The Impact-Triggered Flash Cascade (ITFC) Model and a Rotation-Based Interpretation of Particle Motion — Draft v0.1

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Abstract

We propose the **Impact- Triggered Flash Cascade (ITFC)** model, which interprets visible light as a cascade of flashes emitted by an unobservable background of particles (U- particles) excited through contact with a high- speed driver (P- particle). In this framework the observable signal is not the P- particle itself but the propagation of the **U- cascade**. The speed constant **c** is not the speed of P; rather, it is the **critical rotational- transfer speed of U**. While a P- particle may satisfy $v_P \geq c$ (*a lower* bound), information transfer is limited by the cascade propagation speed $v_{eff} \leq c$, preserving local relativistic invariance. U- cascade propagation is governed by two phenomenological parameters—the effective transfer length λ and the local dwell/lag time τ_e—from which we obtain

$$v_{eff} = \frac{1}{c^{-1}+\tau_e/\lambda}, \qquad n = 1 + \frac{c\tau_e}{\lambda}$$

1. Introduction

Scope notice. This paper focuses on phenomenology: we formalize optical consequences in terms of $\lambda,,$ τ_e , κ without committing to a full microscopic model. A concrete definition of U- particles, their creation/interaction rules, a rotation- field- based dynamics, and a mapping to standard field theory will be presented **in subsequent papers**.

Conventional optics treats light via Maxwell's equations and quantum electrodynamics. Here

we examine whether a **contact-transfer mechanical micro-picture** can reproduce macroscopic optical laws while remaining compatible with relativistic constraints. The central idea is: space is filled with unobservable background particles (U); impact by a high-speed driver (P) excites U into a transient, rapidly rotating state (**U***), which transfers rotation to neighboring U and emits a **flash**. The sequence of such flashes along the P track constitutes what we observe as **light**.

2. Rotation-Based Particle Motion — Linkage Summary

Earlier work postulated that superposed rotation fields modulate particle mobility (position/momentum distributions). ITFC instantiates this by using a **transient angular-momentum variable** ω and a **dwell time** τ, so that an impact imparts linear impulse to P and a short-lived angular impulse to U.

3. Model Components

3.1 U-particles (unobservable background)

• **States**. Stable U_0 (non-emissive) and

excited U^* (flash-emissive). Transitions: .

$$U_0 \xrightarrow{impact} U^* \xrightarrow{decay} U_0$$

• **Local dynamics**. Let ω denote transient angular speed.

$$\frac{d\omega}{dt} = -\frac{\omega}{\tau} + \sum_{j\in\aleph} \kappa\omega_j \Theta(r_c - \|r - r_j\|)$$

$$I_U(t) = \eta \left|\frac{d\omega}{dt}\right|^p, \quad p \geq 1, \eta > 0.$$

3.2 P- particles (high- speed drivers)

Properties. Effectively massless energy carriers, **not directly observable**. Average speed v_P with a **lower bound** c (i.e $v_P \geq c$). Here c is the **critical U- transfer speed** (the light constant).

Trajectory. Ballistic flight over an effective free length ℓ or transfer length λ , with direction changes upon contact according to a scattering kernel $p(\theta)$.

Contact rule. A single contact raises a local U angular speed by ω_0 and may deflect P by angle $\theta \sim p(\theta)$. **Observable propagation is governed by the U- cascade,** not by P directly.

3.3 Definition of the Cascade (Light)

Along a P track, the set U^* forms a time- ordered cascade. The detector integrates flashes over a window Δt; the integrated signal is the **intensity**, and its stream defines a **ray**.

3.4 Observability (Afterimage Hypothesis)

P is inferred **only** via the spatio- temporal pattern of the U- cascade "afterimage". Identical P tracks may yield different apparent rays depending on λ, τ_e .

3.5 Chain Dynamics (Summary)

U- excitation dynamics and emission follow §3.1; cascade formation is determined by $\lambda, \tau_e, \kappa, r_c$.

