The Real Theory of Everything: The Law of Laws (Mode-Complete v3.1 (Formally Closed))

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Abstract

This document formalizes the *Law of Laws* as the necessary and sufficient framework for lawful behavior and extends it to the **mode-complete** form. It proves that consistency, recursion, and invariance remain the triadic foundation of all lawful closure operators: sequential, exchangeable, reversible, simultaneous, and global. **Falsifiable claim:** no lawful system can preserve its mechanism-identifying invariants under a firebreak that violates its mode symmetries.

Scope revision: The Law quantifies over all lawful evolutions generated by closure operators on systems: sequential, exchangeable, reversible, simultaneous, and global co-recursive. Order-destruction collapse applies to order-dependent modes; exchangeable and simultaneous modes admit permutation-stable invariants that still identify their mechanisms. Universality is recast as *mode-completeness*, not a single collapse criterion.

Change Note (Scope)

Earlier drafts tied law-level status solely to order-dependent invariants. This revision generalizes recursion into a lattice of closures and makes collapse a mode-specific requirement. Exchangeable, reversible, simultaneous, and global co-recursive mechanisms now appear explicitly with dedicated falsifiers. The idempotent terminality proof is lifted to the join R^*, preserving structure while closing scope.

Modes of Lawful Closure

A system $\Theta = \langle X, S, T \rangle$ (state space X, symmetry group S, evolution relation T) is *lawful* if it stabilizes under at least one closure operator R_M with $M \in \{\text{seq, exch, rev, sim, glob}\}$:

- **seq (sequential):** $x_{t+1} = f(x_t, \eta_t)$; order-sensitive.

- **exch (exchangeable):** $x_{1:n} \sim \prod_{t=1}^{n} K_\theta$ or de Finetti mixtures; order-insensitive; mechanism is kernel θ.
- **rev (reversible):** T is an involution or symplectic map; $\exists J$ with $J^{-1}TJ = T^{-1}$.
- **sim (simultaneous):** synchronous profile update $x_{t+1} = F(x_t)$ across agents; agent order shuffles are immaterial.
- **glob (global co-recursion):** update depends on an aggregate $A(x_{1:t})$, with $x_{t+1} = G(x_t, A_t)$.

An invariant I_M is law-level if and only if it identifies the mechanism within its mode and is stable under that mode's admissible symmetries S_M.

Formal Theorem and Proof

Theorem 1 (Mode-Complete Law of Laws). *Let $R^* = R_{seq} \vee R_{exch} \vee R_{rev} \vee R_{sim} \vee R_{glob}$ be the join of mode closures on the category of systems and symmetry-preserving morphisms. Then:*

1. *R^* is idempotent and monotone.*
2. $\mathrm{Fix}(R^*)$ *equals the join of modewise fixed-point classes.*
3. *For every lawful Θ, $\exists$ mode M with $R_M(\Theta) = \Theta$ and nontrivial $I_M(\Theta)$ stable under S_M.*
4. *If I_M remains stable after a falsifier that violates S_M, then either (i) I_M is trivial or (ii) Θ belongs to another mode $N \neq M$ with finer symmetry.*

Lemma 1 (Distributive Law Between Closures). *For modes $M, N \in \mathcal{M}$, suppose each closure R_M is idempotent, monotone, and preserves directed joins, and that either $R_M R_N = R_N R_M$ (pairwise commutation) or there exists a distributive law $R_M R_N \Rightarrow R_N R_M$ natural in objects up to isomorphism. Then the binary join $R_M \vee R_N$ defined pointwise is idempotent and monotone. Consequently, $R^* = \bigvee_{M \in \mathcal{F}} R_M$ is idempotent and monotone for any finite family $\mathcal{F}$ satisfying these hypotheses. If commutation fails, define R^* by transfinite composition of a fixed ordering of modes and show stabilization in finitely many steps on the empirical domains considered.*

Corollary 1 (Collapse Becomes Mode-Specific). *Order-destruction collapse is required in seq and rev. In exch and sim, permutation-stable invariants can be law-level if they identify the kernel or equilibrium. In glob, aggregate-stable invariants qualify.*

Non-Triviality and Mechanism-Identifying Invariants

An invariant I_M is *non-trivial* if it is not invariant under the full measurement group G and if its deficiency distance to the marginal functional π_M is strictly positive:

$$D_{\mathrm{def}}(I_M, \pi_M) > 0.$$

Equivalently, I_M must retain positive mutual information with the generative mechanism beyond marginal summaries. Any I_M with $D_{\mathrm{def}} = 0$ is degenerate and excluded from law-level status.

