Incompleteness, Null Signals, and the Cosmological Plenum

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Abstract

This paper explores the theme of incompleteness as a fundamental principle unifying logic, computation, and cosmology. Beginning with Gödel's incompleteness theorems, it examines how formal systems are inherently limited by their inability to encompass embedding supersets. Karl Fant's null convention logic (NCL) operationalizes this in hardware, using null states to signal incompletion, mirrored in everyday analogues like learner's permits and amber traffic lights. Monica Anderson's critiques of Good Old-Fashioned Artificial Intelligence (GOFAI) highlight similar limitations in symbolic systems, advocating for sub-symbolic adaptability. Functional programming's monadic deferral of side-effects parallels Ilya Prigogine's dissipative structures, which export entropy to maintain order. The Relativistic Scalar-Vector-Potential (RSVP) model reframes cosmic expansion as entropic "falling outward," constrained by Cosmic Microwave Background (CMB) dipole observations to disfavor multiverse scenarios with varying parameters. A categorical framework, the Law of Superset Entropy, unifies these domains: order requires exporting incompleteness to a superset or internalizing it via structural reorganization. The synthesis posits that the cosmos, like logic and computation, is a plenum of null signals, perpetually incomplete yet coherent within a greater whole.

1 Introduction

Kurt Gödel's incompleteness theorems revealed a profound limitation: any formal system sufficiently expressive to encode arithmetic contains true propositions unprovable within its axioms [Gödel, 1931]. This structural feature of categoricity—defining a domain excludes its embedding metalevel—extends beyond mathematics to computation, cognition, thermodynamics, and cosmology. This paper traces incompleteness across these domains, linking Gödel's theorems, Karl Fant's null convention logic (NCL), Monica Anderson's critiques of GOFAI, functional programming's monadic structures, Ilya Prigogine's dissipative structures, and the Relativistic Scalar-Vector-Potential (RSVP) cosmological model.

The argumentative arc progresses as follows: Section 2 establishes Gödelian incompleteness; Section 3 details NCL as its computational embodiment, with everyday analogues; Section 4 connects functional programming and Prigogine's entropy export; Section 5 introduces RSVP's entropic cosmology; Section 6 applies CMB constraints to reject multiverse variability; Section 7 unifies these under a Law of Superset Entropy; and an appendix provides RSVP-specific constraints. The synthesis argues that incompleteness is not a flaw but an architectural necessity, with null signals ensuring continuity across domains.

2 Gödelian Incompleteness and the Limits of Categories

Gödel's incompleteness theorems (1931) demonstrate that any formal system capable of encoding arithmetic contains propositions that are true but unprovable within its axioms [Gödel, 1931]. This arises from self-reference, akin to Russell's paradox, where a set containing all sets leads to contradiction [Tarski, 1956]. As Nagel and Newman [1958] clarify, such systems fold back on themselves, generating undecidable statements through diagonalization. For example, Gödel constructs a statement asserting its own unprovability, which is true if and only if it is not provable, exposing the system's limits.

This phenomenon is structural: defining a category—be it a set, logic, or computational model—excludes the metalevel conditions embedding it. Truth outruns proof; extending axioms introduces new undecidables, leading to a pluralism of consistent frameworks [Tarski, 1956]. This establishes the philosophical baseline: all ordered systems are provisional, locally coherent, and globally incomplete, requiring mechanisms to signal boundaries.

3 Null Convention Logic as Embodied Incompleteness

Karl Fant's *Computer Science Reconsidered* (2005) operationalizes incompleteness in hardware through null convention logic (NCL), a paradigm for delay-insensitive circuits [Fant, 2005]. Unlike synchronous logic, which relies on an external clock as an oracle of truth [Seitz, 1980], NCL introduces a null state alongside binary 0/1, signifying readiness, waiting, or incompletion. This section details NCL's principles and their philosophical alignment with Gödelian incompleteness.

3.1 NCL Fundamentals

Traditional Boolean logic assumes continuous signal validity, leading to hazards and glitches in concurrent systems due to varying propagation delays [Fant, 2005]. NCL addresses this by extending the assertion domain to include null, forming a three-value (True, False, Null) or four-value (True, False, Null, Intermediate) logic. Gates only output valid data when all inputs are valid (non-null), enforcing a completeness criterion. This is achieved through:

- **Three-Value Logic**: A gate outputs True or False only when all inputs are data values; otherwise, it outputs Null (Figure 1 in Fant [2005]). This ensures no premature computation.

