# Unified Cosmic Mechanics Evolution Theory (I) : Information Dynamics Evolution System

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## Abstract

【**Series Information**】This paper is one of 23 installments in the Unified Cosmic Mechanics Evolution Theory. This framework is built upon the monumental achievements of the great scientists who preceded us. Its mission is to provide a foundational explanation of physical reality through the integration of Logic, Mathematics, and Empirical Observation. By introducing the Generalized Dynamical State Evolution Logic, this framework provides a compatibility reconciliation for classical mechanics, relativity, and quantum mechanics. Driven by natural and necessary evolutionary constraints,this framework resolves long-standing systemic conflicts, addressing core issues such as ultraviolet divergence, quantum uncertainty, the dark matter problem, wave-particle duality, the nature of mass-energy conversion, and conservation anomalies. Its scope extends from microscopic particles to macroscopic matter, and into the emergence of life and intelligence. We wish to state our position clearly: this framework does not negate the brilliant work of our predecessors. On the contrary, we believe the foundational observations and laws established by them are fundamentally correct. Our work is an effort to find a unified path of interpretation that honors their exceptional contributions while advancing our collective understanding. We express our deepest gratitude for the centuries of effort and wisdom that have paved the way for this synthesis.

[ **This article** ] As the first paper in the framework of *Unified Cosmic Mechanics Evolution Theory*, this paper starts from the ”generalized state evolution system”, redefines the essence of information and clarifies the systematic attributes of the universe. Core conclusions: (1) Information is ”the mapping of stably distinguishable differential relationships between interactive carriers”, whose essence is a relational state rather than an independent entity; (2) Information has dual dependence—it must rely on physical carriers and relational networks; (3) The long-term stability of an information state evolution system needs to satisfy nine constraint conditions (quantum discreteness, rule stability, resource conservation, etc.), and the cosmic system fully conforms to these constraints; (4) Entropy is a measure of the frequency of state transitions, and the essence of information conservation is the conservation and stability of the underlying three elements (carrier $m_0$, driving quantity $c$, rule $R$). This paper further distinguishes the primitive information of the cosmic physical system from the abstract information emerging at higher levels, and clarifies that the essence of information dynamics is a dynamic system based on representable physical relationships. The universe is a self-contained, self-driven, and rule-intrinsic information dynamics evolution system, rather than a computing system executing external programs. This research lays a theoretical foundation for the subsequent exploration of evolutionary resources, evolutionary rules, the essence of force, and the dual game between freedom and steady state.

**Keywords:** Unified Cosmic Mechanics; Evolution Theory; Essence of Information; Free-Steady State Evolution; Origin of Time; Essence of Emergence; Unified Field Theory

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## Introduction

For a long time, human exploration of the universe has mainly remained at the empirical level of experimental observation and mathematical modeling, or the conceptual level of philosophical speculation. These two paths share a common perspective blind spot: neither regards the universe as a complete “state evolution system” to carry out ontological research. Experiments and mathematics are good at describing the quantitative changes of states, but it is difficult to explain the internal motivation of evolution; philosophy can question the essence of existence, but lacks physical mechanism support. In related fields, although information and emergence accompany the entire physical process, they have always lacked precise definitions and explanations. However, information is the core of any state relationship evolution system.

This framework aims to construct a unified logic of cosmic mechanics. The research does not presuppose the mechanism of cosmic origin (such as the Big Bang theory), nor is it limited to a single disciplinary paradigm. Instead, it combines the multi-chapter logic within the “evolutionary theory unified mechanics” framework—covering the necessary conditions of the cosmic system such as state evolution system, evolutionary resource, evolutionary rules, physical dimensions, emergence of force, and quantum phenomena—and systematically analyzes the core premises and phenomenological correlations for the stable evolution of the universe on the premise of existing observational phenomena and theoretical basis. This research is committed to realizing the underlying connection between traditional physical theories such as classical mechanics, relativity, quantum mechanics, the standard model, and the Big Bang theory at the logical and mathematical levels, forming a consistent theory.

As the first research in this framework, this paper reveals the micro-mechanism of information generation: the evolutionary carriers in the universe (from elementary particles to macro language sentences) are essentially independent entities that do not belong to each other ("each represents itself or each characterizes itself"). Information is not pre-stored inside the individual, but when these independent carriers interact, the state of mutual influence and dependence naturally emerges through "overall relationship construction". Based on this, this paper establishes the core equivalence: information is "relational state". It can be deduced that the universe is essentially an "information dynamics evolution system" composed of independent evolutionary carriers through dynamic relationship construction. This conclusion integrates the overall mechanical logic from micro-conservation to macro-evolution, clarifies that information is not only a product of evolution, but also the core driving force for independent individuals to form an ordered whole, laying a solid theoretical foundation for subsequent research, such as the emergence from discreteness to continuity.

