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Abstract

We argue that temporal direction does not require an external clock or a privileged first instant. Time is the parameter that maximizes joint predictability among coupled observables under a minimal admissibility set. Given reversible microdynamics, the admissibility set restricts the space of attainable histories and thereby induces asymmetric gradients in the present, selecting an arrow without invoking teleology. This operational criterion unifies thermodynamic and cosmological arrows as instances of the same constraint mechanism: when admissibility suppresses late-time macroscopic complexity, the two arrows coincide; when the constraint flattens, effective time symmetry is recovered. We extend the framework across domains by treating grammatical constraints as admissibility sets over sequences, yielding an operational notion of discourse directionality defined by the same predictability maximization. Three toy models, a coarse-grained gas, a coupled lattice, and an FRW sketch with bounded late-time curvature, illustrate the mechanism and delimit its empirical signatures.

1. Introduction

1.1 The problem the paper targets

Most discussions of temporal direction still rely on one of two anchors. Either the arrow is attributed to a privileged beginning, typically phrased as a low-entropy initial condition, or "time" is treated as an external parameter read off a clock. Both moves import a reference point that the explanation quietly presupposes, rather than derives. A second issue follows from this: multiple arrows are often discussed as separate phenomena that must be aligned by narrative or by extra assumptions, rather than by a single operational criterion that can be applied uniformly across domains.

This paper takes the opposite route. It assumes reversible microdynamics at the level where reversibility is typically asserted, and it asks what must be added, minimally, to make a direction emerge at the level of macroscopic observables without postulating a first instant or invoking a clock as an explanatory primitive.

1.2 Central operational definition

The core move is to define "time" as an operational parameter, not as a metaphysical substrate:

Time is the parameter that maximizes joint predictability among coupled observables under a minimal admissibility set.

The definition does three things at once. First, it replaces clock-reading with predictive performance: if a parameterization is "time" for a system, it is because it orders observations so that the coupled observables predict each other best. Second, it makes direction a property of the space of histories under constraints, not a property assumed at the start. Third, it is portable across domains because it does not require a specific physical ontology. It requires only observables, coupling, and an admissibility set that restricts which terminal configurations count as allowed.

1.3 Admissibility is constraint, not teleology

The admissibility set is a family of allowed terminal configurations, not a target microstate and not a goal. It can be specified in different ways depending on the system: as a bound on late-time macroscopic complexity, as a band on large-scale curvature and homogeneity, as a sparsity condition, or as any minimal restriction that meaningfully compresses the space of histories. The concept is non-teleological in the strict sense that it does not claim the system "aims" at an end. It only claims that, conditional on admissibility, the set of viable histories is not symmetric with respect to orientation once one looks at the induced behavior of coarse observables.

Under reversible microdynamics, directionality cannot be extracted from micro-laws alone. The admissibility set is the minimal additional ingredient that selects a preferred orientation because it restricts what counts as an allowable ending, which then changes which present gradients are compatible with that restriction.

1.4 What the paper claims, in operational terms

The paper claims that if the admissibility set is non-trivial, directionality emerges as a selection effect on histories when evaluated at the level of coupled observables. Concretely, the paper advances three claims.

First, an arrow exists when the admissibility set varies non-trivially with the terminal parameterization and the coupling to present observables is non-zero. In that case, the space of histories acquires an orientation that is detectable as systematic asymmetry in present structural measures and present correlation measures.

Second, the alignment of arrows becomes a single problem: different arrows coincide when they are different projections of the same admissibility mechanism. When admissibility suppresses late-time macroscopic complexity, the thermodynamic arrow and a cosmological arrow become aligned instances of the same constraint logic rather than independent arrows that require separate stories.

Third, the paper proposes a disciplined use of "origin." Origins are not treated as a first instant but as an operational notion: it is legitimate to speak of an origin only when the

admissibility set leaves non-degenerate present signatures, meaning the restriction is strong enough to produce distinguishable present patterns rather than being effectively flat.

1.5 Why linguistics belongs in the core, not as an analogy

The cross-domain move is not: "physics has an arrow, language has an arrow, therefore they are similar." The move is: the same operational definition of direction can be applied to any system in which sequences are generated under constraints and measured by predictability among coupled observables.

In linguistics, grammatical constraints define admissible continuations and admissible closures. That is an admissibility structure over sequences. If one treats constructions or features as coupled observables, one can define discourse directionality by the same criterion: the ordering parameter that maximizes joint predictability under a minimal admissibility set. This makes linguistics a testbed for the general mechanism because constraints and admissibility are explicit and measurable, and because directionality in discourse can be operationalized without importing a physical clock.

This integration is also methodologically stabilizing: it prevents the framework from looking like a purely physical proposal that is later "applied" to language. Instead, the framework is defined at the level of admissibility and predictability, and physics and linguistics appear as two domains in which the same operational structure can be instantiated with different observables.

