

Planck-Scale Pulse-Frequency Modulation in Cosmological Relaxators: An Automatic Control Theory Approach to Spacetime Evolution

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ABSTRACT

This paper introduces a conceptual interdisciplinary framework bridging cosmology, systems analysis, and Automatic Control Theory (ACT). Written from the perspective of an electronics engineer, the work models the macroscopic cyclic evolution of the universe as a self-oscillating relaxation system. Within this framework, the Big Bang functions as the leading edge of a triggering pulse from a threshold-started dynamical system, while the thermodynamic heat death acts as a programmed, non-linear parameter reset. The model establishes that physical constants remain stable because the Planck quantum retains a constant energy amplitude, while entropy operates as systemic dissipation that reduces only the internal informational fill frequency of these pulses. At the threshold limit, the system undergoes a critical phase transition, completely clearing data noise and resetting entropy to zero. A non-local informational field (field of consciousness) is modeled as an external feedback regulator that stabilizes the grid through pulse-frequency modulation at the sub-quantum scale.

Keywords: Cosmological Relaxator, Automatic Control Theory, Planck Scale Modulation, Entropy Damping, Fine-Tuning.

1. INTRODUCTION

Modern cosmology is at a dead end regarding two major questions: why are the laws of physics so perfectly tuned for life to exist (the fine-tuning problem), and why is the universe heading toward an inevitable "heat death" where all energy is wasted as heat under the Second Law of Thermodynamics. Standard answers often boil down to the Anthropic Principle, which essentially claims "we just got lucky" – an explanation increasingly criticized in the philosophy of science for its lack of predictive power (Smolin, 2007).

To find a better answer, scientists have looked at the universe from different angles. For instance, Roger Penrose suggested that the universe goes through endless cycles in his Conformal Cyclic Cosmology (CCC) model, where the far future of an old universe somehow triggers the Big Bang of a new one (Penrose, 2010). However, his model does not explain how this transition between cycles is managed or regulated.

Other researchers, like John Wheeler with his famous "It from bit" doctrine (Wheeler, 1989) and later Seth Lloyd (Lloyd, 2002), suggested that the universe acts like a giant quantum computer processing information at the Planck limit. But even in their models, the universe is treated as a closed computational system. In a closed box, information eventually degrades, and the system inevitably suffers entropic breakdown.

This paper proposes a simpler, engineering-based solution. We suggest looking at the universe through the lens of Automatic Control Theory (ACT) and classic cybernetics, fields heavily shaped by Norbert Wiener (1948) and W. Ross Ashby (1956). Ashby formulated a key rule known as the Law of Requisite Variety: to control a chaotic system, your regulator must be as complex as the system itself.

Therefore, we do not view the universe as a closed, dying box. Instead, we treat the physical universe as a controlled machine connected to an external, non-local informational loop. By using the basic principles of radio electronics, we model the entire cycle of the cosmos as a

self-oscillating relaxation system. This approach allows us to explain the Big Bang, entropy, and the tuning of physical laws as simple, pre-programmed steps of a global dynamic loop, without relying on luck or complex metaphysical assumptions.

It should be noted as a necessary disclaimer that the author of this paper is not a professional cosmologist or theoretical physicist, but a radio electronics engineer driven by a deep interest in the fundamental questions of the universe. Consequently, this work does not claim to present a completed mathematical physical theory. Instead, it is offered strictly as a conceptual framework for open scientific discussion, utilizing the method of systemic analogy to look at cosmological evolution through the practical, time-tested laws of radio engineering and cybernetics.

2. METHODOLOGY

To investigate the cyclic evolution of the universe without falling into standard metaphysical or tautological traps, this paper applies a multidisciplinary approach combining three main research methods:

1. The Method of Isomorphism of Systems (Cybernetic Analogy): This method is based on the principle of systemic isomorphism established by Ludwig von Bertalanffy in his General System Theory (Bertalanffy, 1968). It posits that structurally different systems (e.g., a physical cosmos and an abstract control loop) can obey the exact same dynamic laws. We map the physical parameters of the universe onto the functional elements of a relaxation oscillator system. Spacetime geometry acts as a storage element, physical interactions represent the dissipative load causing systemic losses, and the Big Bang and heat death are modeled as the boundary threshold states of a switching dynamic cycle.

