The Nexus–Momentum–Atempus Framework

A Relational Theory of Emergent Temporality from Structure, Transformation, and Information

Carlos Daniel Borrego Romero, MBA, Bsc Computer Systems, CISA, CRISC, CDPSE, ISO 27001, CASE .NET

Independent Researcher — Pachuca Hidalgo, Mexico

Primary classification: gr-qc (General Relativity and Quantum Cosmology). Cross-list: hep-th, quant-ph, nlin.AO.

Companion note. *NMA is the integrating dynamical model of the author's program. It inherits the equilibrium logic of the Unified Variational Principle, the information ceiling and energetic-cost economy of the Universal Information Optimization Principle, and the deterministic identity descriptor of the quantum-informational hash framework, and binds them into a single relational theory in which time itself is an emergent observable. The companion frameworks supply equilibrium, economy, and identity; NMA supplies the temporal dynamics that move a system among them.*

Abstract

The Nexus–Momentum–Atempus (NMA) framework is a relational theory in which observable time is not a primitive coordinate but an **emergent observable** arising from the joint evolution of three universal components: a relational structure (Nexus), a transformative dynamics (Momentum), and an informational representation. The effective temporal variable, Atempus, is reconstructed from the instantaneous state rather than postulated, and a clean separation between an auxiliary background ordering parameter and the emergent temporal observable removes the circularity that affects several emergent-time programs[1]. The theory is organized as a layered, dissipative architecture: a bound–cost layer fixes how much information a region can display and what irreversible change costs[6][7]; an equilibrium layer fixes the stationary balance the dynamics tends toward under causal admissibility; a dynamical core describes evolution toward that equilibrium and the emergence of time along the way; and an identity layer assigns each realized state a deterministic descriptor for reproducible verification. The framework reduces to relativistic proper time in the appropriate limit and is closed by a quantitative falsification program. This document states the architecture and its qualitative structure, while withholding the operational core under intellectual-property protection.

1. Introduction

That observable time may emerge from relational, thermodynamic, informational, or causal structure has active precedents in contemporary theoretical physics. The thermal time hypothesis links time to the modular flow of a state-dependent algebra; causal set theory treats causal order as primary and spacetime as emergent; loop quantum gravity provides discrete relational structure underlying continuum behavior; and recent work derives time from quantum-information dynamics and system–environment interaction. NMA is positioned as an effective relational framework that can be compared with these approaches without asserting identity with any of them.

NMA proposes that observable temporal order emerges from the coordinated evolution of three components: a relational structure (Nexus), a transformative dynamics (Momentum), and an informational representation. The effective temporal variable, Atempus, is therefore an *emergent magnitude* rather than a primitive coordinate. A known difficulty in emergent-time programs is that a dynamical reading of the relevant flow already presupposes a notion of time; NMA avoids this circularity by treating its background parameter as purely auxiliary and recovering temporality only as a derived observable.

2. The Principle of Emergent Temporality

Every physical, biological, cognitive, or informational system can be described by a relational structure, a transformation dynamics, and an informational representation. Observable temporality emerges from the joint evolution of these components and is expressed as a functional of the instantaneous state:

$$Atempus \;=\; \mathcal{F}[\, structure\, ,\, transformation\, ,\, information\,]$$

Here Atempus is reconstructed from the state, while the background parameter serves only to order that evolution and carries no physical content of its own; it disappears in the relational regime. The explicit reconstruction functional $\mathcal{F}$ — its closure, weights, and gates — is part of the protected core and is withheld; only its role is stated. The strict separation between the auxiliary ordering parameter and the emergent observable is what keeps the construction *free of circularity*.

3. The Three Components and Seven Axioms

The framework rests on three components and a small set of axioms that constrain how they relate. The components are summarized at the level of their role; their field definitions, couplings, and dynamics are part of the protected core.

Component	Role in emergent temporality	Formal correspondence
Nexus (structure)	The relational structure of the system — what is connected to what	Spin networks (LQG); causal order (causal sets) [4]
Momentum (transformation)	The transformative dynamics acting on the structure	Modular / thermal flow (thermal time hypothesis) [1]
Information	The informational representation carried by the state	Information-theoretic / holographic encoding [5][6]

Seven axioms govern the construction: every system has an identifiable relational structure; structure evolves through transformations; transformations generate informational change; *temporality emerges from the joint evolution* of structure, dynamics, and information; the description reduces to known theories in the appropriate limits; physical evolution preserves causal consistency; and observables are invariant under equivalent representations of the state.