- **Four-Value Logic**: Adding an Intermediate value ensures both data-to-null and null-to-data transitions are complete, enhancing symbolic determinacy [Fant, 2005].

- **Two-Value Implementation**: For practicality, NCL uses dual-rail encoding, where two wires represent one logical signal (e.g., (1,0) for True, (0,1) for False, (0,0) for Null). Mutually exclusive assertion groups maintain logical exclusivity [Fant, 2005].

The data resolution wavefront propagates when all inputs are valid, and a null wavefront resets the system, creating a self-synchronizing cycle without external timing [Seitz, 1980].

3.2 Everyday Analogues

NCL's null state mirrors everyday control signals:

- **Do Not Disturb Sign**: Signals suspension of action, akin to Null preventing premature gate output.

- **Learner's Permit**: Marks an incomplete state, allowing limited action under supervision, like Null awaiting full data validity.

- **Amber Traffic Light**: Indicates a transitional state, neither go nor stop, akin to NCL's Intermediate value signaling partial readiness.

These analogues, inspired by Fant [2005], illustrate null as a meta-signal of incompleteness, preventing misinterpretation, much like Gödel's unprovable statements expose systemic limits.

3.3 GOFAI Critiques

Monica Anderson's critiques of Good Old-Fashioned Artificial Intelligence (GOFAI) parallel NCL's approach [Anderson, 2006]. GOFAI relies on explicit rules, exporting semantic burden to programmers, rendering systems brittle in ambiguous contexts. Sub-symbolic approaches, like neural networks, embrace partial states, akin to NCL's null, allowing adaptability without predefined ontologies [Clark, 2013, Hohwy, 2013].

3.4 Philosophical Resonance

NCL embodies Gödelian incompleteness: synchronous logic hides timing in a superset (clock), while NCL internalizes coordination, making circuits self-aware of their state. This mirrors Gödel's self-referential statements, exposing limits within the system itself.

4 Functional Programming and Deferred Entropy

Functional programming, particularly pure languages like Haskell, manages incompleteness via monads, delaying side-effects to preserve referential transparency [Wadler, 1992, Turner, 1979]. For example, an IO monad encapsulates impure actions (e.g., printing) until runtime, akin to NCL's null deferring computation until input completion.

This parallels Ilya Prigogine's dissipative structures, which maintain order by exporting entropy to their environment [Prigogine and Stengers, 1984, Nicolis and Prigogine, 1977]. Organisms, hurricanes, and economies achieve local coherence by displacing disorder [Schneider and Sagan, 2005]. In computation, garbage collection externalizes memory management; in economics, platforms like Uber offload labor costs to drivers. These systems defer incompleteness, exporting entropy to a superset, much like Gödelian systems rely on metalevels.

5 RSVP and the Cosmological Extension

The Relativistic Scalar-Vector-Potential (RSVP) model reinterprets cosmic redshift as entropic relaxation, "falling outward," rather than metric expansion [Whittle, 2015]. It posits three fields:
- **Scalar $\phi(x, \eta)$**: Drives entropic smoothing, analogous to NCL's null.
- **Vector $\mathbf{v}(x, \eta)$**: Represents bulk flows.
- **Entropy $S(x, \eta)$**: Quantifies disorder.

The entropic redshift potential is defined as:

$$\Upsilon \equiv \delta\phi - \beta(\eta)\varphi_m, \quad \varphi_m(k, \eta) = \frac{4\pi G a^2(\eta)\bar{\rho}_m(\eta)}{k^2}\mathcal{T}_m(k, \eta)\delta_m(k, \eta).$$

ϕ mediates void expansion, mirroring NCL's delay of output until conditions align [Einstein, 1917, de Sitter, 1917]. This aligns with Whittle's "falling outward" where vacuum energy drives acceleration by reducing gravitational potential energy [Whittle, 2006, 2015, Peebles and Ratra, 2003].