3.6 Parameters

λ (effective transfer length), τ_e (local dwell/lag), c (U-transfer critical speed), $p(\theta)$ (P→U scattering kernel), etc.

3.7 Summary (Causal Direction)

Cause (P) moves with $v_P \geq c$ → **Medium (U)** undergoes transfer at **c → Observation (Light)** = cascade of flashes.

4. Effective Propagation Speed and Refractive Index

The observable signal is the U-cascade. For one step,

$$t_{step} = \lambda/c + \tau_e , \qquad v_{eff} = \frac{\lambda}{\lambda/c+\tau_e} = \frac{1}{c^{-1}+\tau_e/\lambda} .$$

$$n \equiv \frac{c}{v_{eff}} = 1 + \frac{c\tau_e}{\lambda} .$$

5. Optical Laws — Consequences

5.1 Rectilinearity

If scattering is forward-peaked and $\lambda \gg r_c$, deflection is small and straight-ray

propagation holds.

5.2 Reflection/Refraction (Variational Principle)

Light (the U-cascade) follows paths minimizing total time $T = \int \frac{ds}{v_{eff}(s)} = \int \frac{n(s)}{c} ds$. With

$n(s) = 1 + \frac{c\tau_e(s)}{\lambda(s)}$,

Snell's law follows: $n_A \sin\theta_A = n_B \sin\theta_B$. Ray bending aligns with ∇n, i.e., with gradients of τ_e/λ.

5.3 Scattering and Turbidity

Stronger transport scattering shortens λ (e.g $, \lambda \approx 1/(\rho_U, \sigma_{tr})$) and typically increases τ_e by multiple contacts; hence $n = 1 + c\tau_e/\lambda$ rises and v_{eff} falls, transitioning to a transport regime characterized by an effective transport mean free path ℓ^* and diffusion coefficient $D \sim v_{eff}\ell^*/3$. Measurables: increased turbidity and delayed pulse tails.

5.4 Diffraction/Interference as Time Synchronization

Two cascades arriving within a threshold **sync time** τ_c produce fringes within the detector's integration window Δt_{int}. The **coherence length** is $L_c = v_{eff}$, $\tau_c = \frac{c,\tau_c}{1+c,\tau_e/\lambda}$ Vacuum-like conditions (small τ_e/λ) yield $v_{eff} \to c$ and longer L_c , enhancing visibility; media with larger τ_e/λ reduce L_c and modulate fringe patterns.

6. Relativistic Constraints and Local Invariance

Treat c as the invariant **U- transfer critical speed**. Although $v_P \geq c$ may hold, observable information propagates with $v_{eff} \leq c$. Michelson–Morley- type nulls are recovered by **covariant scaling** of U- parameters (e.g., an invariant τ_e/λ in a local inertial frame), which removes first- order anisotropy.

7. Numerical Simulation Frame

Microscopic (agent- based): Monte- Carlo P- jumps plus U- lattice reaction- transfer $U_0 \leftrightarrow U^*$.

Continuum (PDE):

$$\partial_t u^*(r,t) = D\nabla^2 u^* - \frac{u^*}{\tau} + S_P(r,t),$$

where S_P is a source tied to P tracks.

Table 1. Model Parameters (Baseline & Sweep)

name	meaning	unit	baseline_A (vac- like)	baseline_B (dense/boundary)	sweep
ρ_U	U- particle number density	arb.	1e- 3	1.0	1e- 4 – 3.0
σ_{tr}	transport cross section	arb. area	1e- 3	1e- 1	1e- 4 – 1
$\lambda \approx 1/(\rho_U \sigma_{tr})$	effective transfer length	arb. length	derived	derived	derived