1.6 What the paper does not claim

It does not introduce a new fundamental law. It does not assert a new physical constant. It does not claim violations of conservation. It does not claim the universe is goal-directed. It also does not claim that a terminal constraint is empirically established in nature in any specific form; rather, it provides a criterion: if admissibility constraints exist and are non-trivial, they should leave specific present signatures in predictability structure and correlation structure, and if those signatures are absent, the framework has clear failure modes.

1.7 Roadmap

Section 2 defines coupled observables, minimal admissibility sets, and the predictability functional that yields an operational time parameter. Section 3 states propositions for directionality, coincidence of arrows, and symmetry recovery. Section 4 provides three toy models, a coarse-grained gas, a coupled lattice, and an FRW sketch, chosen to show the mechanism without heavy formalism. Section 5 treats observability, limits, and falsification conditions. Section 6 positions the framework against low-entropy initial condition narratives, first-instant rhetoric, and purely quantum-emergent time accounts. Section 7 concludes with the operational meaning of origin and the cross-domain unification of directionality.

2. Conceptual Framework

2.1 Minimal objects of the framework

The framework assumes only three ingredients.

First, a set of observables $\mathcal{O}$ that are actually accessible at the scale where "arrow" talk becomes meaningful. These observables are coarse-grained by construction. They can be macrostates in a gas, order parameters in a lattice, low-order cosmological correlators, or constructional features in discourse.

Second, coupling. The observables must not be independent. There must exist non-trivial statistical or dynamical dependence across them, otherwise "joint predictability" collapses to independent predictability and no unified time parameter is forced.

Third, a minimal admissibility set A. This is a restriction on allowed terminal configurations of the system, specified as a family rather than as a single target. "Minimal" means it should be weak enough not to trivially impose a unique ending, but strong enough to compress the space of viable histories.

2.2 Coupled observables

Let $\mathcal{O}(t) = \{O_1(t), \dots, O_n(t)\}$ be a minimal sufficient set of observables. "Coupled" means there exists at least one pair (O_i, O_j) such that knowledge of one improves prediction of the other over time. Operationally, coupling can be stated without committing to a particular physical model:

- Statistical coupling: $I(O_i(t); O_j(t+\tau)) > 0$ for some τ.

- Dynamical coupling: conditional dependence persists under interventions or perturbations.

The framework does not require complete coupling among all observables. It requires enough coupling that a single ordering parameter can improve the predictability of the set as a whole.

2.3 Joint predictability and the operational time parameter

Define a predictability functional I_{joint} that measures how well the present values of $\mathcal{O}$ predict future values of $\mathcal{O}$, evaluated under admissibility A. One can use mutual information, conditional mutual information, transfer entropy, or a model-based forecasting score; the framework is agnostic as long as the metric is explicit and comparable across parameterizations.

The operational definition of time is:

$$T^{\backslash *} = \arg\max_{\tau} I_{\text{joint}}(\mathcal{O}(t), \mathcal{O}(t+\tau) \mid A).$$

Interpretation: among all candidate orderings or lags, the one that makes the coupled observables jointly most predictive is selected as "time." This definition does not presuppose an external clock. It builds an ordering from within the system's own dependencies.

Robustness constraints are part of the definition, not optional add-ons. A candidate $T^{\backslash *}$ is meaningful only if it is stable under:

- Coarse-graining changes that preserve the observable class.

- Small perturbations of admissibility A.

- Noise in measurement of $\mathcal{O}$.

If $T^{\backslash *}$ is not stable, then the system does not support a well-defined operational time under the chosen observables and admissibility.

2.4 What "minimal admissibility set" means

An admissibility set A is a specification of what counts as an allowed terminal configuration. It is not an initial condition and not a target microstate. It can be defined by macroscopic constraints such as:

- Late-time low macroscopic complexity (compressed description length, low effective entropy).

- Bounded curvature and bounded inhomogeneity in a cosmological sketch.

- Sparsity or regularity constraints in a pattern-forming system.

- Grammatical or closure constraints over sequences in discourse.

"Minimal" means two constraints.

First, the admissibility must be weaker than fixing a unique endpoint. It should define a family, not a point.

Second, it must be non-degenerate relative to the observables. If the admissibility constraint does not change what the observables can do, then it is flat with respect to $\mathcal{O}$, and it cannot generate an arrow. Operationally, "flatness" means that conditioning on A does not change I_{joint} or the induced ordering compared to the unconstrained case.

2.5 Directionality as selection in history space

Given reversible microdynamics, both orientations of a micro-trajectory are allowed in principle. Directionality enters when one evaluates histories at the level of $\mathcal{O}$ under admissibility A. The admissibility constraint eliminates large regions of history space, and the elimination is not symmetric with respect to orientation once coarse observables are used. That asymmetry manifests as:

- A systematic drift in structural measures of $\mathcal{O}$ (order, coherence, compressibility).

- A systematic drift in correlation structure among the observables.

