The PNP Theory of Cause and Effect: Causality from Topological Persistence

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Abstract

We derive causality from first principles within the Point–Not–Point (PNP) framework. At its core lies the topological irreducibility of the (1) mode, the simplest closed oscillation of the scalar field U exhibiting a π phase inversion. This $\mathbb{Z}_2$ invariant enforces loop persistence and forbids extinction without a phase slip. From this, we prove that the state of such a mode must evolve in time, formalizing cause–effect as the inevitable action of the field propagator on a persistent topological sector. We extend the result to minimal self-awareness via internal imprints and derive a force law from energy–flow stresses that links causality to gravitation-like dynamics.

One-Sentence Summary

In PNP, conserved loop topology makes causality, self-imprint, and force from stress unavoidable.

Keywords

PNP, causality, topology, $\mathbb{Z}_2$ invariant, energy flow, stress–energy, self-imprint, gravitation

Introduction

In standard formulations, causality is assumed as a primitive ordering of events. In PNP, it emerges from topology: a minimally nontrivial loop of the scalar field U persists under evolution and necessarily advances its state. Thus, cause–effect is the temporal manifestation of topological persistence, not a separate axiom.

PNP framework and the (1) mode

Let $U : \mathcal{M} \to \mathbb{R}$ be a scalar energy field with envelope

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

A (1) mode is a closed loop C encircling a core such that one traversal advances ϕ by π, requiring two traversals to return to the initial phase.

Holonomy along C:

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

defines the $\mathbb{Z}_2$ index:

$$\nu = \frac{1 - H(C)}{2} \in \{0, 1\}.$$

Phase slips correspond to $\rho = 0$ at a point on C and are the only way to change ν.

Field dynamics and stress–energy

The source-free PNP equation is:

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

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

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

Energy density and flow (in any chosen time direction t^ν) are:

$$u = T^{00}, \qquad J^\mu = T^\mu{}_\nu\, t^\nu, \qquad \nabla_\mu J^\mu = 0.$$

Derivation of causality

1. **Sector decomposition by topology**

   The configuration space decomposes into disjoint sectors labeled by ν. Evolution generated by $d(\star dU) = 0$ preserves sector labels except at phase slips. Hence a (1) mode satisfies:

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

2. **Persistence forbids stasis**

   Let $\Phi(t)$ denote the full state (geometry and phase) of the loop. If $\Phi(t + \Delta t) = \Phi(t)$ for an interval, then $\partial_t U = 0$ on the loop and its neighborhood, implying vanishing local exchange of field momentum. For a persistent (1) loop with nonzero stored energy, this would only be compatible with a phase slip or extinction, both excluded in the sector $\nu = 1$. Therefore:

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

   i.e., the state advances.

3. **Propagator form of cause–effect**

   Let $\mathcal{P}_{\Delta t}$ be the evolution operator induced by $d(\star dU) = 0$. On the $\nu = 1$ sector:

   $$\Phi(t + \Delta t) = \mathcal{P}_{\Delta t}\, \Phi(t), \qquad \mathcal{P}_{\Delta t} \text{ invertible on the sector,}$$

   establishing effect as the next state required by the propagator acting on a persistent loop.

4. **Arrow from energy flow**

   Choose the time orientation by $J^0 > 0$. Then the ordered pair $(\Phi(t), \Phi(t + \Delta t))$ is fixed by (ν, J^0) without an extra causality postulate.

Minimal self-awareness from internal imprints

Let m_t be an internal imprint extracted from $\Phi(t - \tau)$ and retained in the loop. If it modulates the next state beyond the information in $\Phi(t)$, then:

$$I(m_t;\, \Phi(t + \Delta t) \mid \Phi(t)) > 0,$$

where I denotes conditional mutual information. Loop topology preserves the structure that carries m_t, yielding minimal self-awareness as imprint-enabled prediction.

Force from stress–flow

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 (angle-averaged), $T^{rr} \approx -u(r)$. The induced radial acceleration on compact test configurations is:

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

When $u(r) \sim 1/r$ at large r, this yields $a_r \sim -1/r$ and asymptotically flat rotation curves. Thus a force law emerges from the organization of energy flow and stress, not from added matter.

Results

- Causality derived as the inevitable evolution of a persistent topological sector.
- Cause–effect formalized as propagator action on $\nu = 1$ loops.
- Minimal self-awareness defined by positive imprint information on the next state.
- Central acceleration arises from stress–flow without invoking additional substances.

Discussion

In PNP, causality is not assumed; it is a corollary of topological persistence and conserved energy flow. The same structure that guarantees temporal progression also supports imprint retention and a force-from-flow mechanism, unifying logic, memory, and dynamics in one field description.

Conclusion

Topological persistence ($\nu = 1$) implies state advancement, which is causality. Internal imprints make that advancement informed. Stress–energy organization produces effective forces. Causality, awareness, and gravitation-like behavior arise as facets of one scalar-field ontology.

Next Work

- Quantify imprint strength and its predictive advantage across nested loops.
- Compute lensing and time-delay signatures from stress–flow profiles.
- Classify phase-slip events as controlled transitions between causal histories.
- Extend multi-loop interactions and sector algebra for composite systems.

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References

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