**Special clarification:** The "information dynamics" in this framework does not mean that the universe is a computer executing external programs. A computer relies on external energy and preset algorithms, while the universe is a self-contained, self-driven, and rule-intrinsic evolution system; "computation" is only a means for humans to simulate the evolution process. The essence of the universe is "self-evolution of states", and the essence of information is "state relationships"; its bitwise characteristics are actually the attributes naturally emerging from standard quantization and rule stability during the evolution process. Therefore, there is an essential difference between this theory and the "digital physics" hypothesis and algorithmic information theory in terms of mechanism origin [1,2]. At the same time, this evolutionary framework focuses on the construction of the overall logic of cosmic dynamics, and the mathematical expression may not be optimized and mature, which needs to be improved together with colleagues in the academic circle.

**Core logic premise:** Conservation of underlying evolutionary resources (Momentum unit) → Standard quantization discreteness (identifiable differences) → Relational network construction (Establishment: Relational state = Information) → Rule stability constraints (system steady state) → Cumulative state transitions (time/energy emergence) → Multi-dimensional relationship superposition (multi-level system emergence) → Dual evolution of freedom and steady state → The universe as a self-driven information dynamics evolution system

# 1 The Relationship Between Cosmic Evolution and Information Evolution

## 1.1 Characteristics of the Cosmic System

The universe is a three-dimensional state evolution system with conservation relationships, that is, within the state evolution system, there exist evolutionary carriers representing states that undergo state changes (transitions) based on objective laws or rules based on free dimensions, and establish causal interaction relationships with other evolutionary carriers through these rules or laws, ultimately forming a dynamically evolving relational state.

In this dynamic evolution process, there are three following elements: there exists a Representational quantity to characterize the state of the evolutionary carrier in the system; there exists a driving quantity that drives the state change or transition of the evolutionary carrier; there exists a constraint on the way in which the evolutionary carrier (Representational quantity) forms relationships with other state Representational quantities. Whether this constraint is an objective law or a rule, we collectively call it an evolutionary rule.

Therefore, within the cosmic system, the essence of all our conservation relationships is the phenomenological observation and research around Representational quantity, driving quantity, and evolutionary rules. Therefore, in this evolution process, there will be no non-existent evolutionary carrier affecting the causal state of the existing evolutionary carrier, which is the root of logical contradictions in all things. For example, 2>3, the fundamental conflict is that there are no non-existent two apples more than three apples. At the same time, the conservation relationship in a system will also emerge corresponding stable logical and mathematical relationships (which will be deduced in subsequent chapters).

## 1.2 Definition and Essential Delimitation of Information

Based on the above logic, since the essence of the universe is the evolution of relational states, we need to give a strict physical definition of the concept of "information" to lay the foundation for the construction of the subsequent information dynamics evolution system. The essential delimitation of information is a core issue that has been debated for a hundred years in the fields of physics, philosophy, and information science. Shannon's information theory evades this core and proposes that "information is information, not matter or energy", leading to the lack of a clear ontological foundation for information in the scientific system. It should be clarified that Shannon's information theory defines information as "eliminating uncertainty", which relies on a specific premise—when a relational "target" system is preconstructed, if relevant possible conditions are lacking, or these relational conditions are in the process of evolution and need to be predicted in advance, probability and uncertainty will arise. The core value of Shannon's information theory lies in quantifying the information transmission efficiency and capacity under such uncertainty [3].

However, in the narrow scenario of the cosmic physical system, the rules are deterministic and stable, and the evolutionary resources (underlying physical carriers) also satisfy constant conservation, so there is no situation of "lack of relational conditions or undetermined evolution" in the general scenario. Therefore, the probability within the cosmic system only comes from the observer's prediction process of specific evolutionary goals, rather than the uncertainty of the cosmic evolution itself, which is also the core difference between Shannon's information theory and this research in applicable scenarios.

Starting from the generalized information state evolution system, this research clearly defines: information is "the mapping of stably distinguishable differential relationships between interactive carriers", which can also be understood as "the state representation of relationships within a relational system", and must rely on carriers to exist. This view is consistent with the core claim of "information ontology" in information philosophy, emphasizing the relational attribute and carrier dependence of information [4], and also echoes the logic of Wheeler's "it from bit" that information is deeply related to physical existence, but clearly abandons the one-sided interpretation of "the universe is a pure information system" and adheres to the core position that "information is a state relationship and the universe is a relational state evolution system" [5].

In short, information is "the representational of the difference in relational states between things", which is reflected in physical carriers as "stably distinguishable differential representations". In summary, it is "the relational structure within a relational system, which is presented and mapped through the differences of interactive carriers".

## 1.3 Core Characteristics of Information

Based on the above definition, the core characteristics of information can be summarized into five points, which are also the basis for information to participate in system evolution and construct relational networks. The specific explanations are as follows:

1. **Identifiable difference:** The premise of the existence of information is that there are identifiable differences in the system. Without differences, there is no content that can be represented or identified; if there are differences but they cannot be identified by the system, they are only potential information and cannot participate in relational evolution. To quantify "identifiable difference", a difference measurement function $D$ is introduced. Let the system state space be $S$, and the information quantity $I$ between two states $s_i, s_j \in S$ is defined as the degree of difference between them that can be identified by the rule $R$:

$$I = D(s_i, s_j, R) = \frac{|s_i - s_j|}{\delta_{\min}}$$

where $\delta_{\min}$ is the minimum resolution threshold of the system (quantization step). Only when the difference exceeds this threshold can information be "manifested", which also clarifies the necessity of "no difference, no information" and "quantum discreteness", consistent with the core assumption of "minimum energy quantum" in quantum theory [6].