The framework does not require that every individual trajectory be monotone in an entropy-like measure. It requires that the constrained ensemble of admissible histories displays a preferred orientation detectable in aggregate.

2.6 Operational meaning of "origin"

The paper uses "origin" only in a constrained sense. An origin is not a first instant; it is an identifiability condition.

Call an origin admissible to talk about when the admissibility set leaves non-degenerate present signatures, meaning that different admissibility families would produce distinguishably different present predictability structures. If admissibility is effectively flat, origin talk is empty because no present signature distinguishes one admissibility family from another.

This converts "origin" into a falsifiable concept: if the framework cannot identify non-degenerate present signatures, then it cannot justify origin claims.

2.7 Linguistics as a co-equal domain

The framework treats linguistics as a domain where admissibility is explicit. Grammar defines admissible continuations and admissible closures. If constructions or features are treated as observables $\mathcal{O}_{\mathrm{disc}}$, then discourse time is defined identically:

$$T_{\mathrm{disc}}^{\backslash *} = \arg \max_{\tau} I_{\mathrm{joint}}(\mathcal{O}_{\mathrm{disc}}(t), \mathcal{O}_{\mathrm{disc}}(t + \tau) \mid A_{\mathrm{ling}}).$$

This is not physics imported into language. It is the same operational criterion applied to sequential systems with constraints. The admissibility set is the regla compilada in the linguistic domain: it restricts allowable sequences, and directionality emerges as the ordering that maximizes predictability among coupled constructions under that restriction.

2.8 Summary of commitments

At this stage the framework commits to only four claims:

1. Time can be defined operationally by predictability maximization under admissibility.

2. Admissibility is terminal, minimal, and non-degenerate relative to observables.

3. Directionality is an ensemble-level selection effect in history space under constraint.

4. The same operational structure applies to physical and linguistic sequential systems without requiring shared ontology.

Section 3 turns these commitments into explicit propositions and the conditions under which each claim succeeds or fails.

3. Propositions

3.1 Notation and scope of the claims

Let $\mathcal{O}(t) = \{O_1(t), \ldots, O_n(t)\}$ be a minimal sufficient set of coupled observables, measured at a coarse-grained level. Let A denote a minimal terminal admissibility set, understood as a constraint family over allowable terminal configurations. Let I_{joint} be an explicit predictability functional, for example conditional mutual information or a forecasting score, evaluated under A (Cover & Thomas, 2006; Shannon, 1948). Time is defined operationally as the parameter that maximizes joint predictability among $\mathcal{O}$ under A.

The propositions below are not claims about new microscopic laws. They are claims about identifiability, orientation, and arrow alignment at the level of constrained histories over coarse observables.

3.2 P1: Directionality

P1 (Directionality). If the admissibility set is non-degenerate with respect to $\mathcal{O}$ and induces a stable maximizer $T^{\backslash *}$ of joint predictability, then there exists a preferred orientation in the space of coarse-grained histories, detectable as an asymmetry in predictive performance between opposite orderings.

"Non-degenerate" means conditioning on A changes the joint predictability structure in a way that is not equivalent to a reparameterization, namely there exists at least one τ such that

$$I_{\text{joint}}(\mathcal{O}(t), \mathcal{O}(t+\tau) \mid A) \neq I_{\text{joint}}(\mathcal{O}(t), \mathcal{O}(t+\tau))$$

,

and the maximizer is stable under small perturbations of A and coarse-graining choices.

Operational test. Compute the predictability gap

$$\Delta(\tau) = I_{\text{joint}}(\mathcal{O}(t), \mathcal{O}(t+\tau) \mid A) - I_{\text{joint}}(\mathcal{O}(t), \mathcal{O}(t-\tau) \mid A)$$

.

P1 predicts that for at least one range of τ around $T^{\backslash *}$, $\Delta(\tau)$ has a stable sign across admissible ensembles. This is a measurable orientation criterion, not a metaphysical statement.

Why this is sufficient. If the admissibility constraint compresses the space of viable histories, then the induced ensemble is not invariant under history reversal at the level of $\mathcal{O}$. Predictability is precisely a statistic that detects that non-invariance. The claim is minimal: it asserts existence of a detectable asymmetry, not monotonic entropy for every trajectory.

3.3 P2: Coincidence of arrows

P2 (Coincidence of arrows). If A suppresses late-time macroscopic complexity for the relevant coarse observables, then thermodynamic and cosmological arrows align as projections of the same admissibility mechanism.

Here "suppresses macroscopic complexity" means that admissibility privileges terminal macrodescriptions with shorter effective description length or lower coarse complexity, relative to the unconstrained ensemble. This can be instantiated with a practical proxy such as minimum description length, not requiring inaccessible Kolmogorov quantities (Grünwald, 2007; Rissanen, 1978).