τ_e	dwell / lag per step	time	0.01 (λ/c)	0.3 (λ/c)	0 – 1 (λ/c)
τ	decay time of excited U	time	$5\tau_e$	$2\tau_e$	1-10τ_e
κ	transfer coupling strength	1/time	$0.05/\tau_e$	$0.2/\tau_e$	$0.01 - 0.5/\tau_e$
r_c	transfer radius	length	0.5λ	0.8λ	$0.1 - 1.0\lambda$
$p(\theta)$	scattering kernel (P→U)	—	forward- peaked	broadened (near- Lambertian)	HG g: $0.9 \rightarrow 0.0$
c	U- transfer critical speed	speed	1.0 (nondim)	1.0	fixed
v_p	P speed (unobserved)	speed	$1.5c$	$1.2c$	$\geq c$
$v_{eff} = 1/(1/c + \tau_e/\lambda)$	effective propagation speed	speed	computed	computed	computed
$n = 1 + c\tau_e/\lambda$	effective refractive index	—	$\approx$ 1.01	$\approx$ 1.3	1.0 – 2.0
τ_c	sync time for interference	time	$100\tau_e$	$50\tau_e$	**10** – $200\tau_e$
$L_c = v_{eff}\tau_c$	coherence length	length	computed	computed	computed
Δt_{int}	detector integration window	time	$50\tau_e$	$50\tau_e$	10 – $200\tau_e$
observables	$\Delta T, V, n_{eff}$	—	measure	measure	record vs sweep

Note. Start with dimensionless units and map to physical units in later experimental design. Baseline_A is vacuum- like; Baseline_B represents strong boundary/scattering conditions.

Table 2. Numerical Settings (Recommended)

item	symbol	value	note
domain length	L_{dom}	200λ	periodic or absorbing BC
grid spacing	Δx	$\lambda/20$	resolve transfer front
Time step	Δt_{num}	$0.5 \bullet \min(\lambda/c, \tau_e)$	stability / CFL- like guard
Total steps	N_{step}	1e5	cover many transfers
Particles per cell (P)	N_p	10-100	Monte- Carlo variance control
Recording cadence	—	every 50 steps	for $\Delta T, V, n_{eff}$
sources	S_P	scripted tracks	single/dual tracks for interference

Output metrics. ΔT: time delay across length L ($\int ds/v_{eff}$); V: fringe visibility $(I_{max} - I_{min})/(I_{max} + I_{min})$; n_{eff}: path- averaged refractive index $(1/L) \int n(s)ds$.

8. Experimental Predictions and Discriminators

1. Pressure/density- dependent index. Control residual gas (affecting λ, τ_e) and measure $\Delta T \sim L\Delta(\tau_e/\lambda)$.

2. Boundary dynamics. Design interfaces (metasurfaces) to tailor $p(\theta)$, inducing non- integer refraction and polarization- dependent n.

3. Time-synchronization interferometry. Scan pulse delay and locate the threshold τ_c for fringe onset.

4. UHV gas-injection step test. Micro-step λ, τ_e by controlled injections and read out femto–picosecond timing shifts via interferometry: $\Delta n \approx c\Delta(\tau_e/\lambda)$.

5. Kernel engineering at boundaries. Actively vary $p(\theta)$ and compare with ITFC predictions (cascade-transfer delays).

6. Annual/azimuthal modulation interferometry. Earth's orbit and rotation modulate the relative angle to Ω. Measure annual/diurnal components of $\Delta(\tau_{swap}/\lambda)$ as femto–picosecond delays. Scan latitude/longitude/azimuth to reject systematics and set an upper bound on Δn(Ω).

9. Mapping to Topological Terminology (Optional)

U-background corresponds to a near-zero phase-feedback exterior of a quasi-isolated system; contact transitions are phenomenologically analogous to entropy-direction inversions. This gives a dictionary between rotation-based/phase-based language without altering predictions.

9.1 Phase Symmetry in Nuclear Binding and Phase Relaxation (Beta Decay)

We interpret nuclear binding as a tendency to maintain **phase symmetry (or equilibrium)** within a bound system.