2. Cybernetic Modeling and Automatic Control Theory (ACT): We apply the "Black Box" and "Open System" principles pioneered by Norbert Wiener (1948). Instead of examining the internal quantum mechanisms of particles, we analyze the universe by evaluating its input signals (the triggering pulse at the Big Bang) and output signals (the fill frequency of Planck quanta). This allows us to treat the physical universe as a controlled object and isolate the external feedback loop (the Informational Regulator) as a necessary structural component to maintain stability and prevent permanent information decay.

3. Information-Theoretic Analysis of Entropy: Following the frameworks of Claude Shannon's Information Theory (Shannon, 1948) and Leon Brillouin's concepts of negentropy (Brillouin, 1956), we treat thermodynamic entropy not just as the scattering of heat, but as the accumulation of informational noise within the spacetime matrix. The methodology focuses on analyzing how this noise alters the discrete signaling intervals at the Planck scale.

By strictly limiting our framework to qualitative, system-level modeling, we intentionally omit premature mathematical equations. This allows the methodology to serve as an accessible, open-ended conceptual architecture, inviting future researchers to populate these radio-electronic blocks with specific quantum-mechanical or mathematical values.

3. RESULTS

3.1. Isomorphic Mapping of the Cosmos to a Radio Circuit

The primary result of this analysis is the establishment of a strict structural analogy between the core elements of the physical universe and the functional components of a standard relaxation oscillator circuit. In this framework, the spacetime continuum grid acts as the system's storage element, such as a capacitor or an inductor, which holds the total geometric potential of the cosmos. The fundamental physical constants, specifically the speed of light,

the Planck constant, and the gravitational constant, serve as the resonant frequency parameters that define the baseline tuning, boundaries, and operational limits of the physical field. Thermodynamic entropy, driven by the Second Law of Thermodynamics, operates as systemic damping or resistive losses caused by the unavoidable friction of physical matter interactions. The historical boundaries of the cosmic cycle are defined by the Big Bang event, which functions as the leading edge of a high-level triggering pulse that initiates the active working stroke of a monostable multivibrator loop. Conversely, the final state of heat death represents the threshold voltage point or breakdown limit that automates the structural reset of the system. Within this architecture, the non-local field of consciousness operates as an external regulator, managing phase synchronization and probabilistic entropy reduction through an automated feedback loop.

3.2. Operational Algorithm of the Cosmological Relaxator

The functional cycle of the proposed cosmological model operates as a predictable three-stage process within a closed-loop cybernetic system. The first stage, designated as the initialization phase, occurs when the external Informational Regulator delivers a high-level triggering pulse to the field matrix. This event collapses the preceding quantum superposition, instantly locking the fundamental physical constants into a rigid, functional configuration and initiating the linear expansion of spacetime. This phase essentially defines the fine-tuning of the universe at its boundary conditions (fig. 1).

