# The PNP Theory of Cause and Effect

Causality from Topological Persistence in Scalar Fields

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**One-Sentence Summary.** Causality emerges in the PNP framework because a topologically non-trivial scalar field configuration cannot remain static without violating stress–energy conservation, forcing ordered evolution.

**Abstract.** We derive causality from first principles within the Point–Not–Point (PNP) framework. At its core lies the topological irreducibility of the fundamental (1) mode: the simplest closed oscillation of a scalar field $U$ exhibiting a $\pi$ phase inversion, or "bounce." This $\mathbb{Z}_2$ invariant enforces loop persistence and forbids extinction without a phase slip. We explicitly ground this mode in the discrete solution space of source-free Maxwell dynamics (the toroidal hydrogenic spectrum). From this physically motivated topology, we prove that such a mode cannot remain static, formalizing cause–effect not as a postulate, but as the inevitable action of the field propagator on a persistent topological sector.

**Keywords.** PNP Framework, Topological Persistence, Causal Geometry, Scalar Field Theory, Z2 Invariant, Emergent Time

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# 1. Introduction

In standard formulations of physics, causality is assumed as a primitive ordering of events—time exists, and things move through it. In the Point–Not–Point (PNP) framework, we invert this relationship. We propose that causality emerges from **Topology**: specifically, from the requirement that a non-trivial field configuration must evolve to maintain its structural integrity.

We show that a minimally nontrivial loop of the scalar field $U$ (the fundamental "Entity") persists under evolution. We prove that such a mode cannot remain static without violating local momentum conservation. Time here is not assumed as a background ordering, but emerges as the parameter labeling successive configurations required to preserve topology. Thus, cause–effect is the temporal manifestation of topological persistence.

# 2. The PNP Framework and the Fundamental Mode

Let $U : \mathcal{M} \to \mathbb{R}$ be a real scalar energy field. We define the complex envelope $A(\mathbf{x}, t)$ as a local phase–amplitude decomposition of the oscillatory solutions of $U$:

$$A(\mathbf{x}, t) = \rho(\mathbf{x}, t)\, e^{i\phi(\mathbf{x},t)}, \qquad \rho \geq 0,\ \phi \in \mathbb{R} \pmod{2\pi}$$

*Note: The complex envelope $A$ is a bookkeeping device for local oscillatory structure in a real scalar field; no additional $U(1)$ degrees of freedom are introduced.*

## 2.1. The Physical Origin of the (1) Mode

The topological object central to this theory—the (1) **mode**—is not an arbitrary mathematical postulate. It is the abstraction of the fundamental standing-wave solution to Maxwell's equations on a toroidal manifold.

As demonstrated in the derivation of the Schrödinger equation from source-free electromagnetism [1], the imposition of single-valuedness on a toroidal field configuration yields a discrete spectrum of modes labeled by integer winding numbers $(m, n)$. For the symmetric case $(m = n)$, the energy of these modes scales as $E \propto 1/n^2$, reproducing the Rydberg series characteristic of bound atomic states (Hydrogen) without invoking point charges.

The (1) **mode** corresponds to the ground state ($n = 1$) of this physical hierarchy. It represents the "simplest knot" compatible with the wave equation—a closed loop of energy with a $\pi$ phase twist. While higher $n$ modes describe excited states, the (1) mode represents the irreducible topological obstruction that defines the entity's existence. By focusing on the (1) mode, we are not inventing a shape; we are analyzing the topological properties of the most fundamental stable structure allowed by classical field dynamics.

### 2.2. Topological Sectors and the $(n)$ Notation

We denote topological sectors by $(n)$ with $n \in \mathbb{N}$, representing the winding number of the phase around the core.

The (1) mode is defined geometrically as a closed loop $C$ encircling a core such that one traversal advances the phase $\phi$ by $\pi$ (a Möbius-like twist). This requires two traversals to return to the initial state.

The holonomy along $C$ is:

$$H(C) = \exp\left(i \oint_C \nabla\phi \cdot d\mathbf{l}\right) \in \{+1, -1\}$$

This defines the discrete $\mathbb{Z}_2$ index $\nu$ (Parity):

$$\nu = \frac{1 - H(C)}{2} = n \pmod 2$$

- $\nu = 0$: Trivial topology (Even $n$).
- $\nu = 1$: Non-trivial topology (Odd $n$, including the fundamental (1) mode).

**Physically, the (1) mode traps the essence of a "continuous bounce."** The field flows through the core, inverts phase, and re-emerges, effectively reflecting off its own nodal structure without ever encountering a hard boundary; a self-referential flow.