Interpretation. Under such admissibility, the preferred ordering for thermodynamic observables (coarse entropy-like structure) and for cosmological observables (large-scale correlators, homogeneity measures) is selected by the same predictability maximization criterion. The paper does not claim a single scalar "entropy" governs both domains. It claims the orientation that maximizes joint predictability under admissibility is shared when admissibility enforces a common reduction of late-time macroscopic complexity.

Consequence. Arrow pluralism becomes a single problem of constraint structure: if different arrows disagree, either the admissibility sets differ across domains, or the chosen observables are not coupled in the required sense, or admissibility is degenerate with respect to those observables.

3.4 P3: Reversibility limit

P3 (Reversibility limit). If admissibility is flat with respect to $\mathcal{O}$, or if its influence vanishes in the sense that conditioning on A does not change the predictability structure, then the framework recovers effective time symmetry at the level of $\mathcal{O}$.

Formally, if for all τ in the relevant range,

$$I_{\text{joint}}(\mathcal{O}(t), \mathcal{O}(t + \tau) \mid A) = I_{\text{joint}}(\mathcal{O}(t), \mathcal{O}(t + \tau))$$

then A is operationally flat for $\mathcal{O}$, and no preferred orientation is justified by the framework. Likewise, if the maximizer $T^{\backslash *}$ is unstable under perturbations, then time is not operationally well-defined for the chosen observables under the chosen admissibility.

This is a built-in failure mode. It prevents the framework from being trivially universal.

3.5 P4: Linguistic isomorphism as operational equivalence

P4 (Linguistic isomorphism). If a linguistic admissibility set A_{ling} restricts allowable continuations and closures in a way that is non-degenerate with respect to coupled constructional observables, then discourse directionality emerges as the ordering parameter that maximizes joint predictability under A_{ling}.

Let $\mathcal{O}_{\text{disc}}(t)$ be a set of coupled discourse observables, for example constructional features, dependency patterns, register markers, or closure cues, and let I_{joint} be measured on sequences under explicit grammatical constraints. Then discourse time is defined by the same criterion:

$$T_{\text{disc}}^{\backslash *} = \arg\ \max_{\tau} I_{\text{joint}}(\mathcal{O}_{\text{disc}}(t), \mathcal{O}_{\text{disc}}(t + \tau) \mid A_{\text{ling}}).$$

This is not an import of physical formalism into linguistics. It is an equivalence at the level of constrained sequence spaces: admissibility constrains trajectories, coupled observables generate dependency structure, and predictability maximization selects an orientation. The admissibility set functions as a *regla compilada* in the linguistic domain, and the realized sequence dynamics instantiate an *executing sovereign* at the level of observable form, in the sense developed in your prior work on syntactic sovereignty and executable legitimacy (Startari, 2025b; Startari, 2025c).

3.6 Falsifiability and discrimination against adjacent accounts

The framework is distinguishable from initial low-entropy accounts because it does not require a privileged first macrostate; it requires detectably non-degenerate admissibility signatures in present predictability structure. It is distinguishable from purely clock-based accounts because the ordering parameter is learned from predictive structure, not assumed. It is also distinguishable from unconstrained reversible models because it predicts measurable asymmetries only when admissibility is non-flat.

The relevant empirical discriminators are: (a) stability of $T^{\backslash *}$ under coarse-graining, (b) sign-stable predictability gaps between opposite orderings, and (c) sensitivity of those quantities to controlled changes in admissibility constraints.

3.7 Positioning within your canon

Within your canon, admissibility is the operative restriction on allowable sequences or outcomes, thus a regla compilada, while the system that realizes the constrained dynamics functions as the executing sovereign at the scale where structure and correlation are measured. This keeps the link to your formal program without requiring the paper to inherit a physics-first formula as its centerpiece (Startari, 2025b; Startari, 2025d).

4. Toy Models

4.1 Purpose and design constraints

This section provides three closed "toy" systems that instantiate the mechanism without relying on a privileged first instant or an external clock. The models are not presented as empirical proofs. They function as controlled demonstrations of how a minimal admissibility set can select an oriented history at the level of coarse observables, even when microdynamics is reversible in principle. The selection is evaluated operationally through predictability structure and through the stability of the inferred ordering parameter $T^{\backslash *}$ under coarse-graining (Kadanoff, 1966; Jaynes, 1957a, 1957b).

Across all models, the common structure is:

1. choose coupled observables $\mathcal{O}(t)$,

2. define a minimal admissibility set A over terminal configurations,

3. evaluate whether the ordering that maximizes joint predictability is stable and oriented.

4.2 M1: Coarse-grained gas with terminal low macrocomplexity

System. A gas of many particles with reversible microdynamics. The paper does not require specifying a particular integrator. What matters is the separation between

microstates and macrostates, and the existence of a coarse-graining map from microstates to observable summaries (Jaynes, 1957a, 1957b; Lebowitz, 1993).

Observables. Define $\mathcal{O}(t)$ using standard coarse summaries that are mutually coupled in a nontrivial way, for example: density field at a finite resolution, low-order velocity moments, and a coarse correlation proxy such as a two-point function over spatial bins. The observables are chosen so that improvements in predicting one improve prediction of others under the inferred ordering.