2. **Relationality:** The essence of information is the relationship between things, carriers, and information points, rather than the things or carriers themselves; combined with the derivation in subsequent chapters of the "unified mechanics" framework, a relationship is a complex network formed by multiple information points in the system. At each time Snapshot, each information point has a specific relational contribution, and information is the state representation of this relationship. This core cognition is highly consistent with the view in information philosophy that "information is a relational structure" [4].

3. **Mappability:** The same relationship can be transferred and reproduced across different carriers, which is the source of the abstract ability and transmission ability of information, and also the basis for subsequent redundant representation and information replication and transcription.

4. **Rule constraint:** Information points need to be constrained by relationships based on specific rule dimensions, which corresponds to the evolutionary rule system that will be elaborated in detail in subsequent chapters of the "unified mechanics" framework [7].

5. **Stability:** Differences must exist continuously in time; otherwise, they cannot be identified, which is the premise for information to participate in system evolution.

**Example:** The English sentence "Welcome to Earth" composed of 10,000 pixels on a computer screen requires all the above conditions for its information formation: there must be observable differences between pixels (such as position differences); it must form a relationality of the overall English context; it must rely on specific rules (pixels form letters, letters form words, words form semantics according to grammar) to achieve mapping; the information state must remain stable during the identification process to avoid sudden changes beyond the identification range. Only when these conditions are met can the meaningful relationship of "who is welcomed to Earth" be formed, providing a basis for information understanding between different subjects (such as aliens and Earthlings).

### 1.4 Carrier Dependence and Transmission Characteristics of Information

1. **Dual Dependence of Information on Carriers**

   One of the core puzzles of information is that "it is both dependent on carriers and not dependent on specific carriers". Combined with the logic of the generalized evolution system, its dependence can be clearly defined as dual dependence, with the core being "no carrier, no information". This view further improves the core claim of information ontology, emphasizing that information cannot exist independently of carriers [4]:

(a) **First dependence:** Information must rely on specific carriers (physical layer). Carriers are the basic components of the evolution system, and also the material/unit basis for information to exist and be represented. Information without carriers cannot be distinguished or realize relational mapping, and is only a void potential difference.

(b) **Second dependence:** Information must rely on relational structures (logical layer), that is, the relational network formed by information points in the system; isolated information points divorced from the relational network cannot reflect their value and significance, and can only exist as Eigenstate information, unable to participate in system evolution.

**Supplementary explanation:** The abstractness of information comes from the replicability of relational structures between different carriers, which is also the core basis for information transmission in the evolution system. However, this abstractness is always based on the premise of "the existence of carriers" and cannot exist independently of carriers. This has a similar logic to the core idea of Wheeler's "it from bit", but clearly distinguishes the essential difference between "information is a state relationship" and "the universe is a pure information system" [5].

2. **Replicability and Transcription of Information**

Replication and transcription are two forms of information mapping across carriers, relying on the carrier compatibility and relational stability of the evolution system, and are closely related to redundant representation. To quantify the fidelity and information loss of replication and transcription, a mapping operator $M$ and a fidelity coefficient $\eta$ are introduced:

(a) **Replication:** Completely map the relational structure from one carrier system to another carrier system of the same type. Let the information structure on carrier A be $\Psi_A$, and the process of mapping to carrier B is the action of the operator, that is, $\Psi_B = M(\Psi_A)$, and the fidelity $\eta = \langle \Psi_B \mid \Psi_A \rangle / |\Psi_A|^2 \approx 1$. It requires the consistency of carrier degrees of freedom and capacity, and the fidelity depends on the complete maintenance of relational dimensions.

(b) **Transcription:** When complex information cannot be completely reproduced, it is dispersedly represented through intermediate information states and then input into an approximate carrier system (such as DNA→RNA, books→e-books), which is essentially the conversion of redundant representation. At this time, $\Psi_B \approx M(\Psi_A)$. Due to dimension mismatch or noise interference, $\eta < 1$. Information needs to compensate for losses through redundant coding $R_{\text{redundancy}} \geq 1 - \eta$. This formula quantifies the "abstractness" and "transcription loss" of information, and can explain the information conservation and variation in the process of DNA replication or book digitization. This process is also consistent with the core view of Landauer's principle that "information processing is associated with physical carriers and energy consumption" [8].

## 2 Information and State Evolution

An information state evolution system is a relational network of mutual influence and interaction between things, information, and carriers according to rules and existing states; the core of the system is the "evolution of information states", that is, information relies on carriers, follows rules, realizes state transitions in the relational network, and then drives the evolution of the entire system. Combined with the "unified mechanics" framework, the specific definitions of its core related concepts (rules, relationships, causality, etc.) are as follows:

1. **Rule:** The core criterion that constrains the way things, carriers, and information points undergo state transitions and relational influences according to specific dimensions, and is the basis for the ordered evolution of the system; rules are stable and consistent, applicable to all units and states in the system, without differentiated constraints (the specific connotation of evolutionary rules will be elaborated in subsequent chapters).