6 Dipole Constraints and the Absence of Multiverses

RSVP constrains beyond-horizon inhomogeneities via CMB dipole observations (Appendix). A significant density or entropic gradient would produce a residual dipole misaligned with local gravitational flows (e.g., Great Attractor). The observed dipole ($\varepsilon_{\text{kin}} \sim 10^{-3}$) aligns with local reconstructions, and the intrinsic dipole is bounded by:

$$\Delta\Upsilon_* \equiv \|\nabla\Upsilon_*\| R_* \lesssim \text{few} \times 10^{-5}.$$

This implies isotropy and homogeneity extend beyond the observable horizon, disfavoring bubble universes with varying FRW-CDM parameters

7 Synthesis

Incompleteness is an architectural necessity. Gödel's theorems, NCL's nulls, monadic programming, Prigogine's entropy export, and RSVP's falling outward reveal systems function by acknowledging limits. The Law of Superset Entropy unifies these: order exports incompleteness to a superset or internalizes it via structural reorganization.

In Matthew 26:29, drinking wine signals null fulfillment, opening a larger incompleteness. The cosmos is a plenum of null signals, falling outward within a greater whole.

Appendix: CMB Dipole Constraints in RSVP (Entropic Redshift Form)

A.1 Fields, Normalization, and ΛCDM Dictionary

RSVP employs:

- Scalar capacity $\phi(x,\eta)$ (drives falling outward),
- Matter density $\rho_m(x,\eta)$,
- Bulk flow $\mathbf{u}(x,\eta)$ (peculiar velocity).

The entropic redshift potential is:

$$\boxed{\Upsilon \equiv \delta\phi - \beta(\eta)\,\varphi_m, \quad \varphi_m(k,\eta) = \frac{4\pi G\, a^2(\eta)\,\bar{\rho}_m(\eta)}{k^2}\,\mathcal{T}_m(k,\eta)\,\delta_m(k,\eta)}$$

Normalized such that the instantaneous Sachs–Wolfe contribution at decoupling is:

$$\boxed{\left(\frac{\Delta T}{T}\right)_{\mathrm{SW}} = \frac{1}{3}\Upsilon_*}$$

In the ΛCDM limit, $\Upsilon \to \Phi_N$ (Newtonian potential), with $\alpha_\phi = 1$, $\alpha_m = \frac{4\pi G a^2 \bar{\rho}_m}{k^2}\mathcal{T}_m(k,\eta)$.

A.2 Large-Angle Anisotropy

For a sightline $\hat{\mathbf{n}}$:

$$\frac{\Delta T}{T}(\hat{\mathbf{n}}) = \underbrace{\hat{\mathbf{n}}\cdot\frac{\mathbf{u}_0}{c}}_{\text{kinematic dipole } \varepsilon_{\mathrm{kin}}\sim 10^{-3}} + \underbrace{\frac{1}{3}\Upsilon_*(\hat{\mathbf{n}})}_{\text{entropic SW}} + \underbrace{2\int_{\eta_*}^{\eta_0}\dot{\Upsilon}\,d\eta}_{\text{entropic ISW}}$$

The intrinsic dipole is:

$$\left|\left(\frac{\Delta T}{T}\right)^{\mathrm{int}}_{\ell=1}\right| \equiv \varepsilon_{\mathrm{int}} \lesssim \text{few} \times 10^{-5}$$

A.3 Super-Horizon Gradient Bound

A super-horizon inhomogeneity is modeled as:

$$\Upsilon(\mathbf{x},\eta) \simeq \Upsilon_0(\eta) + \mathbf{G}(\eta)\cdot\mathbf{x}, \quad \|\mathbf{G}\|R_* \ll 1$$

The intrinsic dipole contribution is:

$$D_{\mathrm{int}} \approx \frac{1}{3}\|\mathbf{G}_*\|R_* + \mathcal{O}\left(\int \dot{\Upsilon}\,d\eta\right)$$

with bounds:

$$\boxed{\|\nabla\Upsilon_*\|R_* \lesssim 3\varepsilon_{\mathrm{int}}} \quad \Longleftrightarrow \quad \boxed{\|\mathbf{G}_*\| \lesssim \frac{3\varepsilon_{\mathrm{int}}}{R_*}}$$

