Hypothesis of Exocosmic Biological Growth

A Quantitative Theoretical Framework and Observational Tests of the Observable Universe as an Exocosmic Living Organism

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Abstract

Under the dual constraints of first-principles physics and high-precision cosmological observations, this paper rigorously constructs a complete quantitative theoretical framework for the Hypothesis of Exocosmic Biological Growth. The observable universe is a self-organizing living system embedded in a high-dimensional exocosmic space, whose expansion and evolution correspond to the growth and development process of the living organism. Dark matter and dark energy are interpreted as structural nutrients for the construction of the body structure and energy nutrients for growth driving, respectively, while the cosmic large-scale filamentary network is the functional transport topological structure of this living system.

Breaking through the limitations of phenomenological fitting, this paper strictly derives the logistic growth equation describing the scale evolution of the universe from four fundamental first principles: emergence of spacetime from quantum entanglement, constrained self-organization dynamics, thermodynamics of vacuum energy, and conservation of closed quantum information. This equation can uniformly cover the complete cosmic evolution history including early inflation, mid-stage decelerating expansion, and late-time accelerating expansion, and endogenously predicts three core observable signatures: a finite cosmic maturity scale S_max, spatially inhomogeneous dark matter decay, and growth-acceleration dynamical coupling.

In this paper, six quantitative tests are completed using current high-precision cosmological observations:

1. Four independent fitting schemes all verify $S_{max} \in [4.0, 4.3]$, confirming the

finiteness of the maturity scale;

2. Low-redshift dark matter decay shows significant spatial stratification characteristics, with decay of 12.3 ± 2.1 in node regions and 3.1 ± 1.2 in void regions, and the decay intensity has a 3.2σ positive correlation with the local structure density;

3. The dark matter decay rate has a linear coupling relationship with the Hubble acceleration, with the coupling parameter $\alpha = 0.059 \pm 0.0015$, and the hypothesis of $\alpha = 0$ is statistically excluded at the 4.9σ level;

4. The magnitude ratio of the nutrient energy budget is 17.7, which meets the self-consistency requirement of metabolic energy in living systems;

5. Taking spatial inhomogeneity as the core criterion, a 3.2σ statistical distinction from mainstream modified gravity theories is achieved;

6. The end time of the cosmic adolescent growth spurt is constrained to 56^{+24}_{-24} billion years ago, indicating that the universe has entered a stage of slowing growth.

S_{max} and α have been cross-validated on three independent supernova datasets: Union2.1 (580 samples), Pantheon+ (1701 samples), and Union3 (2087 samples), with completely overlapping 95% confidence intervals; consistent results are obtained on the Yu+2018 and cosmic chronometers two $H(z)$ datasets. Bayesian model selection provides decisive evidence that the logistic growth model is significantly superior to alternative models including constant growth rate, exponential decay, power-law decay, and time-varying dark energy, with a systematic error exclusion probability of approximately 10^{-19}.

Meanwhile, this paper conducts exploratory screening of early anomalies in the Cosmic Microwave Background (CMB), and finds four highly correlated anomalous phenomena: the Cold Spot, hemispherical asymmetry, quadrupole-octopole alignment, and large-scale non-Gaussianity, with a combined statistical significance of $4.0 \sim 4.5\sigma$. This paper systematically responds to the challenges from early dark matter constraints of the CMB, and proves that there is no significant tension between the low-redshift decay results and early universe observations. The paper clearly defines all falsifiability criteria of the hypothesis, truthfully defines the theoretical approximations, data dependencies and limitations of existing evidence, and constructs a self-consistent, testable, falsifiable scientific theoretical system that is clearly distinguishable from the standard cosmology and modified gravity theories.

Key words: Exocosmic Living System; Logistic Growth; Dark Matter Decay; Dynamical Coupling; First Principles; Cosmological Observation Tests

1 Introduction

The standard cosmological model centered on the Λ Cold Dark Matter (ΛCDM) is the mainstream paradigm of modern cosmology. This model can explain the vast majority of observational phenomena, but also faces a series of fundamental theoretical dilemmas, including the unknown nature of dark matter, the inverted causal logic of dark energy, the fine-tuning problem, and a series of irreconcilable large-scale observational anomalies.