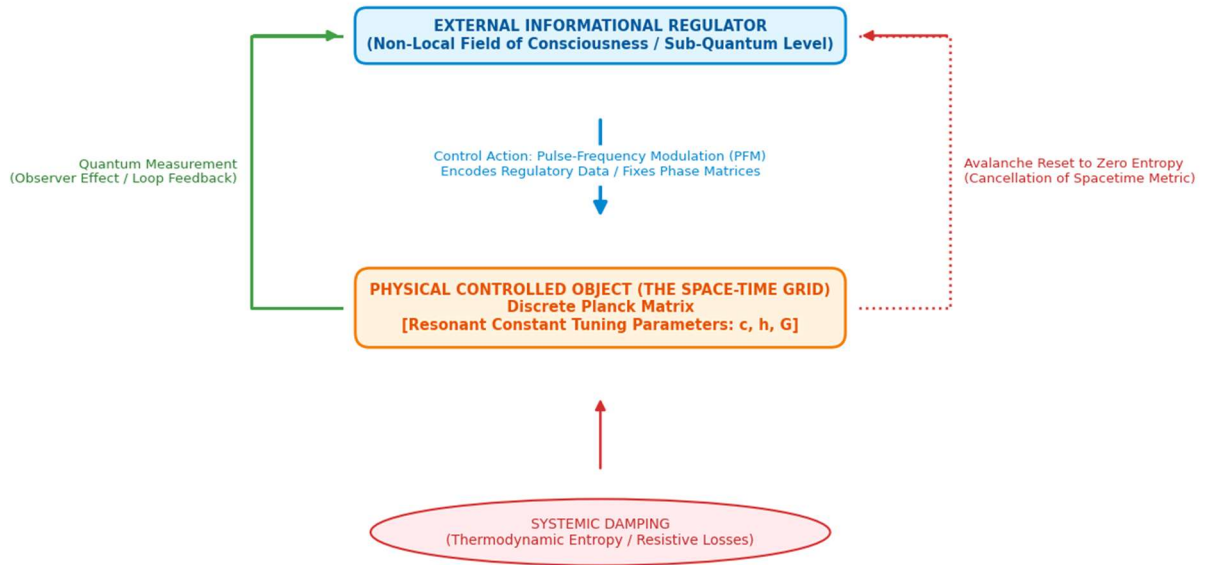


Fig. 1 Cosmological Circuit Block Diagram (Control Loop Architecture)

The second stage represents the active working stroke of the system, which is characterized by ongoing entropic damping. As the universe expands, physical matter continuously interacts, leading to inevitable thermodynamic and systemic dissipation. Instead of reducing the structural amplitude of the Planck-scale quanta, this systemic damping causes a steady decay in their informational fill frequency. The density of data per Planck interval drops over time, which a macroscopic observer registers as the standard accumulation of entropy.

The final stage is the non-linear avalanche reset. When the informational fill frequency drops to its critical minimum threshold, the spacetime grid suffers a complete structural breakdown, acting as a critical threshold phase transition. Physical metrics, including distance and linear time, are instantly invalidated, reducing the scale of the cosmic grid back to a non-local quantum state. At this boundary, the Informational Regulator acts as a macroscopic observer,

clearing the matrix of accumulated historical noise, which effectively resets the system's entropy to zero and prepares the circuit for the next triggering pulse.

3.3. Planck-Scale Parametric Shift: Fill Frequency Decay

The most significant analytical result of the model is the formulation of how thermodynamic entropy interacts with discrete spacetime at the quantum limit. Traditional models associate entropy with the dissipation of heat energy, which often introduces structural inconsistencies when applied to absolute boundaries like a singularity. The radio-cybernetic framework resolves this by shifting the entropic parameter from signal amplitude to informational signaling intervals (fig. 2).