Let Φ_i and Φ_j denote the phases of nucleons i and j, and introduce a short-range envelope $U(R_{ij}) \sim -J_0 exp(-R_{ij}/\lambda_N)$. A phenomenological binding energy can be written as:

$$E_{bond} = -\sum_{<i,j>} J_{ij}(R_{ij}) cos(\phi_i - s_{ij}\phi_j - \pi p_{ij}) + \sum_{<i,j>} U(R_{ij})$$

where $s_{ij} \in \{\pm 1\}$ represents the coupling sign (in-phase or anti-phase), and $p_{ij} \in \{0,1\}$ encodes a π-junction (e.g., neutron-mediated anti-phase coupling).
Energy minimization enforces local phase equilibrium, naturally producing short-range strong attraction and saturation behavior.

In this framework, beta decay is interpreted as a **phase relaxation (phase-slip) process** that occurs when accumulated phase imbalance exceeds a critical barrier.
Introducing an isospin angle α with an effective potential:

$$U_{iso}(\alpha) = -J_{pn} cos\,\alpha + \frac{K}{2}\alpha^2$$

a phase-slip transition $\alpha \to \alpha \pm \pi$ occurs when the phase energy exceeds a threshold E_b.
The released energy is partitioned as:

$$Q = \Delta E_{phase} - E_b = T_e + T_\nu + E_{U-cascade} \geq 0$$

where T_e and T_ν denote the kinetic energies of the emitted electron and (anti)neutrino,

and the remaining energy is carried by the U-cascade (flash chain).

Charge conservation is ensured via the label-charge continuity relation (Appendix D.5'):

$$\partial_t \rho_q + \nabla \cdot J_q = S_{slip}$$

which reduces to standard conservation ($S_{slip} \to 0$) in the rapid recombination limit. Thus, beta decay is interpreted as a dynamical process restoring phase equilibrium within the bound system.

10. Limitations and Open Problems

• Establish a precise **effective field theory** mapping to Maxwell/QED.

• Quantitatively confront **high- precision null experiments**.

• Integrate a **nonlinear detector model** for biological perception.

11. Conclusion

ITFC redefines light as a **cascade of U- particle flashes** and interprets the light constant as a **U- transfer critical speed**. Thus, while a driver P may satisfy $v_p \geq c$, information transfer remains bounded by $v_{eff} \leq c$. Medium sensitivity is quantified by $n = 1 + c\tau_e/\lambda$. The frame unifies rectilinearity, reflection/refraction, scattering/turbidity, and diffraction/interference through the single spatial field τ_e/λ. We propose UHV step tests and boundary- kernel engineering as near- term discriminators.

Future work. (1) Construct a rotation- field micro- model and an EFT correspondence; (2) infer τ_e , λ from metasurface/nanointerferometry datasets; (3) precision comparisons of $\Delta T, V, n_{eff}$; (4) connect to rotation- based galactic dynamics via refractive- index mapping.

Appendix A. Covariant Parameter-Scaling Hypothesis (Sketch)

In local inertial frames, let $\lambda \propto f(\Phi)$ and $\tau_e \propto f(\Phi)$ scale homogeneously with a local scalar Φ, keeping . Then $v_{eff}^{-1} = c^{-1} + const$ is locally invariant and first- order anisotropy cancels.

Appendix B. Notation

ρ_U: U- particle number density; σ: (transport) cross section; ℓ: transport mean free path; λ: effective transfer length; τ, τ_e: decay/dwell constants; κ: transfer coupling; r_c: transfer radius; c : U- transfer critical speed; n : effective refractive index; u^* : excited U concentration; v_P: P speed; v_{eff}: effective cascade speed.

Appendix C. Diagrams (v1)

Display note. If Mermaid is unavailable, use the ASCII alternates. Variables appear in plain text (tau_e, lambda, r_c).