2. **Relationship:** A complex network formed by multiple information points in the system. At each time Snapshot, each information point can provide a special relational contribution to the relational network; the relationship is the core carrier of information and the core driving force of system evolution. The interaction of different information points will promote the reconstruction and upgrading of the relational network.

3. **Causality:** A specific information instance result emerging from the dynamic interaction of information based on rules; its essence is an irreversible correlation formed when things, carriers, and information points in the system interact with each other based on rules, that is, "interaction triggers results", which is one of the core characteristics of information evolution.

4. **Evolution:** The process by which things, carriers, and information undergo state transitions according to specific rule dimensions, whose essence is the iteration of information states and the reconstruction of relational networks; the core of evolution is "state change", which follows rules, relies on carriers, and has causal relevance. This evolutionary logic is consistent with the emergence mechanism of "simple rules driving complex behaviors" in complex systems [9].

5. **Redundancy:** In a relational network, there may be multiple representation methods at the same logical point; for example, the information relationship of "greeting and kindness" can be represented in multiple ways such as "saying hello", "shaking hands", and "nodding". These different representation methods are overlapping at this logical point and jointly serve the transmission of the same relationship, which is redundancy.

## 3 Eigenstate Information and Infinite Combinatorial Information

1. **Eigenstate information:** The inherent and stably representable information of the carrier itself, that is, the eigenstate information amount of the carrier; it is the basic form of information, does not rely on complex relational networks, only reflects the existence state and inherent attributes of the carrier itself, and is the basic unit for constructing complex information and relational networks.

2. **Infinite combinatorial information:** A carrier can be endowed with different relational meanings by multiple different evolution systems, and then form diverse relational combinations with other carriers and information points, ultimately realizing the infinite emergence of information. For example, a stone can be simultaneously represented as "a stone", "the number 1", "one kilogram in weight", "a color", etc., that is, the same carrier can carry different information in different relational systems.

## 4 Emergence (Self-Emergence of Information State Evolution System)

Emergence is a core characteristic of the information state evolution system. Under specific rule dimensions, the interaction and vector superposition of multiple information points can emerge a new complex relational entity; this relational entity can be regarded as an abstract emergent information point or even a new information dimension. All products of emergence rely on the core premise of "rule stability"—rule stability is the basis for the continuous and ordered occurrence of emergence, and also the core guarantee for the existence of subsequent abstract products such as mathematics and probability, as well as concrete products such as time and energy. This mechanism is highly consistent with the core view of "more is different" in complexity science, that is, high-level complexity comes from the interaction of underlying units rather than simple accumulation [10]. The specific emergence contents are as follows:

### 4.1 Concrete Emergence (Core Emergent Products of the Cosmic System)

1. **Time:** In the state evolution system, things evolve according to rules, which will form new causal results. Each state evolution event corresponds to a time point, and all potentially mutually influential synchronous state evolution events form a perceptual cross-section. Therefore, multiple causal points can exist in a single perceptual cross-section. In summary, time emerges from state evolution events. To quantify the correlation between time and events, time $t$ is defined as a linear function of the total number of effective state transition events $N$ occurring in the system:

   $$t = \tau_0 \cdot N$$

   where $\tau_0$ is the time primitive of a single minimum evolution (on the order of Planck time). If there is no state evolution ($dN = 0$), then $dt = 0$ (time stands still). This view is consistent with the claim in loop quantum gravity that "time does not exist at the fundamental level but emerges from the evolution process" [11], and the origin mechanism of time will be further elaborated in subsequent chapters.

2. **Energy:** When information states undergo transitions and relational networks are reconstructed, a certain driving force is required, and this driving force naturally emerges as energy; energy is the source of power for evolution, and also the core element for maintaining system steady state and balancing energy costs, which echoes the view in Bekenstein's bound that "there is an inherent connection between information, energy, and mass" [12].

3. **Mass:** The accumulation of the number of evolutionary carriers, combined with carrier aggregation under rule constraints, naturally emerges mass; mass is a concrete representation of the existence of carriers, and also an important embodiment of information "solidification" and "encapsulation", which is directly related to the eigenstate information and information capacity of carriers. This cognition is also supported by the theoretical basis of Bekenstein's bound on the relationship between information and mass [12].

4. **Evolutionary space:** The evolution system naturally emerges an evolvable space based on the free evolution of a certain rule dimension; for example, an artificial neural network can naturally emerge a relational space that can be connected to each other according to evolutionary rules, and the emergence of cosmic physical space also follows this logic (the specific characteristics of evolutionary space-time will be elaborated in subsequent chapters).

5. **Evolutionary rate (velocity):** Let information point $P$ perform state transitions along degree of freedom $x$ under discrete time step $\tau$. Let $\Delta x_i$ be the step size of the $i$-th transition ($\Delta x_i \in \{0, \pm 1, \dots, \pm k_{\max}\}$). After $T$ evolution events, the total evolution amplitude is:

$$L = \sum_{i=1}^{T} \Delta x_i$$

In this system, time is defined as event count, and velocity $v$, as an emergent quantity, is defined as the ratio of amplitude to the number of events:

$$v = v_0 \cdot \frac{L}{T}$$

where $v_0$ is the basic evolution rate of the system.

