Global Worldline Selection, Reflection Invariance, and the De Giuseppe Theorem

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Abstract

We introduce a spacetime selection framework in which quantum and relativistic phenomena are governed by globally admissible configurations of worldlines. Reflection, quantum entanglement, and relativistic consistency emerge naturally without modifying local dynamics. We propose a universal spacetime emergence threshold, expressed as the *De Giuseppe theorem*, to quantify the minimal action required for a configuration to become physically selectable. A key illustrative example is reflection from extended relativistic systems, such as fast-moving trains, where global coherence explains the observed invariance of reflected images.

1 Motivation

Quantum mechanics and relativity successfully describe local interactions, yet they do not explain why only specific spacetime histories are realized. Phenomena such as entanglement, interference, and relativistically consistent reflection suggest that physical reality is constrained not only locally but also globally.

We propose that physical events correspond to globally admissible configurations of worldlines, selected by a spacetime-level criterion.

2 Reflection and the moving train paradox

Consider an observer looking at their own reflection on the side of a long train moving at high constant velocity. Empirically, the observer sees a stable, non-distorted reflected image, even though the reflecting surface is in relativistic motion.

Locally, photon-electron interactions occur continuously along the train surface. However, no single local interaction explains why the reflected image appears stationary and coherent across the entire surface.

In the proposed framework, the explanation is global:

> The reflected photons belong to a single globally admissible worldline configuration connecting emission, reflection, and detection.

Only spacetime configurations in which the full set of photon worldlines remains causally accessible and phase-consistent across the extended object are selectable. Configurations that would produce distorted or incoherent reflections are globally inadmissible, even if locally allowed.

Thus, the reflection invariance does not arise from a force or signal propagating along the train, but from a global spacetime constraint.

3 Global worldline selection principle

We formalize this idea through the following principle:

> A spacetime configuration of worldlines is physically realized if and only if it satisfies local equations of motion and exceeds a minimal global emergence threshold.

This threshold is quantified by a universal constant introduced below.

4 The De Giuseppe theorem

We define the *configurational emergence time* τ_C as the minimal time required for a spacetime configuration to become operationally selectable as a single physical entity:

$$\tau_C = \frac{K_D}{E_{\text{bound}} + E_{\text{grav}}} F_C$$

where $F_C \in (0, 1]$ is a dimensionless configurational coherence factor.
We now give an explicit form for the De Giuseppe constant K_D:

$$K_D = \alpha \, \hbar \, \frac{E_{\text{scale}}}{E_{\text{bound}} + E_{\text{grav}}}$$

where:

- $\hbar$ is the reduced Planck constant, representing the fundamental quantum of action,
- E_{scale} is a reference energy scale characteristic of the system (e.g., photon energy, atomic binding energy),
- $\alpha \sim 1$ is a dimensionless calibration factor,
- E_{bound} is the total binding energy stabilizing the configuration,
- E_{grav} is the accessible gravitational energy contribution.

4.1 Physical meaning

This theorem implies that configurations with higher accessible energy emerge faster, while poorly bound or incoherent configurations fail to reach global selectability. No new forces or modifications of quantum mechanics or relativity are introduced; the theorem encodes a universal emergence threshold based on fundamental constants.

5 Application to reflection

In the train example, the reflected photon field emerges on timescales far shorter than any macroscopic measurement resolution. The corresponding τ_C is extremely small due to the large binding energy and high coherence factor of the reflecting surface. As a result, the entire reflection process behaves as a single spacetime configuration, explaining the observed image stability without invoking instantaneous coordination or signaling.

6 Relation to quantum entanglement

Quantum entanglement corresponds to configurations in which multiple particles share a single globally admissible spacetime structure. No exchange of energy or information beyond local interactions is required. The De Giuseppe theorem sets the timescale for entanglement emergence and applies equally to microscopic and macroscopic systems, subject only to decoherence effects reducing F_C.

7 Relativistic consistency

Because the selection criterion is spacetime-based, Lorentz invariance is preserved. Different observers describe the same admissible configuration using different foliations, without contradiction.

8 Conclusion

By introducing a global worldline selection principle and the De Giuseppe theorem, we provide a unified interpretation of reflection, entanglement, and relativistic consistency. The framework remains fully compatible with established physics while clarifying why only specific spacetime histories are physically realized.