Admissibility set A. Terminal admissibility specifies that allowed end macrostates have low macrocomplexity relative to the coarse description. Operationally, "low macrocomplexity" can be implemented via a compressibility proxy or a minimum description length bound on the binned fields, without invoking inaccessible exact Kolmogorov complexity (Rissanen, 1978; Grünwald, 2007). Importantly, A is a family, not a single endpoint.

Mechanism. Conditioning on A compresses history space: among all coarse histories consistent with reversible microdynamics, only those that remain compatible with low terminal macrocomplexity survive. This induces asymmetry at the coarse level: histories that drift toward increased coarse disorder in the "wrong" orientation are eliminated more strongly because they are less likely to land within the allowed terminal family. The arrow emerges as the orientation that yields a stable maximizer $T^{\backslash *}$ and a stable predictability gap between opposite orderings, as stated in P1.

Expected signature. Under admissibility, joint predictability among $\mathcal{O}(t)$ increases for one orientation and decreases or becomes unstable for the reversed orientation. The model also supports P3: if admissibility is made flat, for example by widening the macrocomplexity bound until it becomes non-informative, the predictability asymmetry collapses.

Why this is not a restatement of initial entropy accounts. The model does not posit a special initial macrostate. It selects among histories by a terminal family. The operational discriminator is not "entropy grows from a low start," but "predictability and correlation structure become orientation-sensitive under admissibility" (Lebowitz, 1993).

4.3 M2: Coupled lattice with terminal large-scale pattern admissibility

System. A coupled lattice system, such as an Ising-type model, used here as a minimal pattern formation laboratory. The details of update rule can vary; the key is that coarse observables such as magnetization and domain structure exist and are coupled (Ising, 1925; Onsager, 1944).

Observables. Let $\mathcal{O}(t)$ include magnetization at multiple coarse scales, a domain-size statistic, and a simple correlation length proxy. These are coupled: domain growth changes correlations, which changes magnetization statistics.

Admissibility set A. Terminal admissibility is specified as membership in a family of large-scale target patterns, not a unique final configuration. One way is to bound the terminal state by a low description length at a coarse scale, which corresponds to "few large domains" rather than many small domains. Another is to require terminal correlation length above a threshold. These are weak, macroscopic constraints, not a precise target.

Mechanism. Conditioning on terminal large-scale structure selects oriented histories where coarse domains grow in a way compatible with the admissible family. The opposite orientation becomes less compatible because it would require domain fragmentation that is inconsistent with the terminal constraint. Again, the criterion is operational: the orientation is the one that stabilizes joint predictability among coarse observables.

Expected signature. Under admissibility, one orientation yields consistent growth of coarse correlation structure and improved predictability across $\mathcal{O}(t)$. When admissibility is flattened, for example by allowing any terminal correlation length, the orientation preference disappears, recovering P3. This toy model also motivates P2: when the same minimal complexity suppression is imposed in different subsystems, arrows align because the same admissibility logic governs which coarse histories survive.

4.4 M3: FRW sketch with bounded late-time curvature and homogeneity band

System. A minimal FRW cosmological sketch used as a conceptual demonstration, not as a precision cosmology. The purpose is to show how a terminal admissibility family can be

formulated in cosmological terms without committing to a first instant narrative (Misner, Thorne, & Wheeler, 1973; Wald, 1984).

Observables. Let $\mathcal{O}(t)$ include a small set of low-order large-scale observables, for example a coarse homogeneity indicator, a curvature-band indicator, and a correlation proxy at large scale. The precise choice is flexible as long as the observables are coupled in the sense of Section 2.

Admissibility set A. Define A as a band constraint on late-time curvature and homogeneity: terminal configurations must lie within a bounded range of curvature and within a bounded range of coarse inhomogeneity. This is a family, not a single state. It is also minimal in the sense that it does not determine detailed microstructure, only large-scale admissibility.

Mechanism. Conditioning on late-time boundedness compresses the space of cosmological histories at the level of coarse observables. The arrow emerges as the orientation that yields stable maximal predictability among the chosen observables under that admissibility. This provides a route to the "coincidence of arrows" claim: if admissibility suppresses late-time macroscopic complexity, then the preferred ordering extracted from large-scale correlators and the preferred ordering extracted from coarse thermodynamic observables can align as projections of the same constraint logic, rather than as separate arrow stories.

Expected signature. The operational signature is not a new cosmological parameter. It is a stability and orientation signature: under admissibility, the predictability structure among large-scale observables becomes orientation-sensitive; if the admissibility band is loosened until it becomes non-informative, the orientation effect collapses. This is the same P3 failure mode expressed in cosmological variables.

4.5 Optional cross-domain testbed: discourse sequences under grammatical admissibility

This is optional depending on whether you want the linguistics thread to remain in the core empirical narrative or only in the conceptual and discussion layers.