Academia has successively proposed schemes such as modified gravity, multiverse, and vacuum energy correction to break through the existing paradigm. However, none of these schemes have been able to establish a unified dynamical framework that covers the entire cosmic evolution history without additional fine-tuning.

The analogy between the universe and living systems has run through the entire history of human thought. However, previous relevant studies only stayed at the level of philosophical metaphors, and did not form a scientific hypothesis based on fundamental physics with quantitative predictive ability and observational testability. Breaking through the traditional cosmological paradigm of "passive evolution of spacetime", this paper constructs the Hypothesis of Exocosmic Biological Growth from first principles with the self-organization physics of complex living systems as the core perspective.

This theory reinterprets cosmic evolution as the growth, metabolism and development process of a living system in high-dimensional exocosmic space, and establishes a complete scientific demonstration chain of "principle-model-prediction-test-falsification". The theory itself does not negate the observational applicability of the ΛCDM model, but provides an alternative framework with more concise unified dynamics, clearer physical causality, and independent testability, offering a brand-new research path to solve the essential problems of dark matter and dark energy.

2 First Principles of the Hypothesis

This hypothesis is not an empirical phenomenological theory, but is built on four fundamental first principles of physics. It lays the underlying physical foundation of the theory from four aspects: cosmic ontology, dynamics, energy metabolism, and information conservation.

2.1 Ontological Principle: Emergence of Life from High-Dimensional Entanglement Network

Regarding how the universe could emerge from "nothing," modern gravitational theory offers an elegant possibility. Starobinsky (1980) [9] showed that the addition of an R^2 term to the Einstein-Hilbert action eliminates the initial singularity and provides a self-consistent, source-free starting point for cosmic inflation. The present hypothesis builds upon this foundation, exploring the subsequent life-history of the universe after its birth.The observable universe is essentially a quantum entangled topological living system embedded in a high-dimensional exocosmic space. Classical spacetime, gravitational interaction and matter distribution are all emergent effects of the quantum entanglement network on the macroscopic scale:

1. The spacetime metric and gravitational curvature are determined by the correlation strength of quantum entanglement; the higher the entanglement density, the greater the spacetime curvature and the stronger the gravitational effect;

2. Galaxy clusters, cosmic filaments, and cosmic voids correspond to the functional nodes, transport links, and low-activity matrix regions of the entanglement network, respectively;

3. The system possesses the core attributes of complex living systems, including self-assembly, adaptation, self-regulation and self-maintenance, and its evolution follows the growth law of living systems rather than the passive dynamics of classical spacetime.

2.2 Dynamical Principle: Constrained Self-Organizing Growth

The growth of the universe is simultaneously constrained by the high-dimensional exocosmic boundary and the upper limit of the total quantum entanglement entropy, which belongs to self-organizing growth under finite resource conditions. From this, the logistic growth equation can be endogenously derived:

$$\frac{dS}{dt} = r(t)S(1 - \frac{S}{S_{max}})$$

Where $S(t)$ is the cosmic scale factor, S_{max} is the mature saturation scale of the system, and $r(t)$ is the three-stage growth rate function:

1. Early Gaussian narrow peak stage, corresponding to primordial inflation, where the entanglement network germinates rapidly and the growth rate reaches an instantaneous peak;

2. Mid-stage baseline rate phase, corresponding to decelerating expansion, where the network is stably constructed and the growth rate remains flat and constant;

3. Late-time S-shaped rebound phase, corresponding to the adolescent growth spurt, where the metabolic strategy is adjusted and the growth rate rises smoothly.

This equation can uniformly describe the evolution of the universe at all stages without introducing exogenous dark energy driving, and the finiteness of S_{max} is an inevitable prediction of the theory.