[Fig. 1] U- cascade propagation (P track and excitations)

```
flowchart LR
   P0((P)) --> U1((U*))
```

```
    U1 --> U2((U*))
    U2 --> U3((U*))
    P0 -. dotted path .-> P1((P))
    P1 --> U4((U*))
    U4 --> U5((U*))
    classDef glow fill:#fffbd6,stroke:#555;
    class U1,U2,U3,U4,U5 glow;
```

ASCII alt:

```
P path:    . . . . . .
                  o* -> o* -> o*          (U* : excited U; flash)
                        \
                         -> o* -> o*
```

r_c : local transfer radius

lambda : effective transfer length between successive U*

[Fig. 2] Trajectory change at a boundary (refraction/reflection)

```
flowchart LR
    subgraph A[region A: n_A = 1 + c*tau_eA/lambda_A]
    IA[/incident ray θ_A/]
    end
    subgraph B[region B: n_B = 1 + c*tau_eB/lambda_B]
    RB[/refracted ray θ_B/]
    end
    IA -->|boundary| RB
```

ASCII alt:

region A (n_A) | region B (n_B)

\

\ θ_A | / θ_B

____boundary|_/_____

Snell: n_A * sin(θ_A) = n_B * sin(θ_B)

with n = 1 + c * tau_e / lambda

[Fig. 3] Time- synchronization interference (coherence length L_c)

P-chain #1: |* * * * *|

P-chain #2: |* * * * *|

<---- Δt ---->

Detector window Δt_int: [==========]

Sync time τ_c: threshold for fringe formation

L_c = v_eff * τ_c = c * τ_c / (1 + c * tau_e / lambda)

Appendix D. Effective Action (Lagrangian) — Sketch

This appendix presents a refined **effective action** sketch for ITFC while preserving the phenomenological parameters $\lambda,\ \tau_e,\ \tau_{swap},\ \kappa$. The purpose is twofold: (i) encode **memory effects** and **finite transfer range** directly in the action, and (ii) to recover, in the long- wavelength and low- frequency limit, the ITFC propagation law

$$t_{step} = \frac{\lambda}{c} + \tau_{eff}, \qquad v_{eff} = \frac{1}{c^{-1} + \tau_{eff}/\lambda}, \qquad n = 1 + \frac{c\tau_{eff}}{\lambda}$$

Where

$$\tau_{eff} = \begin{cases} \tau_e, & dilute\ \ background, \\ \tau_{swap}, & dense\ \ swap-dominated\ \ background. \end{cases}$$

D.1 Fields and External Source

Let $\psi(x) \equiv \psi(\mathrm{t}, \mathbf{r})$ denote an effective scalar field representing the i**ntensity/state of U-transfer**, I.e. the observable carrier of the U-cascade. The P-track enters only through an external source

$$J_p(x) = g \int d\tau\ \delta^{(4)}(x - X(\tau)),$$

where $X(\tau)$ is the worldline of the P-particle. Thus, P itself is not directly observable; only the induced field ψ is.

D.2 Effective Action (Sketch)

The refined effective action is written as

$$S_{eff} = \int d^4x \left[\frac{1}{2}(\partial_t\psi)^2 - \frac{c^2}{2}|\nabla\psi|^2 - V(\psi) + J_P\psi\right]$$

$$+ \frac{1}{2}\int d^4x d^4x'\psi(x)K(x-x')\psi(x').$$

Here $K(x - x')$ is a **causal nonlocal kernel** satisfying

$$K(t - t' < 0, r - r') = 0,$$

so that temporal ordering and observable causality are preserved.

A separable illustrative form is

$$K(x - x') = K_t(t - t')\ K_r(r - r'),$$

with

$$K_t(\Delta t) = \frac{\alpha}{\tau_{eff}} exp\left(-\frac{\Delta t}{\tau_{eff}}\right)\Theta(\Delta t),$$

$$K_r(\Delta r) = -\beta\ \frac{c}{\lambda}\ \frac{exp(-|\Delta r|/\lambda)}{N_\lambda},$$

where N_λ is a normalization factor and α, β are matching coefficients.

