The Meta-Principle of Structural Self-Consistency and its Realization in Temporal Synchronization Theory

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This paper introduces and formalizes the meta-principle of structural self-consistency as a criterion for evaluating the fundamental status of physical theories. This principle requires that a theory's principle of action and its fundamental operators mutually justify each other in a closed logical loop, thereby eliminating the arbitrariness of postulates. We demonstrate that Temporal Synchronization Theory (TST)—with its principle of minimal desynchronization $\delta\langle\hat{I}\rangle = 0$ and its operator $\hat{I} = \hat{I}_{\text{sync}} + \hat{I}_{\text{grad}} + \hat{I}_{\text{ent}}$—is a paradigmatic example of a structurally self-consistent theory. In contrast, classical theories such as Lagrangian mechanics and standard quantum mechanics, despite their empirical effectiveness, fail to meet this condition.

I. THE META-PRINCIPLE OF STRUCTURAL SELF-CONSISTENCY

This work define a *justification loop* as a bidirectional logical relationship between the principle of action and the structure of the operators of a physical theory:

- **Direction 1 (Principle → Operator):** The principle of action must constrain the fundamental properties of the theory's operators, such as locality, additivity, unitarity, or analytical form.
- **Direction 2 (Operator → Principle):** The specific form of the operators must justify the adoption of the principle by leading to stable, emergent, and falsifiable consequences.

A theory satisfying both conditions achieves structural self-consistency, eliminating arbitrariness and replacing it with internal logical necessity.

II. TEMPORAL SYNCHRONIZATION THEORY AS A SELF-CONSISTENT FRAMEWORK

TST describes emergent reality arising from the dynamics of a discrete Planck-scale network minimizing a global desynchronization operator.

A. Axioms and Derivation of the Operator

The foundation of TST is based on the following axioms:

1. **Existence:** A discrete Planck network exists.
2. **Additivity:** Total desynchronization is the sum of local contributions:
$$\langle\hat{I}\rangle = \sum_n f(n)$$
3. **Locality:** $f(n)$ depends only on node n and its neighbors.
4. **Linearity:** Evolution equations are first-order in time.

From these axioms, the operator must be additive, local, and quadratic:

$$\hat{I} = \sum_n \left[A(\Delta\hat{\omega}_n)^2 + B \sum_{m\in N(n)} (\hat{T}_m - \hat{T}_n)^2 + C(X_n)\hat{S}_n \right] \tag{1}$$

where:

- $\Delta\hat{\omega}_n$ is the time-energy desynchronization,
- $\hat{T}_n$ is the local time operator,
- $\hat{S}_n$ is the informational entropy operator,
- $C(X_n)$ is a coupling function depending on the configuration type.

B. Realization of the Justification Loop

- **Principle → Operator:** The principle $\delta\langle\hat{I}\rangle = 0$ constrains the operator to the form in Eq. 1.
- **Operator → Principle:** Only this form leads to:
  - Stable particle-like solutions,
  - Emergent spacetime and gravity,
  - Predictive constants (e.g., α, α_s),
  - Falsifiable effects (e.g., gravity–entropy coupling).

III. COMPARISON WITH NON-SELF-CONSISTENT THEORIES

A. Classical Mechanics

The principle $\delta S = 0$ does not constrain the form of $L = T - V$, which is chosen ad hoc. Likewise, L does not justify the principle.

B. Standard Quantum Mechanics

The Schrödinger equation $\hat{H}\,|\Psi\rangle = i\hbar\partial_t\,|\Psi\rangle$ does not constrain the form of $\hat{H}$, which is constructed from symmetry or analogy. The equation and operator are modular and independent.

IV. CONCLUSION

This work introduced the meta-principle of structural self-consistency and showed that TST uniquely satisfies it. Classical theories fail this criterion, revealing their effective, non-fundamental nature. TST, by closing the justification loop, stands as a strong candidate for a fundamental theory of everything. Future work should focus on experimental verification of its key predictions, such as gravity–entropy coupling.

[1] S. Mroczek, *Zunifikowana Pregeometria: Teoria Synchronizacji Czasowej*, Internal Research Notes ZNCW_8_0, ZNCW_9_0, ZNCW_10_0 (2025).

[2] A. Einstein, *The Field Equations of Gravitation*, Preussische Akademie der Wissenschaften (1915).

[3] S. Weinberg, *The Quantum Theory of Fields*, Cambridge University Press (1995).

[4] J. D. Bekenstein, *Black Holes and Entropy*, Phys. Rev. D **7**, 2333 (1973), DOI: 10.1103/PhysRevD.7.2333.

[5] S. W. Hawking, *Particle Creation by Black Holes*, Commun. Math. Phys. **43**, 199 (1975), DOI: 10.1007/BF02345020.