System. Discourse sequences generated under explicit closure constraints.

Observables. Constructional features, dependency patterns, closure markers, register shifts, measured in a reproducible pipeline.

Admissibility set A_{ling}. A grammatical admissibility family specifying allowable closures and continuations, defined operationally via a bounded description length or an explicit grammar constraint set.

Mechanism and signature. Same as the physical toys: directionality is the orientation that maximizes joint predictability among coupled constructional observables under A_{ling}. This instantiates the equivalence between admissibility in physics and in syntax without importing a physics-first equation. In your canon, this corresponds to treating admissibility as regla compilada and the realized sequence dynamics as an executing sovereign at the level of observable form (Startari, 2025a; Startari, 2025b; Startari, 2025c).

5. Observability and Limits

5.1 What counts as an empirical signature here

The framework does not claim a new microscopic law. Its empirical content is therefore not a single "parameter to measure," but a set of observable signatures that should appear when a non-degenerate admissibility set is operative relative to a chosen observable set $\mathcal{O}$. The signatures are expressed in terms of predictability structure, stability under coarse-graining, and orientation asymmetries that can be measured on ensembles of histories, simulations, or constrained generative processes (Cover & Thomas, 2006).

A signature is "present" only if it is robust: it must persist under reasonable changes in measurement resolution and small perturbations of admissibility, otherwise it is a modeling artifact rather than a directional constraint.

5.2 Signature class I: stability of the operational time parameter

S1 (Stability of $T^{\backslash *}$). Compute

$$T^{\backslash *} = \arg \max{}_{\tau} I_{\text{joint}}(\mathcal{O}(t), \mathcal{O}(t + \tau) \mid A)$$

The first signature is that $T^{\backslash *}$ exists and is stable under:

1. coarse-graining changes within the same observable class,

2. small perturbations of admissibility A,

3. measurement noise.

If $T^{\backslash *}$ is unstable or non-identifiable, then "time" is not well-defined operationally for that $\mathcal{O}$ under that A. This is not a failure of physics, it is a failure of the framework's applicability for that observable choice.

Why it matters. The paper's central definition lives or dies on stability. Without it, directionality becomes an artifact of representation choice.

5.3 Signature class II: predictability asymmetry under reversal

S2 (Orientation gap). Define the predictability asymmetry:

$$\Delta(\tau) = I_{\text{joint}}(\mathcal{O}(t), \mathcal{O}(t+\tau) \mid A) - I_{\text{joint}}(\mathcal{O}(t), \mathcal{O}(t-\tau) \mid A)$$

A directional constraint predicts that $\Delta(\tau)$ has a stable sign near $T^{\backslash *}$ across admissible ensembles, and that this stability weakens as admissibility is flattened (P3).

Falsification condition. If $\Delta(\tau) \approx 0$ for all τ in the relevant range, or if its sign is unstable across admissible ensembles and resolutions, then there is no operational arrow under the chosen $\mathcal{O}$ and A. In that case, the framework cannot justify direction talk beyond conventional narratives.

5.4 Signature class III: coupling-sensitive correlation drift

Because the definition uses coupled observables, a third signature is that directionality is not reducible to a single scalar trend but appears in the coupling structure itself.

S3 (Correlation drift under admissibility). The conditional dependence structure among observables should shift under admissibility in an oriented way. Operationally, one can test whether the dependence graph or mutual information matrix changes asymmetrically between the forward and reversed orderings.

This matters because it distinguishes the approach from purely "entropy-only" stories. The arrow, here, is a property of the joint predictive structure.

5.5 Signature class IV: discriminability of admissibility families

The framework's notion of "origin" requires that admissibility be non-degenerate not only in a weak statistical sense, but in an identifiability sense.

S4 (Non-degenerate present signature). Different admissibility families $A^{(1)}$ and $A^{(2)}$ should generate detectably different present predictability structures for the same observable set. If all admissibility choices yield the same present signatures, admissibility is flat relative to $\mathcal{O}$, and origin talk is not licensed by the framework.

This converts "origin" into a testable discriminability condition rather than a narrative.

5.6 Where empirical traction is realistically strongest

The paper's strongest empirical pathway is not "testing the universe." It is testing the mechanism in controlled settings where admissibility can be imposed or varied.

Controlled physical tests.

- Lattice models with terminal pattern constraints.

- Coarse-grained particle systems with terminal complexity bounds.

- Reversible cellular automata with end-family admissibility.

Controlled linguistic tests.

- Human corpora segmented by closure constraints (genre, register, formal endings).

- Constrained generation in language models with explicit closure families. In both cases, the same empirical signatures apply: stability of $T^{\backslash *}$, orientation gap Δ, correlation drift, and discriminability across admissibility families (Startari, 2025b; Startari, 2025c).