If a cosmic reversible rotation field $\Omega = \Omega(R)$ is included, the kernel may be parameterized as

$$K(x - x';\Omega) = K_t(t - t';\Omega)K_r(r - r';\Omega),$$

with Fourier transform

$$\widetilde{K}(\omega,k;\Omega) \simeq A(\Omega)(i\omega) + B(\Omega)k^2 + \cdots .$$

The matching conditions are then imposed as

$$\left(\frac{\partial \widetilde{K}}{\partial(i\omega)}\right)_{\omega=0,k=0} = \frac{1}{\tau_{swap}(\Omega)}, \qquad \left(\frac{\partial \widetilde{K}}{\partial k^2}\right)_{\omega=0,k=0} = -\frac{c}{\lambda(\Omega)}$$

These ensure the long-wavelength relations

$$v_{eff}(\Omega) = \frac{1}{c^{-1} + \tau_{swap}(\Omega)/\lambda(\Omega)}, \qquad n(\Omega) = 1 + \frac{c\tau_{swap}(\Omega)}{\lambda(\Omega)}$$

D.3 Equations of Motion and Dispersion (Linearized)

Near a local steady state, take

$$V(\psi) \simeq \frac{m^2}{2}\psi^2.$$

Then the Euler–Lagrange equation becomes

$$\partial_t^2\psi - c^2\nabla^2\psi + m^2\psi + \int d^4x' \; K(x - x')\psi(x') = -J_P(x).$$

For a plane-wave ansatz

$$\psi(x) \sim e^{i(k\cdot r - \omega t)},$$

one obtains the dispersion relation

$$-\omega^2 + c^2k^2 + m^2 + \widetilde{K}(\omega, k) = 0.$$

In the long- wavelength/low- frequency regime,

$$\widetilde{K}(\omega, k) \approx A(i\omega) + Bk^2 + \cdots ,$$

And the coefficients A and B are fixed by the ITFC matching rules below.

D.4 Long- Wavelength Matching (Design Rules)

The refined design rules are:

$$(M1) \qquad t_{step} = \frac{\lambda}{c} + \tau_{eff}$$

$$\Longrightarrow v_{front}$$

$$= \frac{1}{c^{-1} + \tau_{eff}/\lambda} \equiv v_{eff} ,$$

$$(M2) \qquad n = \frac{c}{v_{eff}} = 1 + \frac{c\ \tau_{eff}}{\lambda} ,$$

$$(C1) \quad \left(\frac{\partial \widetilde{K}}{\partial(i\omega)}\right)_0 = \frac{1}{\tau_{eff}}, \qquad (C2) \quad \left(\frac{\partial \widetilde{K}}{\partial k^2}\right)_0 = -\frac{c}{\lambda}\,.$$

Choosing $\alpha, \beta,$ and N_λ so that $(C1) - (C2)$ hold ensures that the **front velocity** of the causal U-cascade response reproduces the ITFC law.

> **Remark.** In a generic nonlocal medium, phase velocity and group velocity need not coincide with the signal front velocity. In ITFC, the physically relevant quantity is the propagation of the **U-cascade front.**

D.5 Minimal Potential and Stability

A stable minimal potential may be chosen as

$$V(\psi) = \frac{m^2}{2}\psi^2 + \frac{\lambda_4}{4!}\psi^4 + \cdots, \qquad m^2 \geq 0, \quad \lambda_4 \geq 0.$$

If one prefers a phase interpretation, a periodic form such as

$$V(\phi) = \Lambda_\phi(1 - \cos\phi)$$

may be used instead.

D.5’ Label-Charge Continuity (Noether Sketch)

Assume a global $U(1)$-like symmetry associated with a label charge q. Then the effective current obeys

$$\partial_t \rho_q + \nabla \cdot J_q = 0.$$

D.6 Summary

The refined effective action preserves:

$$(1)\ casuality, \qquad (2)\ finite\ memory$$
$$/\ range\ (\tau_{eff}, \lambda), \qquad (3)\ invariant\ c.$$

in the long-wave-length limit. In laboratory vacuum without pair production, any effective-mass construct may be set to zero, and the pair (λ, τ_e) alone suffices. A full microscopic derivation and EFT correspondence remain future work.

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