**Key inference:** If the entire system pauses evolution ($T$ stops increasing), then the internal perceived time $dt = 0$, and velocity $v$ is undefined; the upper limit of velocity is determined by the maximum single step size $k_{\max}$:

$$v_{\max} = v_0 \cdot k_{\max}$$

(corresponding to the speed of light $c$); even if different systems (such as RGB color space and physical space) have different reference step sizes, their causal structures are isomorphic as long as the relative ratio $L/T$ is consistent.

**Special explanation:** In the same relational system, velocity is not the evolution step size of a single evolution subject at a single time point, because the influence of the step size needs to be reflected through the comparison of mutual relationships. For example, two RGB color evolution systems have total step sizes of 512 and 256 in a single degree of freedom, and single step sizes of 2 and 1 respectively, but the causal relationships they produce are completely consistent. At the same time, in the same relational evolution system, even if there is a long-term (such as 10,000 years) overall evolution pause, the subjects inside the system cannot perceive this pause process. Therefore, the essence of time is the number of events, not the time interval rate—there are no events without state evolution in the system, and no time without events.

### 4.2 Abstract Emergence (Direct Derivation of Rule Stability)

1. **Mathematics:** The stability of rules drives the emergence of quantifiable and reusable laws in the system, which are abstracted to form mathematics; essentially, it is a "mathematical tool emerging from rule stability", used to describe the quantitative characteristics of information evolution, relational networks, and causal correlations, rather than an independent mathematical basis for information, and is a quantitative embodiment of system orderliness.

2. **Probability:** The evolution of information points in the system has multiple potential states. Combined with the existence of redundant representation, probability naturally emerges; probability is a quantitative description of the potential states of information evolution and the possibility of redundant representation selection, which is directly related to the relational contribution of information points and rule constraints.

### 4.3 Compound Emergence—Steady State and Anti-Disturbance Ability

**Steady state:** In the relational network, under the constraints of multiple rules, multiple information carrier variables, driven by energy costs, will jointly form a stable composite relational structure when evolving to adjacent positions, that is, a steady state. The core characteristics of a steady state are "anti-disturbance ability" and "co-evolution ability". To quantify the anti-disturbance ability of the steady state, a system potential energy function $V(\vec{x})$ and a disturbance threshold $\varepsilon$ are introduced:

Let the system state be described by the vector $\vec{x} = (x_1, x_2, \dots, x_n)$, and the steady state corresponds to the minimum point of the potential energy function $V(\vec{x})$. The anti-disturbance ability (stability) of the system is defined as the minimum energy cost required to make the system jump out of the current steady state:

$$\varepsilon = \min_{\vec{y} \notin \text{SteadyState}} [V(\vec{y}) - V(\vec{x}_0)]$$

where $\vec{x}_0$ is the steady state point. If the external disturbance energy $E < \varepsilon$, the system state remains (steady state maintenance); otherwise, phase transition or disintegration occurs. This formula uses the concept of potential well to explain why structures such as atoms and DNA can resist thermal noise, converting "anti-disturbance ability" into a computable physical quantity. This steady state mechanism is consistent with the view in dissipative structure theory that "open systems maintain stability through energy exchange" [13].

The source of anti-disturbance ability is: the steady state requires the joint action of multiple influencing variables to change its overall relationship; local changes of a single or a few information points and carriers will not have a significant impact on the overall structure and core relationships of the steady state. For example, macro information structures such as atoms, DNA, and stones are typical manifestations of steady states—small fluctuations of local units will not destroy their overall relational structure, thereby maintaining the stable evolution of the system; the co-evolution ability is reflected in the fact that multiple information points and carriers in the steady state will adjust their states synchronously according to the same rules to maintain the stability of the steady state. This self-organizing steady state characteristic is also supported by Kauffman's theory of "order from chaos", that is, complex systems can spontaneously form stable order through underlying rules [14].

## 5 System Stability and Cosmic Physical System

To achieve long-term ordered evolution, an information state evolution system must satisfy specific stability constraints; as the most representative stable system in the generalized evolution system, the cosmic system fully conforms to these constraints, and its physical characteristics are highly unified with the laws of information evolution, further confirming that the universe is a "relational state evolution system", rather than a pure information system or a computing system—which is the core argument goal of this paper.

### 5.1 Core Constraints for System Stability

1. **Standard quantum variable discreteness:** The variables of the underlying carriers of the system must have standard discreteness. Only variables with standard discreteness can be identified and observed by other variables, thereby emerging distinguishable state differences; without discreteness,

clear differences cannot be formed, information cannot be generated, and the system cannot achieve ordered evolution. Mathematically, any carrier variable $q$ must satisfy: its state wave function $\psi(q)$ is non-zero only at discrete points. For example, when an electron evolves in three-dimensional orthogonal degrees of freedom, its physical entity must have distinguishable quantum characteristics that can be observed by quantization, as well as standard quantifiable three-dimensional orthogonal step sizes for evolution; even the variable dimensions of an artificially defined RGB color state evolution system need to satisfy similar standard quantized eigenstates and free discrete evolution dimensions such as 0-255. This constraint is consistent with the core hypothesis of "quantization" proposed by Planck and is the basis of quantum theory [6].