5.7 What the framework explicitly does not claim

1. It does not claim a specific terminal constraint exists in nature in a particular parametric form.

2. It does not claim a new constant, a new force, or a new conservation-violating effect.

3. It does not claim that every system has a well-defined $T^{\backslash *}$. Some systems will not, under some $\mathcal{O}$ choices.

4. It does not claim that admissibility is the only possible source of arrow phenomena, only that it is sufficient under reversible microdynamics and provides a unified operational criterion.

5.8 Limits and failure modes

The framework has clear failure modes; stating them is part of making it rigorous.

L1 (Observable mismatch). If $\mathcal{O}$ is too weak, uncoupled, or chosen at the wrong scale, joint predictability cannot force a stable ordering.

L2 (Admissibility flatness). If admissibility is too weak relative to $\mathcal{O}$, conditioning on A changes nothing measurable.

L3 (Non-robustness). If results depend sensitively on resolution, preprocessing, or minor admissibility perturbations, the effect is not a directional constraint.

L4 (Overconstraint). If admissibility is too strong, the effect becomes trivial and loses explanatory content because it effectively fixes an endpoint.

These limits are not peripheral. They are the boundary conditions that prevent the proposal from collapsing into unfalsifiable metaphor.

6. Discussion

6.1 What this framework changes, conceptually

The paper's central move is to replace two habitual primitives, a privileged beginning and an external clock, with an operational criterion: time is the parameter that maximizes joint predictability among coupled observables under a minimal admissibility set. The payoff is that "direction" becomes a property of constrained history space evaluated at the level of observables, rather than a narrative attached to an assumed temporal substrate.

This reframes the arrow problem from "why does entropy increase from a special start" to "under what admissibility constraints do coupled observables support a stable, oriented ordering." The shift is not rhetorical. It modifies what counts as evidence. Evidence becomes stability of $T^{\backslash *}$, orientation gaps in predictability, correlation drift under constraint, and discriminability of admissibility families, not the postulation of an unobserved first instant.

6.2 Relation to low-entropy initial condition accounts

Standard accounts often place the explanatory weight on a low-entropy initial macrostate and then treat the arrow as an unfolding from that boundary. This is the dominant narrative form in the foundations and pedagogy of statistical mechanics, even when the underlying microdynamics is reversible (Lebowitz, 1993). The present framework differs in three precise ways.

First, it does not require a privileged initial macrostate. It conditions on an admissibility family at the terminal end and asks whether the induced ensemble of histories is orientation-sensitive at the level of coarse observables.

Second, it makes "time" itself operational. The ordering parameter is not assumed to preexist. It is inferred as the maximizer of joint predictability under admissibility.

Third, it embeds a failure mode that initial-condition narratives typically lack: if admissibility is flat relative to $\mathcal{O}$, the framework refuses to license arrow talk for those

observables. This is a stricter epistemic posture than many "special past" stories, which can persist without a discriminability test.

This does not mean initial-condition accounts are "wrong." It means they answer a different question. They posit a boundary; the present paper supplies a criterion for when boundary information is actually doing detectable work in present predictability structure.

6.3 Relation to "first instant" rhetoric and cosmological origin stories

Cosmological discussions frequently pivot on "first instant" imagery, even when the technical content is about boundary conditions, global constraints, or coarse-grained histories. The framework here makes that imagery optional rather than foundational. It offers a disciplined definition of "origin": origins are speakable only when admissibility leaves non-degenerate present signatures. If different admissibility families are not discriminable by present predictability structure, then "origin" becomes empty description rather than an operational claim.

This is a deliberately restrictive use of the term. It is designed to prevent the framework from functioning as a narrative generator. The paper commits to saying less unless present signatures can separate alternatives.

6.4 Relation to time-emergence programs in quantum foundations

A family of approaches treats time as emergent from correlations, relational degrees of freedom, or informational structure in quantum systems. The present proposal is compatible with the general spirit of "time from correlations," but it differs in what it takes as primary.

The primary object here is not a particular quantum construction but a cross-domain operational criterion: maximize joint predictability among coupled observables under admissibility. The criterion can be instantiated in quantum settings, but it is not derived from them. This matters because it keeps the framework portable: it can be tested in classical toy systems, lattice models, or discourse sequences, and does not require resolving foundational disputes about quantum time to become operational.

6.5 Why the linguistic thread is not decorative

A frequent criticism of cross-domain papers is that the second domain is used as metaphor. The paper avoids that by making linguistics a co-equal instantiation of the criterion.

Grammar is an explicit admissibility structure over sequences. It restricts continuations and closures and thereby compresses the space of trajectories through discourse. If one measures coupled constructional observables, the same predictability maximization defines an operational discourse time and yields a measurable notion of discourse directionality. The empirical signatures are the same: stability of $T_{\text{disc}}^{\backslash*}$, predictability asymmetry under reversal, correlation drift among constructional observables, and discriminability across admissibility families.

This also addresses a methodological concern: if the framework were stated only in physical terms, it could be accused of importing a physical formalism into language. By placing the criterion at the level of admissibility and predictability, both physics and linguistics become domains of constrained sequences, without implying ontological identity.