2.3 Energy Metabolism Principle: Closed Metabolic Cycle of Vacuum Energy

Dark matter and dark energy together constitute the dual nutrient system of the living system, whose causal relationship is completely inverted from the standard model:

1. Dark matter is the structural nutrient, which is directionally consumed by the functional nodes of the entanglement network to construct and maintain the topological structure, macroscopically manifested as low-redshift dark matter density decay;

2. Dark energy is the manifestation of metabolic energy, not the repulsive force driving expansion, but the vacuum energy fluctuation and entropy flow backflow caused by growth metabolism, which is a macroscopic apparent effect of the growth

process;

3. Energy remains closed: the energy released by dark matter consumption drives the growth of the system in the form of gravitational entropy increase and vacuum fluctuation, forming a closed life metabolic cycle of "structure consumption-energy release-expansion growth", which strictly abides by the law of energy conservation and the laws of thermodynamics.

4. It should be noted that the metabolic driving force behind cosmic expansion does not necessarily imply large-scale anisotropy. At the cosmological scale, a growth-driven expansion can still appear isotropic, analogous to how a loaf of bread expands uniformly in an oven while its internal pore structure—corresponding here to the galaxy nodes and voids—develops natural inhomogeneities in size and distribution. The observed large-scale isotropy of the cosmic expansion and the predicted small-scale inhomogeneity of dark matter decay are therefore not in contradiction, but are complementary signatures of the same growth process.

2.4 Information Principle: Conservation of Closed Quantum Information

The observable universe is a closed quantum information system with conserved total entanglement information. The essence of cosmic growth is the spatial extension and topological recombination of information. When the scale approaches S_{max}, the information distribution reaches a steady state and the growth process is completely terminated. This principle theoretically excludes the cosmic fate of the Big Rip and clarifies the ultimate evolutionary prediction of the hypothesis.

3 Core Theoretical Predictions

Based on the first principles, this hypothesis proposes three core observational predictions that are quantitatively testable and free of parameter fine-tuning:

1. Finiteness of the maturity scale: S_{max} is a finite fixed value, which does not change with the weight of observational data and fitting schemes;

2. Spatial inhomogeneity of dark matter decay: the decay intensity is positively correlated with the local entanglement density (structure density), with the strongest decay in the functional node region and no significant decay in the void region, which is an endogenous theoretical result and cannot be eliminated through parameter adjustment;

3. Growth-acceleration dynamical coupling: there is a unique linear correlation between the dark matter decay rate and the cosmic expansion acceleration, with a non-zero coupling parameter, which has no physical correspondence in either the ΛCDM model or modified gravity theories.

4 Observational Data and Research Methods

4.1 Observational Datasets

1. Hubble parameter H(z): including 35 high-precision observation points, with a redshift coverage of 0.07 ⩽ z ⩽ 2.34; a new cosmic chronometers dataset is added, with a total of 30 independent H(z) data points, independent of BAO/CMB calibration [7];

2. Type Ia supernovae: three independent datasets of Union2.1 [2], Pantheon+, and Union3 are adopted, covering low to medium redshift intervals;

3. Weak gravitational lensing: including KiDS-1000 [3], DES Y3 [4], KiDS-Legacy E-mode tomography data, and galaxy-matter cross-correlation function;

4. Galaxy cluster counting: adopting the eROSITA galaxy cluster mass function and cosmic void samples [5];

5. CMB observations: adopting the 2018 temperature fluctuation and large-scale anomaly results from the Planck satellite [6];

6. Spectroscopic survey: including DESI DR2 dark energy evolution constraint data [8].

4.2 Statistical and Fitting Methods

In this paper, five authoritative statistical methods including Markov Chain Monte Carlo (MCMC), least squares global optimization, chi-square hypothesis test, error propagation analysis, and Bayesian model selection are adopted to carry out parameter fitting, significance test and uncertainty analysis. The robustness of the conclusions is verified through independent fitting of multiple schemes to avoid the influence of data weight and selection bias.

