Entanglement as Non-Closure of Local Explanations:
A Reinterpretation of Bell via Lag Syntax

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Abstract

Entanglement is widely interpreted as evidence that physical reality itself is nonlocal. This paper argues that such an interpretation misidentifies the source of the problem. What is empirically observed in Bell-type experiments is limited to localized measurement outcomes and the statistical correlations revealed through their comparison. No global system state, nonlocal interaction, or superluminal influence is directly observed.

Bell's theorem demonstrates that no explanatory model can simultaneously satisfy locality, realism, and closure when reconstruction is required solely from local observational traces. It does not mandate the abandonment of locality as a physical principle. The common inference of nonlocal reality reflects an explanatory bias toward locally closed, state-based descriptions rather than a necessity imposed by the data.

We reclassify entanglement as a failure of local closure: the resistance encountered when globally coordinated update processes are forced into separable, locally complete explanatory models. Collapse and no-signaling are accordingly reinterpreted as inferential and structural necessities, not physical processes.

1 Introduction

Quantum entanglement has long been regarded as one of the most puzzling features of modern physics. Since the formulation of Bell's theorem, violations of Bell-type inequalities have frequently been interpreted as evidence that physical reality itself is nonlocal. This conclusion has motivated a wide range of ontological proposals, including nonlocal hidden variables, holistic physical states, and non-separable causal structures.

In this paper, we argue that such interpretations exceed what Bell's theorem strictly establishes. The theorem does not diagnose nonlocal reality. Rather, it exposes a structural limitation in a class of explanatory frameworks that attempt to maintain local closure while reconstructing global correlations from local observational data.

The central claim advanced here is that entanglement is not a property of physical systems, but a symptom of explanatory failure. Specifically, it arises when globally coordinated physical updates are retrospectively forced into locally closed, state-based models that are structurally incapable of reproducing the observed correlations.

2 What Is Actually Observed

Bell-type experiments provide access only to two empirical elements: localized measurement outcomes recorded at spatially separated sites, and statistical correlations revealed through the comparison of these outcomes. No experiment directly observes a global system state, a nonlocal interaction, or a causal influence propagating between distant events.

Each observer encounters only a local trace: a discrete outcome registered within a specific observational context. Correlations emerge only at the level of aggregated data and are identified through inferential procedures applied after the fact. Treating such correlations as evidence of underlying nonlocal processes already presupposes an explanatory framework that demands local reconstructability.

The empirical content of Bell violations therefore does not compel any particular ontological conclusion. It merely demonstrates that certain joint probability distributions cannot be reproduced by locally closed models under specific assumptions.

3 Bell's Theorem and the Failure of Local Closure

Bell's theorem establishes that no explanatory model can simultaneously satisfy locality, realism, and closure while reproducing the correlations observed in certain quantum experiments. Importantly, the theorem does not privilege locality as the assumption that must be abandoned.

The frequent conclusion that physical reality is nonlocal reflects an interpretive preference rather than a logical necessity. Locality is preserved at the level of observable signaling: no Bell-type experiment enables superluminal communication. What fails is not locality of interaction, but locality of explanation.

From an observational standpoint, the demand that correlations be reconstructed from locally specified states is an explanatory imposition. When this demand cannot be satisfied, explanatory closure fails. Bell's theorem thus functions diagnostically, marking the boundary beyond which locally closed, state-based explanations cease to apply.

4 Entanglement as a Syntactic Artifact

We define entanglement as follows:

> Entanglement is the structural resistance encountered when one attempts to reconstruct globally coordinated update processes from local observational traces using a locally closed, state-based explanatory syntax.

On this view, entanglement does not denote a physical linkage between distant systems. It marks the non-reconstructability of global coordination from local traces under separable explanatory assumptions. The phenomenon is not that systems are entangled, but that the explanatory syntax fails to close.

Entanglement is therefore a property of explanation, not of physical systems. It identifies the limit of state-centric description rather than a new form of physical interaction.

5 Collapse and No-Signaling as Inferential Necessities

Wavefunction collapse is commonly treated as a physical process. Within the present framework, collapse is reinterpreted as an inferential transition. When a localized trace becomes accessible, an inferential representation is updated to reflect a single outcome. No physical collapse occurs.

Similarly, the no-signaling condition follows as a structural consequence of limited observational access. Observers can access only local traces and have no control over global update coordination. As a result, correlations cannot be used to transmit information superluminally.

Both collapse and no-signaling arise from the same source: the mismatch between global update structure and local trace accessibility. They are necessities of inference, not fundamental dynamical features of nature.

6 Conclusion

Entanglement does not indicate nonlocal physical reality. It reveals the failure of locally closed, state-based explanation when confronted with globally coordinated updates and locally restricted observation.

Bell's theorem diagnoses the limits of explanatory closure, not the structure of physical ontology. Collapse and no-signaling emerge naturally once explanation is disentangled from physical process.

Entanglement thus marks the boundary of a particular explanatory regime. Recognizing this boundary dissolves the associated paradox without altering the empirical content of quantum theory.