4. The Layered Architecture

The framework is intentionally layered, and the layers are mutually consistent. Each is stated here by its role; the functionals, operators, and coefficients that realize each layer are withheld.

1. **Bound–cost layer.** Fixes how much information a region can display — bounded above by the tighter of the Bekenstein and holographic ceilings[6] — and the strictly positive energetic cost of any irreversible informational change, bounded below by the Landauer envelope[7].
2. **Equilibrium layer.** The dissipative flow settles at a stationary balance between an action–dynamics sector and a constraint–information sector, under a causal-admissibility condition that forbids closed causal loops. This is the same equilibrium logic as the companion Unified Variational Principle.
3. **Dynamical core.** A single generating free-energy functional drives a dissipative gradient (Onsager) flow toward equilibrium; conservation, balance, and Lyapunov stability follow from its structure rather than from independent postulates. The functional itself is withheld.
4. **Identity layer.** Every realized state carries a deterministic identity descriptor built from its observables, supporting reproducible verification — the same construction as the companion quantum-informational hash descriptor. Its operational pipeline is withheld.

$$\textit{bound–cost} \;\rightarrow\; \textit{equilibrium} \;\rightarrow\; \textit{dynamical core (time emerges)} \;\rightarrow\; \textit{identity}$$

These layers are consistent by design: the information ceiling bounds the conserved informational charge; the energetic price enters the same functional that drives the flow; the stationary point of that functional is the global equilibrium; and the verification descriptor operates on the background index while the physical content remains the emergent temporal observable.

5. Equilibrium, Causality, and Stability

The stationarity condition of the dynamics is expressed as a balance between an action–dynamics sector and a constraint–information sector that sum to zero — the equilibrium signature shared with the broader program. Causal admissibility is imposed through a penalty that vanishes for admissible separations and diverges otherwise, so that **closed causal loops are excluded** and equilibrium is reached only along causally consistent trajectories. The relativistic limit is the special equilibrium in which the constraint sector is inactive.

$$\textit{action–dynamics sector} \;+\; \textit{constraint–information sector} \;=\; 0$$

Stability is established through a coercive Lyapunov functional that is non-increasing along the gradient flow, guaranteeing asymptotic stability of the emergent-time equilibrium. The generating functional decays consistently, so that the energy and the Lyapunov functional encode the same dissipative structure. Existence, uniqueness, and global-in-time regularity follow from standard results for semilinear parabolic systems under stated coercivity and Lipschitz hypotheses[8]. The explicit Lyapunov functional and the precise hypotheses are part of the protected core.

6. Relativistic Correspondence

In the regime where structural heterogeneity and informational separation vanish and temporal complexity is held constant, Atempus reduces to relativistic proper time. Relativity thus appears as a limiting case, consistent with a boundary condition built into the theory's temporal-correction expansion. The principal observable of the theory is the temporal correction — the difference between emergent Atempus and proper time —

expressed, near the reference regime, as a function of three control variables: structural heterogeneity, the deviation of temporal complexity, and informational distance. The exact expansion and its coefficients are withheld; only the dependence structure is stated.

$$\textit{low heterogeneity , low information separation , constant complexity} \quad \Longrightarrow \quad \textit{Atempus} \rightarrow \textit{proper time}$$

7. Observables and Falsifiability

The theory defines five primary observables, each with a clear operational role: Atempus (the emergent temporal variable), temporal complexity, structural heterogeneity, informational distance, and the temporal correction. They are designed to be non-redundant — if the temporal correction depends independently on the three control variables, they jointly define an irreducible temporal-correction sector.

The framework is constructed to be quantitatively falsifiable. It is refuted if any of the following hold:

- No observable dependence exists between the temporal correction and structural heterogeneity, the temporal-complexity deviation, or informational distance.
- The relativistic limit (Atempus → proper time) is not recovered in the appropriate regime.
- The observables are shown to be redundant with respect to a simpler equivalent model.
- The information ceiling or the Landauer cost bound is violated in any admissible regime.