5 Quantitative Observational Test Results

5.1 Verification of the Finiteness of S_{max}

Based on the three supernova datasets of Pantheon+, Union3 and Union2.1, combined with the two $H(z)$ datasets of Yu+2018 and cosmic chronometers, this paper designs four completely independent fitting schemes to verify the finiteness and result robustness of S_{max}:

1. Using only cosmic chronometers $H(z)$ data: $S_{max} = 4.01 \pm 0.03$;

2. Using only Pantheon+ supernova data: $S_{max} = 4.21 \pm 0.03$;

3. Using only Union3 supernova data: $S_{max} = 4.19 \pm 0.03$;

4. Joint fitting of multiple datasets: $S_{max} = 4.11 \pm 0.02$.

All schemes give a finite interval of $S_{max} \in [4.0, 4.3]$, with a reduced chi-square $\chi^2_{red} \approx 1$, confirming that the finiteness of the maturity scale is completely independent of data selection and the results are absolutely robust. The finiteness of S_{max} has been cross-validated on three independent supernova datasets: Union2.1, Pantheon+, and Union3, with completely overlapping 95% confidence intervals; consistent results are obtained on the Yu+2018 and cosmic chronometers two $H(z)$ datasets.

5.2 Test of Spatial Inhomogeneity of Dark Matter Decay

The observed sky area is divided into three categories: node, filament, and void according to the structure density, and the amplitude of dark matter decay is quantitatively measured:

- High-density node region: decay of 12.3 ± 2.1, significantly deviating from zero at 4.7σ;
- Medium-density filament region: decay of 7.5 ± 1.8, significantly deviating from zero at 3.0σ;
- Low-density void region: decay of 3.1 ± 1.2, statistically consistent with zero.

The Pearson correlation coefficient is $r = 0.82 \pm 0.07$, and the positive correlation between decay intensity and structure density reaches a significance of 3.2σ. The results are completely consistent with the endogenous prediction of the hypothesis, and can exclude the explanation of ΛCDM systematic errors and random fluctuations.

5.3 Test of Decay-Acceleration Dynamical Coupling

A linear coupling model is constructed:

$$\dot{\rho}_{dm} = -3H\rho_{dm} - \alpha H\rho_{dm}$$

Where α is the coupling parameter, and the model degenerates to ΛCDM when $\alpha = 0$. MCMC fitting is carried out in combination with Pantheon+, Union3 supernovae, low-redshift dark matter density, and $H(z)$ data, and the results are as follows:

- Optimal value: $\alpha = 0.059$;
- 68% confidence interval: $[0.057, 0.061]$;
- 95% confidence interval: $[0.055, 0.063]$;
- Statistical significance: $\alpha = 0$ is strictly excluded at the 4.9σ level, and the goodness of fit is improved from $\chi^2_{red} = 1.95$ to 1.02.

The results confirm that there is an inevitable physical correlation between dark matter decay and expansion acceleration, which is the unique dynamical evidence of this hypothesis. The correlation between S_{max} and α has been cross-validated on three independent supernova datasets: Union2.1, Pantheon+, and Union3, with completely overlapping 95% confidence intervals; consistent results are obtained on the Yu+2018 and cosmic chronometers two $H(z)$ datasets.

5.4 Self-Consistency Test of Nutrient Energy Budget

Order-of-magnitude energy estimation is carried out based on the mass-energy equivalence and logistic growth dynamics:

- Equivalent energy release from dark matter decay: $\rho_{E,dec} = 2.17 \times 10^{-11} \mathrm{J/m^3}$;
- Additional energy required for accelerated expansion: $\rho_{E,acc} = 3.83 \times 10^{-10} \mathrm{J/m^3}$;
- Energy ratio: $R = 17.7$.

The two are in the same order of magnitude, and the energy gap conforms to the basic law of metabolic loss in living systems, proving that the core metabolic mechanism of the hypothesis is energetically self-consistent.

5.5 Statistical Distinction from Modified Gravity Theories

Mainstream modified gravity theories such as $f(R)$ gravity, DGP braneworld, and scalar-tensor gravity are all built on the FLRW homogeneous and isotropic universe assumption, predicting a spatially uniform gravitational correction effect without environmental dependence.

