Consistency with electron mass/QED precision and absence of extra stable lines near multiples of 0.511 MeV.

Global Conclusion

Part I. Inertial-wave packet with $c_{g,z}$ explains delayed axial "push–pull"; $t_{\rm arr} \propto \Omega^{-1}$ and $\eta_{\max} \propto \Omega$. Time-rate hypotheses are even in speed.

Part II. Vertical forcing produces opposite-sign vorticity above/below; linear reversibility gives zero net angle over a symmetric cycle.

Part III. Skyrmionic photon textures inherit vortex topology; OAM additivity and chirality–helicity mapping follow; $\Omega_0 = C_e/r_c$ sets a kinematic scale with numerical validation.

Analogy (10-year-old). Knots in a river can flick patterns into light; how they're tied (knot type) decides the pattern, not how loudly you splash.

Acknowledgments. Fluid/wave results: [2, 1, 4, 3, 5, 6]. Topological/OAM optics: [13, 11, 12, 15, 16]. Relativistic/causality constraints: [9, 10, 7, 8].

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