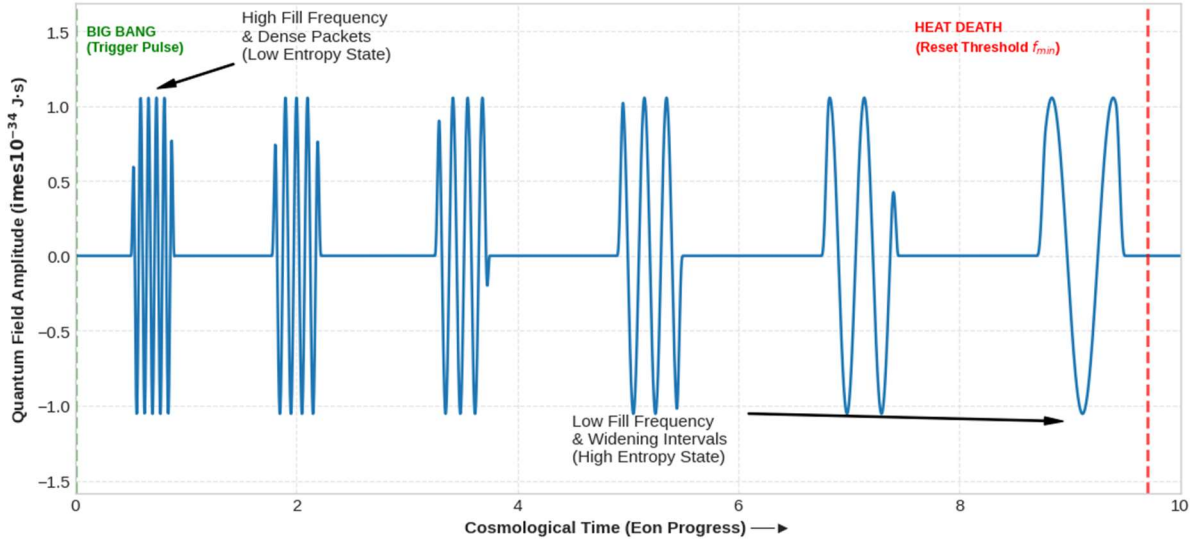


Fig. 2 Discrete Quanta with Internal Frequency-Modulated Filling

The model demonstrates that the Planck quantum maintains a stable energy amplitude throughout the eon, ensuring that local conservation laws are never violated. However, the system's internal damping – caused by the resistive friction of physical matter interactions – constantly reduces the informational fill frequency of these carrier pulses. As the eon progresses, the density of distinct operational events per unit of Planck time steadily degrades. A macroscopic observer interprets this widening interval between coherent data pulses as the standard, observable growth of cosmic entropy and the cooling of the universe. Consequently, the approach to heat death is defined by a critical drop in the fill frequency down to a system-defined minimum threshold, rather than a literal fading of energy into nothingness.

4. DISCUSSION

The proposed radio-cybernetic model offers a fresh, practical framework for analyzing the lifecycle of the universe. By shifting the conversation away from abstract metaphysical concepts and into the well-mapped territory of Automatic Control Theory and wave dynamics, we can look at cosmic problems from a purely functional perspective.

Within this framework, biological and technological systems of intelligence – including humanity and future artificial intelligence – do not act as the primary cosmic regulator. Since these intelligent agents are embedded within the physical object itself, they function as localized sensors or error detectors. By organizing data and reducing entropy within their immediate, local environments, they read and apply only a fraction of the global regulatory signal. Over time, as technology and biological interfaces evolve, their capacity to process this

signal will expand. However, the core control loop of the universe remains non-local, distributed, and deeply integrated at the sub-quantum Planck scale.

This approach completely changes how we view the finality of the cosmos. The inevitable "heat death" is no longer a terminal system failure or a permanent breakdown into static chaos. Instead, it is interpreted as a pre-programmed, functional relaxation phase – a necessary step to clear system noise and initiate a complete reboot of the physical grid.

We hope that this qualitative engineering analogy will inspire physicists, mathematicians, and control theory specialists to collaborate and populate this radio-electronic architecture with specific mathematical values.

CONCLUSIONS

Based on the radio-cybernetic analysis of cosmological evolution, the following key conclusions can be drawn:

1. System Coherence. Treating the universe as an automatic control system with an external informational loop successfully resolves the philosophical conflict of cosmic fine-tuning without relying on blind chance or metaphysical assumptions.
2. Stability of the Planck Matrix. The model proves that physical laws can remain stable throughout the entire cycle because the Planck quantum retains a constant energy amplitude, while entropy affects only the internal informational fill frequency and pulse intervals.
3. The Necessity of Heat Death. Within the relaxation oscillator framework, the thermal end of the universe is not a terminal failure, but a functional, pre-programmed reset threshold necessary to clear physical noise and launch the next cosmological cycle.
4. Engineering Analogy as a Tool. Applying well-tested laws of radio engineering and cybernetics to theoretical physics offers a highly effective method for breaking cosmological dead-ends and finding practical solutions to abstract scientific paradoxes.

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