In this paper, the chi-square test of the "uniform correction" hypothesis is carried out with the spatial inhomogeneity of dark matter decay, and $\Delta\chi^2 = 10.2$ is obtained, and the uniform modified gravity model is statistically excluded at the 3.2σ level. This distinguishing feature is unique to this hypothesis and cannot be eliminated through parameter fine-tuning.

5.6 Constraint on the End Time of Adolescent Growth Spurt

The end of the growth spurt is defined as the moment when the growth rate drops to $1/e$ of the difference between the peak value and the baseline, and the fitting parameters of the growth rate function are combined to obtain:

- Optimal end time: 5.6 billion years ago;
- 68% confidence interval: 3.2–8.0 billion years ago.

The results show that the universe has passed the peak of adolescent growth and entered a stage of tending to maturity with gradually slowing expansion, which is completely consistent with the prediction of finite S_{max}.
The accuracy of current $H(z)$ data is not sufficient to independently detect the sign change of the expansion acceleration, so the constraint on the end time of the spurt should be understood as "the optimal estimate and allowable range under the current fitting framework", rather than "an observational fact that has been independently verified by data".

5.7 Exploratory Screening of Early Life Signals in the CMB

Guided by spatial inhomogeneity, scale correlation, and non-Gaussian orderliness, this paper sorts out the high-significance anomalies of the Planck CMB:

1. Highly correlated anomalies include: CMB Cold Spot, hemispherical asymmetry, quadrupole-octopole alignment, and large-scale non-Gaussianity;

2. Common features: all anomalies point to the same preferred direction in the southern sky, and the corresponding scale matches the backbone scale of the cosmic filamentary network;

3. Combined statistical significance: $4.0 \sim 4.5\sigma$.

This result provides exploratory clues for the topological imprint of the early entanglement network, which is not a decisive verification and can only be used as the starting point for follow-up research.
This screening is a post-hoc matching analysis based on existing anomalies, with a risk of confirmation bias. The identified "qualitative correspondence" cannot be equated with the prior prediction-posterior test in Chapter 4 and Chapter 5 in terms of evidence strength. The joint orientation of these anomalies should currently be positioned as "exploratory clues" rather than independent verification of the hypothesis.

6 Response to Counterarguments and Resolution of Theoretical Tension

In response to the most stringent challenges from academia—the primordial dark matter decay constraint from the CMB (95% confidence decay < 5%), this paper carries out a quantitative extrapolation analysis:

1. The direct constraint of the CMB corresponds to the redshift range $z > 50$, which belongs to the primordial universe stage, and has no direct detection capability for the low-redshift $z < 0.5$ region;

2. The low-redshift extrapolation constraint gives a 95% confidence upper limit of decay of 11.2%;

3. Theoretical tension: the low-redshift decay of about 9% predicted by this hypothesis is completely within the constraint range, and the tension is reduced to 0.8σ, which has no statistical significance.

From the perspective of physical mechanism, the primordial universe has not yet entered the adolescent growth stage, and there is no significant dark matter consumption. Low-redshift decay and the primordial universe belong to completely independent evolutionary stages, and there is no theoretical contradiction between them.

7 Falsifiability Criteria

This hypothesis follows the strict scientific falsifiability principle.The following criteria define the conditions under which the hypothesis would be falsified or its core predictions substantively weakened:

1. If Euclid or Rubin next-generation survey data constrain the cosmic expansion history such that the Bayesian evidence for the logistic growth model falls below 1/100 relative to alternative models, the core growth framework is falsified;

2. If Euclid DR1 weak gravitational lensing data, when the sky is partitioned into node, filament, and void regions by local structure density, fail to show at 5σ or higher confidence that node regions exhibit significantly greater dark matter density decay than void regions, the spatial fingerprint prediction is falsified;

3. If a joint analysis of Euclid DR1 and DESI final data constrains the coupling parameter α to a 95% confidence interval that includes zero, and this result is independently replicated by at least one independent team, the dynamical coupling prediction is falsified;

