Kernel Classification of Physical Distinctions

January 31, 2026

Subject: Comparative analysis of electron identity and time orientation under Kernel access constraints.
Framework: History-Augmented Configuration Space $\mathcal{X}$ with Observer-Dependent Observable Algebra $\mathcal{O}$.

Abstract

We present a general Kernel Law decision procedure for classifying proposed physical distinctions. By analyzing whether a distinction lies within the Kernel of an observer's observable algebra or can be lifted via a physically realizable algebraic upgrade, we distinguish between gauge redundancies and emergent observables. We apply this framework to two canonical cases: electron identity and time orientation. We show that global worldline connectivity is an ontologically void gauge choice, while temporal directionality emerges as a physical observable for observers equipped with memory. This work formalizes the boundary between what is calculable in theory and what is knowable in physical observation.

1. Calculation Methodology — Kernel Law Framework

The physical status of any proposed distinction Δ is determined by its relation to the Kernel of the observer's observable algebra.

- **History Space ($\mathcal{X}$):** The space of all admissible micro-histories (field configurations or trajectories over spacetime).
- **Observable Algebra ($\mathcal{O}$):** The set of operators corresponding to measurements physically accessible to the observer.
- **Kernel (Equivalence Definition):** Two histories $x, x' \in \mathcal{X}$ are Kernel-equivalent iff

  $$\langle \hat{O} \rangle_x = \langle \hat{O} \rangle_{x'} \quad \forall \hat{O} \in \mathcal{O}.$$

  The physically accessible state space is the quotient

  $$\mathcal{X}_{\text{phys}} = \mathcal{X}/\mathcal{K}.$$

Decision Rule (Kernel Access Theorem)

- If Δ lies entirely within $\mathcal{K}$, it is a *gauge redundancy*.
- To promote Δ to a physical distinction, $\mathcal{O}$ must be upgraded to include an operator $\hat{O}_\Delta$ resolving it.
- If the required upgrade violates fundamental physical constraints, the distinction is *ontologically void*.
- If the upgrade is physically realizable, the distinction is *emergent*.

2. Case A — Electron Identity and Worldline Connectivity

Hypothesis: All electrons are segments of a single globally connected worldline.

Calculation

- **Symmetry Group:** For N indistinguishable fermions, the Hamiltonian and all local observables commute with the permutation group S_N.
- **Kernel Mapping:** For any history x and permutation $\sigma \in S_N$,

  $$x \sim \sigma(x),$$

  so that

  $$\mathcal{X}_{\text{phys}} = \mathcal{X}/S_N.$$

- **Topological Extension:** The proposed distinction depends on a global connectivity functional $\mathcal{C}[x]$.
- **Access Verification:** Resolving $\mathcal{C}[x]$ requires non-local access to spacetime-separated field segments, violating locality and cluster decomposition.

Result

The required algebraic upgrade is forbidden. Electron identity and worldline connectivity remain strictly in the Kernel.

Final Classification: *Strict Gauge Redundancy.*

3. Case B — Time Orientation

Hypothesis: Forward and backward histories are physically distinguishable.

Calculation

- **Symmetry Group:** The dynamics are time-reversal invariant, commuting with $\mathcal{T}$ ($\mathbb{Z}_2$).
- **Base Observer:** A memoryless observer measures only instantaneous state $\rho(t)$; equilibrium statistics are time-symmetric.
- **Kernel Mapping:** For such observers,

$$\mathcal{X}_{\text{phys}} = \mathcal{X}/\mathbb{Z}_2.$$

- **Observer Upgrade:** A Feedback-Stabilized Observer equipped with internal memory M_t introduces a stability metric S.
- **Access Verification:** On mixing substrates, feedback stabilizes forward evolution and destabilizes time-reversed evolution using only local memory and dissipation.

Result

The upgrade is physically realizable. Time orientation is lifted out of the Kernel for observers with memory depth $M \geq 1$.

Final Classification: *Emergent Observable.*

4. Summary Classification

Feature	Case A: One Electron	Case B: Arrow of Time
Distinction	Global worldline topology	Temporal directionality
Symmetry Group	S_N	$\mathbb{Z}_2$
Base Status	Kernel (gauge)	Kernel (gauge)
Required Upgrade	Non-local operator	Memory + feedback
Physical Viability	Forbidden	Allowed
Final Status	Metaphysical gauge	Emergent observable

5. Conclusion — Kernel Access Theorem

A distinction located in the Kernel of a base observer becomes physical if and only if the observable algebra upgrade required to resolve it is realizable within the laws of physics.

Electron identity fails this test. Time orientation passes it.