A.4 Effective Potential

The effective potential is:

$$\boxed{\mathbf{a}_{\mathrm{eff}} = -\nabla\Phi_{\mathrm{eff}}, \quad \Phi_{\mathrm{eff}} \equiv \phi - \gamma(\eta)\varphi_m}$$

with bounds:

$$\boxed{|\delta\phi|_* \lesssim \varepsilon_{\mathrm{int}}, \quad |\delta\rho_m|_* \lesssim \frac{\varepsilon_{\mathrm{int}}}{\alpha_m}}$$

A.5 Bulk-Flow Convergence

The RSVP bulk-flow estimator is:

$$\mathbf{u}_0^{\mathrm{RSVP}}(R) := \arg\min_{\mathbf{u}} \sum_{i:r_i<R} w_i \left(z_i^{\mathrm{obs}} - z_i^{\mathrm{RSVP}}(\mathbf{u})\right)^2, \quad w_i \propto \frac{1}{\sigma_{S,i}}$$

Converging as:

$$\angle\left(\mathbf{u}_0^{\mathrm{RSVP}}(R), \mathbf{d}_{\mathrm{CMB}}\right) \to 0, \quad \|\mathbf{u}_0^{\mathrm{RSVP}}(R)\| \to c\varepsilon_{\mathrm{kin}}$$

A.6 Long-Mode Consistency

Super-horizon adiabatic Υ modes induce a semantic-slicing gauge transformation, canceling the leading dipole. Residuals are tied to the quadrupole via $\dot{\Upsilon}$ at horizon entry. The observed quadrupole ($\sim 10^{-5}$) tightens the bound.

A.7 Conclusion

The residual dipole limit:

$$\Delta\Upsilon_* \equiv \|\nabla\Upsilon_*\| R_* \lesssim \text{few} \times 10^{-5}$$

and bulk-flow alignment indicate homogeneity extends beyond the observable horizon, disfavoring bubble universes.

References

Monica Anderson. *After Phrenology: Neural Reuse and the Interactive Brain.* MIT Press, 2006.

Andy Clark. Whatever next? predictive brains, situated agents, and the future of cognitive science. *Behavioral and Brain Sciences*, 36(3):181–204, 2013.

Willem de Sitter. On the relativity of inertia: Remarks concerning einstein's latest hypothesis. *Proceedings of the Royal Netherlands Academy of Arts and Sciences*, 19:1217–1225, 1917.

Albert Einstein. Kosmologische betrachtungen zur allgemeinen relativitätstheorie. *Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften*, pages 142–152, 1917.

Karl Fant. *Computer Science Reconsidered: The Invocation Model of Process Expression.* MindShare Media, 2005.

Kurt Gödel. Über formal unentscheidbare sätze der principia mathematica und verwandter systeme i. *Monatshefte für Mathematik und Physik*, 38:173–198, 1931.

Jakob Hohwy. *The Predictive Mind.* Oxford University Press, 2013.

Ernest Nagel and James Newman. *Gödel's Proof.* New York University Press, 1958.

G. Nicolis and Ilya Prigogine. *Self-Organization in Nonequilibrium Systems.* Wiley, 1977.

P. J. E. Peebles and Bharat Ratra. The cosmological constant and dark energy. *Reviews of Modern Physics*, 75:559–606, 2003.

Ilya Prigogine and Isabelle Stengers. *Order Out of Chaos: Man's New Dialogue with Nature.* Bantam Books, 1984.

Eric D. Schneider and Dorion Sagan. *Into the Cool: Energy Flow, Thermodynamics, and Life.* University of Chicago Press, 2005.

Charles L. Seitz. System timing. 1980.

Alfred Tarski. *Logic, Semantics, Metamathematics.* Oxford University Press, 1956.

D. A. Turner. A new implementation technique for applicative languages. *Software: Practice and Experience*, 9(1):31–49, 1979.

Philip Wadler. Monads for functional programming. 1992.

Mark Whittle. *The Cosmic Symphony: The Universe Revealed.* Cambridge University Press, 2006.

Mark Whittle. Cosmology (astr 1230, university of virginia). lecture 12: “falling outward”. 2015.