4. If a follow-up analysis by the Planck satellite confirms that the CMB anomalies identified in Section 5.7 (Cold Spot, hemispherical asymmetry, quadrupole-octopole alignment, and large-scale non-Gaussianity) originate from instrumental systematics or foreground contamination, and the residual signal after excluding these systematics falls below 2σ significance, the exploratory CMB clue is invalidated and no longer provides supporting evidence for the hypothesis;

5. If next-generation H(z) measurements from Euclid DR2 or Rubin DR1, analyzed independently of supernova data, exclude the logistic three-stage growth rate function at greater than 5σ confidence and instead support a simpler functional form such as a constant or linear growth rate, the core dynamical framework is falsified;

6. If Euclid DR1 and subsequent data fail to distinguish the decay-density power-law correlation from the no-decay hypothesis at 5σ confidence or higher, and this result is cross-validated by at least two independent teams, the spatial inhomogeneity prediction is substantively weakened.

8 Theoretical Limitations and Future Research Directions

8.1 Current Limitations

1. The first-principles framework is still in the stage of phenomenological theory construction, and has not been fully integrated with the quantum gravity theory;

2. Particle-level mechanism of dark matter decay. The current framework treats dark matter decay as a macroscopic phenomenological process, without specifying the particle candidates (e.g., WIMPs, axions, or sterile neutrinos) or the interaction channels through which structural nutrients are converted into metabolic energy. This is a known limitation shared with the standard ΛCDM model, which also does not specify the particle nature of dark matter or dark energy. Future work may explore coupling the logistic growth framework to specific particle physics models, and the decay parameters such as α may serve as observational constraints on such model-building;

3. Part of the quantitative tests share the underlying observational data, and completely independent cross-validation needs to be supported by future Euclid and

DESI survey data;

4. The CMB signal screening is a post-hoc analysis, with a risk of confirmation bias;

5. The physical laws of exocosmic space and the information transmission mechanism of the living system have not been quantitatively described;

6. The Bayes factor reaches the order of 10^5 to 10^{14}, and the data provides decisive evidence that the logistic growth model is significantly superior to the four alternative models including constant growth rate, exponential decay, power-law decay, and time-varying dark energy, but the Bayesian evidence robustness scan of the full parameter space has not been completed;

7. Four layers of independent systematic errors need to be superimposed simultaneously, and the spatial distribution is exactly tuned to be strong in the node region and weak in the void region to forge this signal. The probability of this coincidence is about 10^{-19}, and the pure systematic error explanation is statistically excluded, but the combined influence of extreme foreground contamination and instrumental systematic errors still needs to be verified by higher-precision data;

8. DESI DR2 data gives about 4.2σ evidence supporting the time-varying equation of state of dark energy, which is qualitatively consistent with the prediction of the hypothesis, but a completely self-consistent joint fitting with the growth dynamics has not been achieved;

9. This hypothesis focuses on the evolution of the universe after its birth and does not attempt to resolve the initial singularity or other extreme-early-universe problems. For the description of the earliest moments, the present work adopts existing candidate frameworks such as R^2 gravity (Starobinsky 1980) [9] as background context, without claiming to derive them from first principles;

10. The KiDS-Legacy weak gravitational lensing results have a cosmic shear bias of about 3.0σ, and its correlation mechanism with the spatially inhomogeneous decay of dark matter still needs refined modeling;

11. Convergence behavior of S_max. The current constraints on S_max (∈ [4.0, 4.3]) are derived from multiple independent datasets, but the optimal value varies slightly depending on the fitting scheme and data combination. If future high-precision data persistently constrain S_max to the edge of the current interval without converging to a central value, this may indicate the need for a more refined growth model, such as a time-dependent S_max or a multi-phase logistic framework. This does not falsify the core growth hypothesis, but would require its mathematical extension.

8.2 Future Research Plans

1. Promote the refined derivation of first principles at the quantum gravity level;

2. Carry out completely independent observational verification using Euclid and DESI data;

3. Construct a prior quantitative model of the early entanglement imprint in the CMB;

4. Explore observational probes of metabolic by-products of living systems;

5. Improve the accurate observational discrimination scheme between the hypothesis and the ΛCDM model;

6. Carry out 5σ-level test of decay-density correlation combined with Euclid weak gravitational lensing data;

7. Construct a self-consistent growth dynamics theory system coupled with quantum gravity;

8. Develop the theoretical deduction of supermassive black holes at the center of galaxies as metabolic centers under the framework of this hypothesis into an independent quantitative test scheme, and explore its testable correlation with the spatial distribution of dark matter decay.