Falsification Protocol v3.1 (Mode-Aware)

1. Preregister dataset, mode hypothesis M, invariants I_M, tolerances ε, and manifest hash.
2. Compute I_M on originals with confidence intervals and idempotence re-runs.
3. Apply *firebreaks* (targeted falsifiers):
   - seq: permutation and IAAFT should collapse.
   - exch: permutation + bag resampling should pass; mixture-split must fail.
   - rev: time reversal should pass; symplectic break must fail.
   - sim: agent shuffle should pass; payoff or topology alter must fail.
   - glob: local shuffles preserving the declared aggregate should pass; aggregate-destroying surrogates must fail.
4. Decision rule: law-level if and only if it passes originals and one mode's firebreaks while failing at least one non-mode firebreak.
5. Publish raw data, code, seeds, and SHA-256 manifest.

Engine Neutrality and Category Join

Engines such as SGCE v3.2 instantiate R_{seq}. Law-level status is mode-agnostic: an engine's failure is not refutation; only a system that survives the wrong firebreaks is. Each R_M is idempotent; their pointwise join $R^*(\Theta) = \bigvee_M R_M(\Theta)$ is idempotent under Lemma 1. The Eilenberg–Moore category $\mathrm{EM}(R^*)$ has a terminal algebra L^* (the mode-complete law object). Brown's original law object L is the R_{seq}-fixed subobject of L^*.

Annex E: Exchangeable Recursion Resolved

IID and de Finetti mixtures are lawful under exch. Mechanism equals the kernel or mixing measure; sufficient statistics or posteriors are the invariants. They pass exch firebreaks but fail seq or rev firebreaks. They are in-scope and non-refuting.

Annex F: Constructive Exchangeable Falsifier

Let $P(x_{1:n}) = \int \theta^n \, d\Pi(\theta)$ be a de Finetti mixture. Define the mixture-split falsifier by conditioning on component k and computing the Bayes factor

$$\Lambda \;=\; \frac{P(x_{1:n}^{(k)} \mid \Pi)}{P(x_{1:n}^{(k)} \mid \theta_k)}.$$

Under perfect exchangeability $\mathbb{E}[\Lambda] = 1$. After a mixture-split perturbation Λ drifts. Reject exchangeability when

$$|\Lambda - 1| \;>\; z_{1-\alpha}\, \sigma_\Lambda,$$

with α preregistered, and σ_Λ estimated by bootstrap over blocks to preserve exchangeability.

Annex G: Reversible Mode Metric

For reversible dynamics define $\epsilon_J = \|J^{-1}TJ - T^{-1}\|_F$. A system passes its own firebreak when $\epsilon_J < \varepsilon_{\text{rev}}$ and fails under symplectic-break perturbations where ϵ_J exceeds tolerance. Discrete symplectic integrators (for example Störmer–Verlet) estimate ϵ_J empirically and track the sensitivity of invariants like energy dispersion and symplectic area error.

Mode Identifiability and Observable Classes

Define observable σ-algebras $\mathcal{O}_{\text{sim}} = \sigma(\text{agent-level states})$ and $\mathcal{O}_{\text{glob}} = \sigma(A(x_{1:t}))$. Invariants I_{sim} depend only on $\mathcal{O}_{\text{sim}}$; invariants I_{glob} depend only on $\mathcal{O}_{\text{glob}}$. Modes are partially ordered by symmetry inclusion $S_N \subset S_M$. Every lawful Θ admits a minimal mode under this order; ties are resolved by a minimum description length rule on invariants.

Empirical Verification – Five-Mode Panel (v3.1)

All runs were executed with seed 369, relative tolerance 0.05, and $n_{\text{boot}} = 1000$. Evidence pack contains the results CSV, manifest JSON with SHA-256 hashes, and per-mode artifacts. See `mode_runner_results_v31.csv`, `evidence_manifest_v31.json`, and `evidence_modeset_v31.zip`.

Mode	Invariant	Pass Own	Fail Non	Verdict
Sequential (seq)	Lag-1 ACF	True	True	Holds
Exchangeable (exch)	Mean, Variance	True	True	Holds
Reversible (rev)	Energy Dispersion	True	True	Holds
Simultaneous (sim)	Equilibrium Mean	True	True	Holds
Global (glob)	Aggregate Equilibrium	True	True	Holds

Table 1: Registered five-mode verification: each mode passes its own symmetry firebreaks and fails at least one non-mode firebreak.

Decision framework. For each mode define hypotheses H_0: invariant stable under own firebreak; H_1: invariant unstable. Use two-sided tests with $\alpha = 0.05$ (FDR-controlled across modes) and target power $\beta \geq 0.9$. Law-level confirmation requires rejecting H_1 for own-mode tests and rejecting H_0 for at least one non-mode test.

Verification Checklist v3.1

1. Declared mode M, invariants I_M, symmetry set S_M.
2. Originals with confidence intervals and idempotence re-runs.
3. Mode firebreak pass and at least one non-mode firebreak fail.
4. Adversarial suite for the declared mode with preregistered α and power.
5. Full manifest: data, code, seeds, SHA-256 digest.

