Section 4. Nonlocality Without Signaling

One of the most persistent conceptual tensions in quantum theory is the coexistence of nonlocal correlations with relativistic causality. Experiments reveal correlations between spacelike separated systems that appear effectively instantaneous, whereas relativity excludes any causal influence propagating faster than light. In standard discussions, this tension is usually managed by invoking the no-signaling principle as an external consistency condition.

CUWF addresses the problem at a deeper structural level. In this framework, nonlocality does not arise from superluminal influence, hidden transmission, or delayed communication. It arises from entropic synchronization encoded in collapse-link topology. As a result, signaling is not merely prohibited; it is structurally impossible.

4.1 Why Nonlocality Appears Paradoxical

Nonlocality appears paradoxical because two different observations are routinely conflated:

- spacelike separation of measurement events,
- and strong or apparently instantaneous correlation between outcomes.

Within a spacetime-centered causal framework, this combination is immediately interpreted as implying some form of influence propagating between the systems. The underlying intuition is powerful: if two distant events are correlated, then something must have traveled between them.

That intuition, however, rests on a category mistake. Correlation is a property of joint outcome structure, whereas signaling requires additional features such as directionality, controllability, and causal dependence. The mere existence of correlation does not by itself imply transmission.

In standard quantum mechanics, entanglement is represented through non-factorizable states in Hilbert space. Although this representation reproduces the correct outcome statistics, it does not

sharply distinguish between correlation as an observational fact and influence as a dynamical process. The result is that nonlocal correlation is easily misread as hidden signal transmission.

The paradox is therefore not fundamentally physical. It is conceptual. It arises from interpreting correlation within a framework that assumes all dependencies must be mediated by spacetime processes.

4.2 CUWF Resolution: No Signal, No Influence

In CUWF, entangled systems are not connected by influence or communication. They are connected by shared entropic structure established prior to measurement.

Let C_1 and C_2 denote the collapse configurations of two subsystems. These configurations are not independent. They belong to a common collapse-link topology defined by shared entropic constraints.

The key structural consequences are straightforward:

- No entity propagates from C_1 to C_2.
- No causal arrow exists between the measurement events.
- No local outcome exerts influence on the distant subsystem.

Instead, both subsystems evolve within the same entropic synchronization class. What is synchronized is not the outcome as such, but the space of allowed collapse pathways. In other words, the systems do not respond to one another across space; they co-evolve under a common constraint geometry that restricts which joint outcomes are admissible.

Correlation therefore emerges without transmission, influence, or interaction in the usual dynamical sense.

4.3 Formal Statement: Constraint-Based Correlation

The distinction between causal transmission and constraint-based correlation may be stated more explicitly. Let Ω denote the shared entropic constraint set defining the collapse-link topology, and let o_1 and o_2 denote measurement outcomes.

In a signaling-based interpretation, one would implicitly assume a dependence of the form:

$$P(o_1, o_2) = P(o_1 \mid C_2 \longrightarrow C_1)$$

CUWF rejects this structure. Instead, outcome correlations arise as:

$$P(o_1, o_2 \mid \Omega) = P(o_1, o_2 \mid C_1 \in \Omega \wedge C_2 \in \Omega)$$

The correlation is therefore determined by membership in the same constraint-defined collapse class.

The synchronization condition underlying this structure may be expressed as:

$$\Delta E(C_1 - C_2) \longrightarrow 0$$

where ΔE is the entropic Laplacian. This condition does not imply identity of states, nor does it imply dynamical convergence in spacetime. It indicates structural alignment under shared entropic constraints.

Correlation is thus a geometric property of collapse space rather than a consequence of causal influence.

4.4 Compatibility with Relativity

Relativity constrains the propagation of signals, information, and causal influence within spacetime. CUWF nonlocality operates outside that domain altogether.

Entropic synchronization is treated as:

- pre-spacetime,
- pre-temporal,
- and non-dynamical in the relativistic sense.

It does not involve propagation, velocity, or temporal ordering. For that reason, it cannot violate relativistic causality, because it does not participate in spacetime processes to begin with.

From the CUWF perspective, no event occurs 'faster than light' because no event travels at all. Correlated outcomes are manifestations of a shared structural substrate, not the result of any superluminal mechanism.

Relativity therefore remains intact not because CUWF imposes an external restriction, but because the domain of synchronization lies outside the class of processes to which relativistic propagation constraints apply.

4.5 Relation to the No-Signaling Theorem

In standard quantum theory, the no-signaling theorem is usually presented as a principle: although nonlocal correlations exist, they cannot be used to transmit information. CUWF reverses that explanatory order.

Within CUWF, no-signaling is not assumed first and justified later. It emerges from structure. Collapse-link topology contains no features that could support signaling:

- no direction,
- no capacity,
- no controllable modulation,
- and no degrees of freedom for information encoding.

Formally, if I denotes controllable information content, then for any collapse link:

$$\partial I / \partial C_{link} = 0$$

This is not a prohibition appended from outside the theory. It is a structural identity. There is simply nothing within the topology that could function as a communication channel.

No-signaling is therefore not a patch used to save causality. It is a theorem that follows naturally from the collapse-based structure of entanglement.

4.6 Section Summary

In CUWF, nonlocality is neither mysterious nor paradoxical. It does not involve hidden influence, superluminal transmission, or violations of causality. It is the natural consequence of entropic synchronization within a collapse-link topology that is fundamentally non-causal and non-temporal.

By resolving nonlocality at the structural level, CUWF removes the signaling paradox at its root and prepares the conceptual ground for the later treatments of time and causality in the CUWF series.