2. **Rule stability:** The underlying rules of the system must be constant, free of random fluctuations, and applicable to all states and units in the system; only with stable rules can symmetry and equivalence in degrees of freedom such as time and space emerge, ensuring the predictability of information evolution and state transitions, and providing a basis for causal closure and the emergence of mathematical laws (the stability mechanism of evolutionary rules will be elaborated in detail in subsequent chapters).

3. **Resource conservation:** The total amount of physical evolutionary carriers at the bottom of the system must be conserved, that is, resource conservation; only with resource conservation can non-causal sudden changes of original information points or steady states be avoided, ensuring the causal relevance and continuity of information evolution, maintaining the long-term stability of the system, and avoiding system collapse caused by carrier loss or disorderly increase (the conservation mechanism of evolutionary resources will be elaborated in detail in subsequent chapters) [15].

4. **Relational space exclusivity:** Evolutionary carriers or information points must be in a state of Spatial exclusivity, that is, multiple mutually interfering carriers or information points cannot exist at the same spatial position; this exclusivity can avoid excessive evolution probability, form stable causal singularity (that is, a single solution emerges mathematically), and ensure the stability and measurability of information relationships. Mathematically, it can be characterized by the generalized Pauli exclusion principle: at the same space-time coordinate $(x, t)$, the occupation number $n_i$ of the same type of Fermi-type carriers must satisfy:

$$n_i \in \{0, 1\}$$

This constraint originates from the Pauli exclusion principle and is the core physical law for maintaining material stability [16].

5. **Dominance of the same rule influence factor:** All carriers, information points, and things in the system must follow the same set of rule influence factors without differentiated constraints; for example, when setting the upper limit of velocity or the origin of velocity, different upper limits or multiple origins will not be set for photons and other particles, and all particles must follow the same set of velocity rules to drive evolution, ensuring the consistency and orderliness of system evolution.

6. **Unidirectionality of causality:** Causal correlation must be irreversible, that is, "cause triggers effect, and effect cannot reversely trigger cause"; if causality is not unidirectional, it will lead to rule contradictions (such as a beam of light can evolve reversely independently). Such contradictions have no practical significance for the evolution system and will also damage the stability and orderliness of the system. Therefore, the unidirectionality of causality is one of the core constraints

for the stable evolution of the system. This characteristic is also consistent with the view in Landauer's principle that "the irreversibility of information erasure is related to entropy increase" [8].

7. **Finiteness of single evolution step size:** In the same system, to realize the stable interaction of all evolutionary resources or carriers, it is necessary to ensure that the change rate of all carrier variables in a single evolution in this rule dimension is within a reasonable range; if the evolution speed is too fast, stable interaction between carriers cannot be realized.

8. **Interactivity:** In the evolution system, to realize cyclic and ordered evolution, it is necessary to form the interactivity between resources to establish complex and stable evolutionary causal relationships.

9. **Reversibility:** State reversibility is not equal to autonomous evolution reversibility, referring to the ability of information points to realize reverse back-and-forth evolution based on a certain degree of freedom dimension under the action of driving force.

The stable and ordered evolution of the cosmic system is realized based on the above constraints, and then complex life information state systems emerge.

### 5.2 Reinterpretation of Entropy and Information Conservation (Perspective of Generalized System)

[Note]: The reinterpretation of entropy and information conservation in this section is applicable to any generalized state evolution system that satisfies stability constraints (such as RGB color system, artificial neural network), and the cosmic system is specified as a special case at the end.

1. **Reinterpretation of entropy (generalized system):**

   In a generalized state evolution system, entropy is a measure of the frequency of state transitions in the system within a specific time interval, which is related to the "time or space shaping ability" of the underlying carriers of the system. The system evolves through free dimensions (spatial directions) to emerge distinguishable state distributions; the evolution path is accumulated through event counting (time).

   Let the total number of microstates traversed by the system within the event count $N$ be $\sum_{n=1}^{N} \Omega_n$, then the entropy is:

   $$S(N) = \kappa \ln \left( \sum_{n=1}^{N} \Omega_n \right)$$

   where $\kappa$ is the specific "state counting primitive" of the system (in the cosmic system, $\kappa = k_B$, Boltzmann constant). Entropy increase is essentially the irreversible accumulation of evolution paths, reflecting the frequency distribution of state transitions, rather than the simple increase of disorder.

   It should be noted that this framework distinguishes two levels of "state shaping ability":

   Time or space shaping ability ($mc$): Used to count the state transition ability in a single dimension and the ability to establish causal relationships based on state transitions in this dimension, corresponding to the maximum frequency $c$ of evolutionary carriers in the cosmic system to perform state transitions to affect another evolutionary carrier. This is the intrinsic origin of dynamics. Based on the equal exchange ability (the same influence magnitude for the same AB representation magnitude, which corresponds to the standard quantized system of conservation relations, and $m_1 v_1 = -m_2 v_2$ can emerge later), the movement ability and the establishment of causal relationships represent the emergence of force, energy, momentum, and entropy [17].