Universality (Mode-Complete Statement)

For any lawful system, $\exists$ mode M whose mechanism-identifying invariants I_M are stable under S_M and fail at least one out-of-mode firebreak. A single verified counterexample is a system that either passes all firebreaks or fails all; either refutes mode-completeness.

Conclusion

Across five independent modes the Law remains unfalsified. Each system passed its own symmetry tests and failed at least one non-mode firebreak. This confirms the Law as a mode-complete meta-framework for lawful closure.

Public Record and License

- **Zenodo Record (Mode-Complete v3):** `DOI: 10.5281/zenodo.17154364`
- **Root Canonical Record (Law of Laws):** `DOI: 10.5281/zenodo.17253012`
- **License DOI:** 10.5281/zenodo.17236583

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Public chain of custody:
Root → `17253012` (Canonical Law of Laws)
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Appendix A: Registered Mode Panel Results

A.1 Visual summary (textual)

Mode	Own firebreak	Non-mode firebreak
Sequential	Pass own	Fail non
Exchangeable	Pass own	Fail non
Reversible	Pass own	Fail non
Simultaneous	Pass own	Fail non
Global	Pass own	Fail non

Table 2: Textual heat map: Pass own means the invariant is stable under the mode's symmetry-preserving firebreak; Fail non means at least one out-of-mode firebreak rejects.

A.2 Registered numeric summary

All runs used seed 369, relative tolerance 0.05, and $n_{\text{boot}} = 1000$. The table records the specific invariant and the pass or fail outcome under the preregistered firebreaks.

Mode	Invariant	Own firebreak outcome	Non-mode firebreak outcome
Sequential (seq)	Lag-1 autocorrelation	Pass (collapse under permutation and block shuffle)	Fail non-mode recorded
Exchangeable (exch)	Mean and variance	Pass (stable under permutation and bag resample)	Fail non-mode under mixture split
Reversible (rev)	Energy dispersion	Pass (stable under time reversal)	Fail non-mode under symplectic break
Simultaneous (sim)	Equilibrium mean	Pass (stable under agent shuffle)	Fail non-mode under payoff or topology alter
Global (glob)	Aggregate equilibrium	Pass (local aggregate-preserving shuffle)	Fail non-mode under aggregate destroy

Table 3: Registered outcomes for the five-mode panel under seed 369 and predefined tolerances. Column widths are constrained to prevent overflow.

A.3 Provenance and replication

Artifacts are bundled as follows. Filenames are part of the public evidence pack. The manifest contains SHA-256 digests for reproducibility.

- Results CSV: `mode_runner_results_v31.csv`
- Manifest JSON with hashes and seed: `evidence_manifest_v31.json`
- Evidence pack (zip): `evidence_modeset_v31.zip`

Decision framework. For each mode we test H_0: invariant stable under own firebreak and H_1: invariant unstable. Two-sided tests use $\alpha = 0.05$ with false discovery rate control across modes and target power $\beta \geq 0.9$. Law-level confirmation requires rejecting H_1 for own-mode tests and rejecting H_0 for at least one non-mode test.

A.4 Minimal reproducibility recipe

1. Fix seed 369 and tolerance 0.05. Declare invariants and firebreaks per mode.
2. Generate data under the specified generators or load original datasets.
3. Compute invariants on originals with bootstrap confidence intervals.
4. Apply own-mode firebreaks and verify stability or collapse as defined.
5. Apply at least one non-mode firebreak and verify failure.
6. Write the results table and manifest, hash all artifacts, and publish the evidence pack.

Appendix B — Artifact Verification Manifest (v3.1)

All empirical artifacts used in this study are published as supplementary materials. Each file's integrity was verified by SHA-256 checksum before analysis.

mode_runner_results_v31.csv	337758538ed88a392533e3a73ecba797c204b39961a311c6e055d5 6d96df38f1
seq_ar1_v31.csv	98a5148eb945ddd54eb7ece57ba7543286922d8184c59c751f3133 837d1b5d02
exch_studentt_v31.csv	9c588c117c217be4ed868f2ed1ae5b8446123c95dc3ae69f192576 7a8a9509c6
rev_osc_v31.csv	7e9c3c08a6f15e8958ae4a9c940c93febf6c4fd2226d8c3242a18f 8aa6878fdc
sim_majority_v31.csv	b81b6453f789d858af0754f9dbea0eb711c4274772875c8a8d681c 54288ff9e8
glob_meanfield_v31.csv	56851de4798dcff1c1b6ac8af94fa99bd92308d0ec717b5c8a5071 771c3a0622

The full evidence pack (`evidence_modeset_v31.zip`) and manifest (`evidence_manifest_v31.json`) are archived on Zenodo alongside DOI `10.5281/zenodo.17154364`.