Within your canon, this corresponds to treating admissibility as regla compilada and the realized dynamics of form as an executing sovereign at the level of observable structure, not as an anthropomorphic agent (Startari, 2025b; Startari, 2025c; Startari, 2025d). The point is not metaphorical power. It is operational equivalence.

6.6 What remains open, and what counts as progress

The framework leaves open which admissibility families, if any, are physically instantiated in cosmology or in thermodynamic settings beyond toy models. That is not a weakness of the definition. It is a clear division between:

1. the operational criterion, and

2. the empirical question of which constraints are realized.

Progress is therefore measurable without settling cosmology. Progress is: produce controlled demonstrations where admissibility is manipulated, show stable $T^{\backslash*}$ and

orientation gaps, show correlation drift consistent with constraint variation, and show discriminability across admissibility families. The strongest empirical path is methodological: constrained experiments where the admissibility structure is an experimental variable.

6.7 Differentiation against "future boundary" formalisms

There exists prior work on two-time boundary conditions and formalisms that use final constraints. The present paper's distinguishing feature is not the bare idea of a final condition, but the operationalization of time itself as predictability maximization, and the cross-domain testability in linguistic sequence spaces. In other words, it does not merely assert that "final constraints matter." It specifies what should be measured, how time is inferred, and how failures are detected.

6.8 Synthesis

The upshot is a compact program: define time operationally by predictability under admissibility, treat directionality as an ensemble-level selection effect, unify multiple arrows as projections of the same constraint logic when admissibility suppresses macroscopic complexity, and discipline "origin" by discriminability in present signatures. The linguistics integration is not a rhetorical flourish; it is a second domain in which admissibility is explicit and testable, strengthening the sustainability and methodological clarity of the overall proposal.

7. Conclusion

7.1 Main result in one sentence

Temporal direction does not require a privileged beginning or an external clock: time is the parameter that maximizes joint predictability among coupled observables under a minimal admissibility set, and directionality emerges when that admissibility is non-degenerate relative to the observables.

7.2 What has been established

The paper set out to replace two common explanatory primitives, "first instant" and "clock," with an operational criterion. It did so by (a) defining time through predictability maximization under admissibility, (b) treating admissibility as a terminal family constraint rather than a target microstate, and (c) showing, through propositions and toy systems, how such constraints select an oriented ensemble of coarse histories even when microdynamics is reversible in principle.

At the level of claims, three outcomes follow.

First, directionality is detectable as an asymmetry in predictive structure: the forward and reversed orderings do not perform equivalently under admissibility, and the preferred ordering is the one that yields a stable maximizer $T^{\backslash *}$ under coarse-graining and small perturbations.

Second, arrow pluralism can be reduced to constraint structure. When admissibility suppresses late-time macroscopic complexity, thermodynamic and cosmological arrows align as projections of the same mechanism rather than as separate arrows requiring separate narratives.

Third, the paper introduced a disciplined notion of origin. Origins are not treated as a first instant. They are licensed only when admissibility leaves non-degenerate present signatures, meaning that admissibility families are discriminable in present predictability structure.

7.3 Why the linguistic integration matters for the conclusion

The linguistic extension is not a metaphorical appendix. It supplies a domain where admissibility is explicit, manipulable, and empirically accessible. Grammar constrains admissible continuations and admissible closures over sequences; as such it can be treated as an admissibility set over trajectories in discourse. Under the same operational criterion, discourse directionality becomes the ordering parameter that maximizes joint predictability among coupled constructional observables under grammatical admissibility.

This supports the paper's sustainability in two ways. It provides an independent domain in which the same operational structure can be measured without cosmological commitments. It also clarifies the status of admissibility as a regla compilada: a constraint family that defines what sequences are admissible, while the realized dynamics instantiate an executing sovereign at the level of observable form, consistent with your prior work on syntactic sovereignty and executable legitimacy (Startari, 2025b; Startari, 2025c; Startari, 2025d).

7.4 What the framework enables next, without adding new metaphysics

The framework enables a clean research program based on constraint manipulation and predictability measurement. The next advances are not "more narrative," but tighter discriminators: identify admissibility families that produce distinct present predictability signatures, test stability of $T^{\backslash *}$ under systematic coarse-graining changes, and measure orientation gaps across controlled constraint regimes in both physical toy systems and linguistic sequence spaces.

7.5 Final statement

The paper's proposal is intentionally minimal: reversible microdynamics plus a minimal admissibility set are sufficient to define time operationally, to select an arrow, and to unify multiple arrows as constraint projections. "Origin" is not a metaphysical first point but an identifiability condition: if admissibility is flat, origin talk is empty; if admissibility is non-degenerate, it leaves present signatures that can be measured. In that sense, future-admissibility is not a narrative replacement for causes but a structured way to compress the

space of histories and thereby generate temporal direction as an observable, testable property.

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