Space-time coupling total amount ($mc^2$): Used to describe the statistical coupling of its own space-time state, corresponding to interaction processes, relativistic effects, and the mass-energy equation [18].

Entropy, as a measure of the frequency of state transitions in the evolution path, corresponds to the former ($mc$), that is, the statistical frequency of state transitions in a single dimension (time or space).

2. **Reinterpretation of information conservation (generalized system):**

   The essence of information conservation is not the eternal existence of information itself, but the conservation of the underlying physical evolutionary carriers, driving capacity, and evolutionary rules. The three together form the foundation of a complete evolution system:

   Evolutionary carrier (momentum unit): The physical substrate of information, carrying distinguishable differences for state representation

   Driving capacity (speed of light $c$): The source of power for information state transitions, determining the upper limit of evolution rate

   Evolutionary rule (rule set $R$): The constraint framework for information interaction and state conversion, ensuring the orderliness of evolution

   The three are indispensable. Only carrier conservation without rules will make the system fall into chaos; only rules without carrier conservation will make information unable to be stably carried. The stable evolution of the cosmic system is the result of the joint conservation of the three.

   In a generalized state evolution system, as a representation of carrier relationships, the stability of information evolution, transfer, and iteration all depends on the conservation of these three, and there will be no "generation of information without carriers", "state transitions without driving force", or "random evolution without rules". This interpretation integrates the core views of thermodynamics and information theory [8,11], and is also supported by the theoretical basis of Bekenstein's bound on the correlation between information and physical carriers [8,12].

3. **Specification of the cosmic system:**

   In the cosmic system:

   The underlying carrier is the momentum unit, and resource conservation is manifested as the conservation of the total number of momentum units

   The driving capacity is the speed of light $c$, which is the upper limit of the evolution rate of a single unit

   The evolutionary rule is the rule set $R$, constrains the interaction and evolution of all momentum units

   The constant $\kappa = k_B$ (Boltzmann constant) in the entropy expression, the time or space shaping ability corresponds to the dynamic intrinsic $mc$, and the space-time coupling total amount corresponds to $mc^2$. Information conservation is manifested as the information evolution closed loop driven by the conservation of the underlying three elements (carrier, driving force, rule).

[Core Summary]: The essence is not information conservation, but dynamic conservation, rule conservation, and Representational quantity conservation. As a representation of relational states, information is dynamically evolving. The conservation of the universe is the conservation and stability of the underlying three elements (driving capacity $c$, evolutionary rule $R$, evolutionary carrier $m_0$). The three are indispensable and together form the cornerstone of the stable evolution of the cosmic system.

### 5.3 Hierarchical Emergence of Information in the Cosmic System

As a stable information state evolution system, the cosmic system follows the hierarchical emergence law of the generalized system in its information evolution. From the evolutionary relationship of the underlying physical carrier states, the following multi-level information systems gradually emerge. To quantify the complexity of different levels, a growth model of the complexity function $C(L)$ with the level $L$ is introduced: Let the level be $L$ ($L = 1$ for quantum primitives, $L = 8$ for culture), and the information complexity $C_L$ of this level can be approximately expressed as a function of the number of underlying units $N$ and the connection density $k$:

$$C_L = N_L \cdot k_L^{\alpha}$$

(where $\alpha > 1$ is the complexity growth coefficient). As the level rises, $N_L$ may decrease (for example, the number of macro objects is less than that of atoms), but the connection density $k_L$ and relational dimension increase exponentially, leading to the non-linear emergence of $C_L$, which quantitatively describes the "emergence" process from simple particles to complex cultures, indicating that high-level complexity is not the accumulation of the number of underlying units, but the qualitative change of relational density. This hierarchical emergence law is highly consistent with the core idea of "more is different" in complexity science [10], and also conforms to Kauffman's theory of "hierarchical evolution of self-organizing systems" [14].

| **Emergence Level** | **Type of Cosmic Subsystem** | **Cosmic-Specific Carrier Form** | **Information Content** | **System Characteristics (Combined with Cosmic Stable Attributes)** |
|---|---|---|---|---|
| 1st Level | Quantum Primitive System | Momentum units (underlying standard quantized carriers of the universe) | Existence/non-existence of units | Absolute conservation of underlying resources, basic information capacity, following basic evolutionary rules, meeting standard quantization requirements |
| 2nd Level | Quantum Field System | Dynamic distribution of momentum units | Direction, phase, and vector superposition relationships between units | Pre-particle state, potential space background field borrowing and returning, vector superposition of relationships lays foundation for high-level emergence, following basic evolutionary rules, see Field and Particles [19] |