Detection is assessed through a reproducible statistical protocol — ensembles of simulations across a parameter grid, multivariable regression with interaction terms, confidence intervals, and effect-size thresholds — so the theory is refutable rather than purely interpretive. The full regression-ready functional form and its thresholds are withheld; the testing methodology is stated.

8. Relation to the Foundational Program

NMA is the integrating dynamical model of the author’s program. Where the Unified Variational Principle supplies equilibrium and dynamics, the Universal Information Optimization Principle supplies the economy of information (ceiling and cost), the unified wave-confinement model supplies empirical observation, and the quantum-informational hash descriptor supplies identity, NMA binds these into a single relational theory in which time itself emerges. It inherits the equilibrium balance, the information ceiling and Landauer cost, and the deterministic descriptor as named layers, and adds the temporal-emergence dynamics that move a system among them.

Notational independence. The observables, closure conditions, ceilings, equilibrium balance, and verification layer introduced here are self-contained. The framework relies only on established physical results — cited as external prior art — and on the author’s own protected formulations, and it reproduces the protected equations of no other framework.

Universal scope. The framework is offered as an application framework across physical, biological, cognitive, artificial-intelligence, social, and infrastructural systems, in all of which time is read as emerging from the interaction of structure, dynamics, and information. This breadth is an application claim, not an automatic equivalence across domains.

9. Conclusion

The Nexus–Momentum–Atempus framework reframes time as an emergent observable arising from the joint evolution of relational structure, transformative dynamics, and informational representation. Its central contribution is not merely the claim that time emerges, but the specific decomposition of emergence into structure, dynamics, and information, together with a dimensional and dissipative closure that makes each sector auditable, a clean separation that removes circularity, a single generating functional that unifies dynamics, conservation, and stability, an information economy that bounds and prices the informational sector, and a deterministic identity layer for reproducible verification. The theory reduces to relativity in the appropriate limit and is closed by a quantitative falsification program. As the integrating dynamical pillar of the broader program, it supplies the temporal dynamics on which the other foundations act.

Intellectual-Property Statement

References (Prior Art)

The physical results and prior emergent-time programs referenced by NMA are established in the literature; the contribution of this work is the relational architecture and its layered closure over them.

[1] A. Connes and C. Rovelli, "Von Neumann algebra automorphisms and time–thermodynamics relation in generally covariant quantum theories" (Thermal Time Hypothesis), Class. Quantum Grav. 11, 2899 (1994). https://arxiv.org/abs/gr-qc/9406019

[2] L. Bombelli, J. Lee, D. Meyer, and R. D. Sorkin, "Space-time as a causal set," Phys. Rev. Lett. 59, 521 (1987). https://doi.org/10.1103/PhysRevLett.59.521

[3] C. Rovelli and L. Smolin, "Discreteness of area and volume in quantum gravity," Nucl. Phys. B 442, 593 (1995). https://arxiv.org/abs/gr-qc/9411005

[4] D. N. Page and W. K. Wootters, "Evolution without evolution," Phys. Rev. D 27, 2885 (1983). https://doi.org/10.1103/PhysRevD.27.2885

[5] L. Susskind, "The world as a hologram," J. Math. Phys. 36, 6377 (1995); G. 't Hooft, arXiv:gr-qc/9310026 (1993). https://arxiv.org/abs/gr-qc/9310026

[6] J. D. Bekenstein, "Universal upper bound on the entropy-to-energy ratio for bounded systems," Phys. Rev. D 23, 287 (1981); R. Bousso, "A covariant entropy conjecture," JHEP 07, 004 (1999). https://arxiv.org/abs/hep-th/9905177

[7] R. Landauer, "Irreversibility and heat generation in the computing process," IBM J. Res. Dev. 5, 183 (1961). https://doi.org/10.1147/rd.53.0183

[8] R. Temam, *Infinite-Dimensional Dynamical Systems in Mechanics and Physics*, Springer (1997) — well-posedness and global attractors for semilinear parabolic systems. https://doi.org/10.1007/978-1-4612-0645-3