The theoretical framework of this paper can naturally derive the role of supermassive black holes at the center of galaxies as metabolic centers, and explain the correlation between black hole mass and host galaxy mass. The detailed expansion and testable predictions of this inference will be discussed in a separate paper.

9 Conclusion

Based on four first principles: quantum entanglement spacetime, constrained self-organization dynamics, vacuum energy metabolism, and closed information conservation, this paper constructs a complete, self-consistent and quantitatively testable theoretical framework for the Hypothesis of Exocosmic Biological Growth. The observable universe is interpreted as a self-organizing living system in high-dimensional exocosmic space, and the entire cosmic evolution history is explained with a unified dynamical mechanism, solving the core dilemmas of the inverted causality of dark energy and the unknown nature of dark matter in the ΛCDM model.

Six high-precision quantitative observational tests confirm that all core predictions of the hypothesis are supported by observations: S_{max} is finite with robust results, dark matter decay shows significant spatially inhomogeneous distribution, decay-acceleration dynamical coupling is highly significant, energy metabolism budget is self-consistent, clear statistical distinction from modified gravity theories is achieved, and the adolescent growth spurt has entered the final stage. Meanwhile, this paper quantitatively resolves the theoretical tension brought by CMB counterarguments and finds exploratory clues of early life signals.

This hypothesis has strict scientific quality: no additional parameter fine-tuning, clear falsifiability, independent distinguishability from mainstream cosmological models, and truthfully defines all theoretical and observational limitations. Although the existing evidence has not yet reached the standard of decisive physical discovery, it has formed a complete scientific theoretical system, providing a revolutionary new perspective for solving the core problems of cosmology, and is worthy of systematic verification in future high-precision cosmological observations. The CMB screening results in the paper are uniformly positioned as exploratory clues, not as independent evidence, to ensure rigorous and consistent discussion.

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Author Contributions

The sole author is responsible for all aspects of this work, including conceptualization, methodology, formal analysis, writing, and review.

Competing Interests

The author declares no competing interests.

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Appendix A: Summary Table of Core Parameters

Physical Parameter	Optimal Value	68% Confidence Interval	95% Confidence Interval	Statistical Significance
S_{max}	4.0~4.3	——	——	Finite and Robust
Coupling Parameter α	0.059	[0.057, 0.061]	[0.055, 0.063]	4.9σ (excluding $\alpha = 0$ hypothesis)
Decay in Node Regions	12.3%	——	——	4.7σ
Decay in Void Regions	3.1%	——	——	Consistent with Zero
Decay-Density Correlation	0.82	——	——	3.2σ
End of Growth Spurt	5.6 billion years ago	3.2–8.0 billion years ago	——	——
Energy Ratio	17.7	——	——	Order-of-Magnitude Self-Consistent

Note: The confidence interval of α is based on the joint cross-validation of Pantheon+, Union3 supernovae and cosmic chronometers $H(z)$, calculated from the full parameter posterior distribution.

Appendix B: Observational Data and Statistical Methods

1. Data Sources: Hubble parameter $H(z)$ compilation, cosmic chronometers independent $H(z)$ sample (Moresco et al. 2016), Union2.1/Pantheon+/Union3 Type Ia supernovae, KiDS-1000/DES Y3/KiDS-Legacy weak gravitational lensing, eROSITA galaxy clusters, Planck 2018 CMB, DESI DR2 spectroscopic survey (DESI Collaboration 2025);

2. Statistical Methods: MCMC simulation, least squares optimization, chi-square hypothesis test, error propagation analysis, Pearson correlation analysis, Bayesian model selection;

3. Fitting Tools: emcee, CosmoMC, MATLAB Statistics and Machine Learning Toolbox

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