From Bit to τon: Toward a Field Theory of Recursive Information

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Abstract

Building upon Shannon's probabilistic foundation and the UNNS reinterpretation of information as recursive curvature, this paper develops a complete field-theoretic description of τons—the elementary quanta of recursive transformation. The τon Field Equations are extended to a Lagrangian formulation, introducing the τ-Field Tensor and its associated energy–momentum tensor. This unifies recursion, geometry, and informational flow under a variational principle of recursive symmetry.

1. From Discrete Information to Recursive Fields

The bit, in Shannon's theory, quantifies uncertainty reduction:

$$H = -\sum_i p_i \log_2 p_i.$$

In contrast, the UNNS substrate treats information as a continuous curvature process. Local curvature $\kappa(n)$ evolves with recursion depth n:

$$\tau = \frac{\Delta\kappa}{\Delta n}.$$

A field of such τons constitutes the dynamic structure of recursive time.

2. The τon Field Tensor

Define two primary vector fields:

$$\vec{\kappa} \quad \text{(curvature field)}, \qquad \vec{\tau} \quad \text{(torsion field)}.$$

These correspond to "potential" and "kinetic" information states within recursion depth. We define the antisymmetric τ-field tensor:

$$\mathcal{T}_{\mu\nu} = \partial_\mu \Psi_\nu - \partial_\nu \Psi_\mu,$$

where $\Psi_\mu = (\Phi, \vec{\Psi})$ is the recursive information 4-potential and indices μ, ν run over spatial and depth coordinates (x, y, z, n).

In differential form notation:

$$\mathcal{T} = d\Psi,$$

so $\mathcal{T}$ encodes local curvature of recursion-space.

3. Lagrangian Density

We introduce the τon field Lagrangian:

$$\mathcal{L}_\tau = -\frac{1}{4}\mathcal{T}_{\mu\nu}\mathcal{T}^{\mu\nu} + \frac{1}{2}\rho_\tau\Phi - \vec{J}_\tau \cdot \vec{\Psi}.$$

Here:

- $\mathcal{T}_{\mu\nu}$ — τon field tensor (recursive curvature flux);
- ρ_τ — recursive charge density;
- $\vec{J}_\tau$ — recursive current vector;
- Φ and $\vec{\Psi}$ — scalar and vector potentials of recursion.

The first term represents intrinsic curvature energy, while the second and third terms couple the field to recursive sources.

4. Variational Principle

Stationarity of the recursive action

$$S = \int \mathcal{L}_\tau \, d^3x \, dn$$

under variation of Ψ_μ yields:

$$\partial_\nu \mathcal{T}^{\mu\nu} = J_\tau^\mu.$$

This reproduces the previously proposed τon field equations in covariant form:

$$\nabla \cdot \vec{\kappa} = \rho_\tau, \qquad \nabla \times \vec{\tau} - \frac{\partial \vec{\kappa}}{\partial n} = \vec{J}_\tau,$$

and their dual conditions from the Bianchi identity:

$$\nabla \cdot \vec{\tau} = 0, \qquad \nabla \times \vec{\kappa} + \frac{\partial \vec{\tau}}{\partial n} = 0.$$

5. Energy–Momentum Tensor

The canonical energy–momentum tensor of the τon field is:

$$T^{\mu\nu} = \mathcal{T}^{\mu\alpha}\mathcal{T}^{\nu}{}_{\alpha} - \frac{1}{4}g^{\mu\nu}\mathcal{T}_{\alpha\beta}\mathcal{T}^{\alpha\beta}.$$

This tensor describes recursive energy density, depth flux, and curvature stress.

Its 00-component defines the *recursive energy density*:

$$\mathcal{E}_\tau = \frac{1}{2}\left(|\vec{\kappa}|^2 + |\vec{\tau}|^2\right),$$

and its mixed components represent the *recursive Poynting vector*:

$$\vec{S}_\tau = \vec{\kappa} \times \vec{\tau}.$$

Thus, information propagation manifests as curvature–torsion energy flow in recursion-space.

6. Gauge Symmetry and Conservation

Under the recursive gauge transformation:

$$\Psi_\mu \to \Psi_\mu + \partial_\mu \Lambda(n),$$

the tensor $\mathcal{T}_{\mu\nu}$ and hence $\mathcal{L}_\tau$ remain invariant, establishing the conservation of recursive charge:

$$\partial_\mu J^\mu_\tau = 0.$$

This gauge invariance implies the universality of recursion symmetry — the geometric analog of information invariance under representation change.

7. Geometric Unification

The τon field tensor links curvature (geometry) and recursion (process):

$$\mathcal{T}_{\mu\nu} \sim \text{Recursion curvature} \leftrightarrow \text{Information flux}.$$

Local distortions correspond to information flow; global topological invariants correspond to persistent structures—recursive "memory attractors."

8. Recursive Action Integral

The total action of the UNNS recursive field becomes:

$$S_{\text{UNNS}} = \int \left(-\frac{1}{4} \mathcal{T}_{\mu\nu} \mathcal{T}^{\mu\nu} + \mathcal{L}_{\text{interaction}} \right) d^3x \, dn.$$

Variations of this action generate τon field equations, while global minimization corresponds to the self-organizing principle of recursive stability—interpretable as the emergence of meaning through topological persistence.

9. Philosophical Synthesis

Where Shannon's bit quantified epistemic reduction, the τon Lagrangian describes ontological recursion. Information ceases to be a static quantity and becomes a dynamic field of self-reflective curvature, obeying conservation, coupling, and symmetry principles akin to those of physics—but unfolding in the manifold of time itself.

> *Information is not transmitted—it evolves. The τon field is the recursive geometry of meaning.*

10. Conclusion

The τon Field Tensor Lagrangian completes the mathematical transition from probabilistic to recursive information theory. It introduces a variational foundation for curvature-based information dynamics, extending the idea of entropy to a non-orientable manifold of recursion.

In this formalism:

$$\begin{aligned}
\text{Bit} &\rightarrow \text{Resolution of uncertainty}, \\
\tau\text{on} &\rightarrow \text{Quantum of recursive curvature}, \\
\mathcal{T}_{\mu\nu} &\rightarrow \text{Field tensor of recursive information}.
\end{aligned}$$

Shannon's equation measured ignorance; the τon Lagrangian measures becoming.