

Section 12. One Arrow, Three Domains

Across this paper, the arrow of time has been examined at three levels that are traditionally treated as separate: quantum measurement, thermodynamic irreversibility, and cosmic-scale directionality. Standard physical discourse often handles these arrows as distinct phenomena, only loosely connected, or even as conceptually independent problems requiring different explanations. Within the CUWF framework, they are none of these.

There is one arrow, expressed through three domains.

12.1 Quantum–Thermodynamic–Cosmic Unification

At the quantum level, the arrow appears as the irreversibility of measurement. At the thermodynamic level, it appears as entropy increase and macroscopic irreversibility. At the cosmic level, it appears as the directional accumulation of large-scale structure and the ordered expansion of realized history. CUWF argues that these are not three independent arrows requiring three unrelated foundations.

All three are expressions of the same structural mechanism: collapse-driven history creation under entropic asymmetry. The quantum arrow is the writing of measurement records through realization. The thermodynamic arrow is the accumulation of records as macroscopic constraint. The cosmic arrow is the hierarchical alignment of collapse-generated structure across scales.

The difference among the domains is therefore not the arrow itself, but the level at which realized history is written and made visible. What appears fragmented in standard discourse becomes unified once realization is treated as primary.

12.2 Why Arrows Align Across Scales

A long-standing puzzle in physics is why arrows at different scales point in the same direction. Why should the irreversibility of measurement align with thermodynamic entropy increase, and why should both align with the large-scale directionality of cosmic history? Within CUWF, this alignment is not an additional mystery. It is a structural consequence of constraint propagation.

Collapse events do not remain isolated. Once a history record is created, it becomes part of the condition-space for subsequent collapses. Through interaction, coupling, and shared constraints, local directionality is propagated across domains. The alignment therefore takes the form of a cascade:

local collapse \rightarrow constraint propagation \rightarrow domain coupling \rightarrow arrow coherence

Arrows align because realized history accumulates, and accumulated history cannot coherently point in multiple directions at once. Once constraint-writing becomes structurally directional, subsequent domains inherit and reinforce that direction rather than generate independent alternatives.

12.3 Why Conflicting Arrows Do Not Exist

If arrows were merely properties of time, entropy, or psychology considered in isolation, one might imagine the possibility of conflicting arrows: subsystems running backward relative to one another, or distinct domains possessing incompatible temporal directions. CUWF excludes such scenarios at the structural level.

Because the arrow is defined as a partial order on realized history states, conflicting arrows would require incompatible orderings of the same realized history structure. Such orderings are not physically realizable once records and constraints have been written into a common domain of historical dependence.

Different subsystems may certainly exhibit different rates of history creation, different scales of stabilization, and different local magnitudes of irreversible behavior. But they do not possess different directions in the strong ontological sense relevant here. Direction is fixed by realization itself. There is

no coherent physical operation that could create a realized record while simultaneously undoing the constraints that this realization imposes elsewhere in the same history structure.

Conflicting arrows therefore do not fail merely as a matter of empirical accident. They fail as a matter of structural impossibility.

12.4 Stability of Arrow Direction

The CUWF framework also explains why the arrow is not only aligned across domains, but stable. Once collapse directionality and entropic bias are in place, reversal of the arrow would require erasing realized history, reconstructing unrealized alternatives, and undoing propagated constraints across scales.

As shown throughout the preceding sections, none of these operations are structurally defined. Reverse collapse is undefined. Reverse history writing is undefined. Constraint erasure without contradiction is undefined. The arrow therefore remains stable not because an external law continuously enforces its direction, but because realization itself has no inverse operation.

Direction is not dynamically maintained in the manner of a force. It is structurally locked by the non-invertibility of history creation. That is why temporal directionality remains coherent across quantum, thermodynamic, and cosmic domains without needing a separate stabilizing mechanism at each scale.

Unified Resolution

The conclusion of this section may therefore be stated plainly. There is one arrow, not many. It appears across quantum, thermodynamic, and cosmic domains because all three are expressions of collapse-driven history creation under entropic asymmetry. Alignment follows from constraint propagation. Stability follows from non-invertible realization. The arrow of time is not time itself. It is the structural signature of how reality becomes definite.