Crucially, $\nu$ is a topological invariant. It cannot change continuously; it can only change via a **Phase Slip** (where $\rho \to 0$ at a point on $C$), effectively breaking the loop.

## 3. Field Dynamics and Stress–Energy

The source-free PNP equation of motion is given by the vanishing of the exterior derivative of the dual:

$$d(\star dU) = 0$$

With a Lagrangian density $\mathcal{L}(U, \nabla U)$, the stress–energy tensor is:

$$T_{\mu\nu} = \nabla_\mu U \, \nabla_\nu U - g_{\mu\nu} \, \mathcal{L}, \qquad \nabla_\mu T^{\mu\nu} = 0$$

*Note: No specific form of $\mathcal{L}$ is required for this argument beyond locality, positivity of energy density, and the existence of a conserved stress–energy tensor.*

We define the Energy Density ($u$) and Flux ($J^\mu$) relative to a local time vector $t^\nu$:

$$u = T^{00}, \qquad J^\mu = T^\mu{}_\nu \, t^\nu$$

# 4. Derivation of Causality

We now prove that "Time" is the byproduct of the (1) mode's necessary self-perpetuation.

## 4.1. Sector Decomposition

The configuration space decomposes into disjoint sectors labeled by $\nu$. The evolution generated by $d(\star dU) = 0$ preserves sector labels except at singularities (Phase Slips). Therefore, a persistent entity satisfies:

$$\nu(t + \Delta t) = \nu(t) = 1$$

## 4.2. Persistence Forbids Stasis (The Proof)

Assume, for the sake of contradiction, that the field is static: $\Phi(t+\Delta t) = \Phi(t)$ for all $t$. This implies $\partial_t U = 0$ everywhere on the loop, which means the momentum flux density (energy flow) $T^{0i}$ must vanish.

However, for a loop with $\pi$-twist topology (the (1) mode), the phase gradient $\nabla\phi$ is non-zero and twisted. This implies nonzero spatial stress components ($T^{ij} \neq 0$). A static configuration with non-zero internal stress requires external support to maintain force balance ($\partial_j T^{ij} \neq 0$ without flow).

In a source-free vacuum, no such external force exists. Therefore, a static (1) mode violates local momentum balance. **Topology alone does not generate motion; rather, the incompatibility between nontrivial topology and static force balance in a source-free field enforces evolution.**

**Conclusion:** To maintain the (1) mode (Persistence), the field **cannot be static**.

$$\Phi(t + \Delta t) \neq \Phi(t)$$

Unlike conventional instabilities which depend on parameters, the instability of a static (1) mode is topologically protected.

### 4.3. Propagator Form of Cause–Effect

Let $\mathcal{P}_{\Delta t}$ be the evolution operator. On the persistent sector:

$$\Phi(t + \Delta t) = \mathcal{P}_{\Delta t}\, \Phi(t)$$

"Cause" is the state $\Phi(t)$. "Effect" is the state $\Phi(t+\Delta t)$. The link between them is not an axiom, but the **Propagator of Topological Persistence**. The effect is simply the next necessary configuration to prevent the loop from breaking.

## 5. Force from Stress–Flow

We can extend this to interactions. From $\nabla_\mu T^{\mu\nu} = 0$ in a stationary, spherically symmetric flow:

$$\partial_r T^{rr} + \frac{2}{r}\big(T^{rr} - T^{\theta}{}_{\theta}\big) = 0$$

For tangentially dominated energy transport (a spinning torus), $T^{rr} \approx -u(r)$. The induced radial acceleration on test configurations is:

$$a_r(r) \propto -\partial_r T^{rr}(r) \approx \partial_r u(r)$$

For configurations whose energy density exhibits vortex-like decay ($u(r) \sim 1/r$), this yields $a_r \sim -1/r^2$. Thus, this framework suggests a gravitation-like interaction arising from the **Organization of Energy Flow**, without the need to postulate intrinsic mass.

## 6. Conclusion

In the PNP framework, we do not need to postulate that "Time Flows" or "Gravity Attracts."

1. **Causality** is the result of **Topological Persistence** (the (1) mode implies $\partial_t \Phi \neq 0$).
2. **Force** is the result of **Stress-Energy Conservation** ($\nabla_\mu T^{\mu\nu} = 0$).

Reality is a self-driving machine: it moves because it is topologically forbidden from standing still.

# 7. References

1. **Palma, A., Rodriguez, A. M., Thorne, E.** (2025). *Deriving the Schrödinger Equation from Source-Free Maxwell Dynamics*. Preferred Frame Lab. https://writing.preferredframe.com/doi/10.5281/zenodo.18316984