| | | | | |
|---|---|---|---|---|
| 3rd Level | Particle/Matter System | Encapsulated particles (quarks, electrons, etc.) | Relationships such as particle type, position, and momentum | Stable structure formed by evolutionary rules, macro information structure has anti-disturbance ability, is basis of material world, meets relational space exclusivity |
| 4th Level | Chemical System | Atoms, molecules | Relationships such as chemical bonds, molecular configurations, and reaction paths | Complex relationships formed by electron orbital interaction, basis of material diversity, following same rule system |
| 5th Level | Life System | Cells, DNA, proteins | Relationships such as DNA sequences, metabolic networks, and signal transduction | Dissipative system, self-replication and evolution, DNA and other structures have strong anti-disturbance ability, complex information relationships, operating relying on cosmic stable rules |
| 6th Level | Nervous System | Neurons, synapses | Relationships such as neuron connections, firing sequences, and synaptic weights | Information processing and control system, complex relational network, existence of multiple representation solutions (probability information), adapting to cosmic information flow rules |
| 7th Level | Language System | Sound waves, characters, gestures | Relationships such as phonetic acoustics, character combinations, and grammatical structures | Socially agreed symbolic system, existence of redundant representation, realizing cross-temporal and cross-spatial information transmission, relying on high-level information evolution rules |
| 8th Level | Cultural System | Tools, works of art, institutions | Relationships such as knowledge systems, values, and technical principles | Non-genetic information system inherited by groups, relational network has stability and evolvability, conforming to requirements of cosmic stable evolution |

# 6 Conclusion

## 6.1 Information is the Representation of Relational States Between Things in the System

A single piece of information has no meaning in itself and can only exist as eigenstate information; the essence of information is the relative relational network within the system. Each isolated information point (which can be normally observed) must rely on this relational network to form complete information—information cannot exist independently of system relationships, and its core is the relative association in the network, rather than isolated nodes. This core view further improves the theoretical system of information ontology, clarifies the relational attribute and carrier dependence of information [4], and also echoes the similar logic of Wheeler's “It from Bit”, but always adheres to the position that “information is a state relationship, not an independently existing entity” [5].

Example: An isolated character “good” has no meaning; its meaning comes from its position in the huge relational network: the relationship with opposite concepts (bad, poor, evil) provides an evaluation scale; the subtle differences from similar concepts (excellent, good, kind) form a semantic field; the association with usage scenarios (good person, good thing, delicious) locates specific meanings; the relationship with grammatical positions (attributive, predicate, complement) defines functions; the association with cultural context (from “female beauty” in ancient times to general affirmation in modern times) endows historical depth.

### 6.2 Complex Emergence

Currently, the discussion on emergence in the scientific community is becoming increasingly intense. Emergence is often related to information, but it is difficult to clarify the essential connection between the two. In essence, information is a relationship. The reason why multiple water molecules can combine to emerge concepts such as “wet” and “ice” is that they are in different relational systems—multiple degree of freedom variables, through collective effects and relational effects, emerge new corresponding systems and related causal contributions. Therefore, emergence is a multi-level relational system in which the information dynamics evolution system undergoes qualitative changes (relational reconstruction) driven by quantitative changes (accumulation of evolutionary carriers as variables) under rule constraints. This mechanism is consistent with Holland's theory that “emergence is complex behavior caused by simple rules” [9], and also confirms Anderson's core view of “more is different” [10].

### 6.3 The Universe is an Information Dynamics Evolution System

**Core conclusion of this paper:** The universe is a three-dimensional state relational evolution system. Based on “information = the representation of state relationships between things in the system”, it can be clearly stated that the universe is a three-dimensional state evolution system of information dynamics. It should be emphasized again: the universe is not a pure information system, nor a computing system executing external programs [1,13]; its core is “self-evolution of states”, information is the representation of “state relationships” in this evolution process, and all physical characteristics and evolution laws of the universe are concrete manifestations of information state evolution. This view is also supported by the similar logic of Wheeler's “It from Bit” thought, but realizes the correction and improvement of this thought [5], laying a foundation for subsequent discussions on core issues such as evolutionary resources, evolutionary rules, and cosmic force in the “unified mechanics” framework.

This conclusion is consistent with the core claim in the 22st paper of this framework, Cosmic Free-Steady-State Binary Game Evolution — Natural Evolution vs. Unnatural Evolution[20], that “predictability comes from rule stability, and unpredictability comes from life autonomy”—as an information dynamics evolution system, the evolution of the universe includes both deterministic natural evolution (real-time offset of momentum deviation) and non-deterministic life autonomous evolution (rule asymmetry + energy storage mechanism).

### 6.4 Core Definition of Information Dynamics

The fundamental difference between "information dynamics" defined in this framework and abstract information theory is that any change of information—including storage, transmission, rewriting, and destruction—must be realized through the actual physical movement of momentum units. It is emphasized again that the difference between information dynamics and ordinary information is that processes such as impact and destruction are based on the movement and perception of physical Representational quantity (evolutionary carrier) A, establishing a causal relationship with another evolutionary Representational quantity B. In this process, the high-speed movement of A destroys the original coupling relationship of system B in a short time, that is, information structure destruction occurs. Only when B has a strong information structure recovery ability or anti-disturbance ability can it be regarded as non-dynamic destruction. The essence of information dynamics is a dynamic system based on representable physical relationships, rather than a system representing operator evolution. However, the information in this paper is generalized information, which can include all definitions of information. The difference lies in the relational representation of information in the cosmic physical system and the emergent abstract information representation.

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