The Triple Bounce Cosmological Framework

A Three-Leg Interpretation of Cosmic History

Paper I of the Triple Bounce Cosmology Series

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Status statement. This manuscript presents a speculative, falsifiable, and explicitly replacement-oriented cosmological framework. The observed redshift–distance expansion is retained as the outward third leg; the challenged target is the standard reconstruction of that observed leg as the complete directional history and the associated necessity of a separate primordial inflationary stage. Paper I advances the full outward–inward–outward history as the primary replacement thesis while keeping the pre-singularity oscillation, three-leg trajectory, horizon mechanism, flatness mechanism, perturbation handoff, inherited scaffold, Gravity Triune, GT1 realization, and packet interpretation as technically distinct claim families. Validation is not claimed. Version 1.1.0 supersedes Version 1.0.1 by adding reciprocal falsification, an independent-claim firewall, and explicit rules preventing the success or failure of one claim from propagating to another without a derived dependency.

Abstract

Modern cosmology reconstructs cosmic history through a combination of general relativity, the Friedmann–Lemaître–Robertson–Walker metric, the observed redshift–distance relation, the cosmic microwave background, supernova luminosity distances, baryon acoustic oscillation measurements, light-element abundances, and large-scale structure. Within the standard ΛCDM framework, these observations are organized into a predominantly single-direction expansion history beginning in a hot, dense early state. Inflation is ordinarily introduced to address large-scale homogeneity, near-flat spatial geometry, and causal correlation across regions that appear disconnected under a simpler decelerating expansion history.

This paper introduces the Triple Bounce Cosmological Framework, a three-leg interpretation in which the observable expansion is proposed to be the third leg of a longer outward–inward–outward sequence. The proposed history consists of an initial outward release of a provisional radiation-like sector called *Electro*, an inward return of the active *Electro* component through an inherited cosmic scaffold, and a renewed outward leg associated with the organization of the presently observable universe. Dark matter, dark energy, and classical gravity are organized within the framework as distinct but connected members of a Gravity Triune, carrying scaffolding, chasing, and binding functions, respectively.

The framework does not require the entire universe to contract. It distinguishes the large-scale expansion of the cosmic volume from the effective radial trajectory of *Electro*. The cosmic volume may continue expanding while *Electro* reverses direction internally. Electro pathways and a dark-matter scaffold are proposed to co-form during the first leg, persist through the inward leg, and provide inherited structure that the third leg largely reoccupies while allowing collisions, branching, asymmetry, transformation, and matter organization.

Paper I defines the architecture, terminology, scope, methodological commitments, and principal hypotheses. The series-level thesis is that the complete three-leg history can replace the standard single-direction historical reconstruction and can remove the need for a separate primordial inflationary stage, while retaining the observed third-leg expansion. This replacement thesis is a declared research hypothesis, not a completed result. Its constituent claims are compartmentalized: the pre-singularity oscillation, directional history, horizon mechanism, flatness mechanism, perturbation handoff, inherited scaffold, Gravity Triune, GT1 realization, and packet interpretation are tested separately unless a mathematical dependency is explicitly derived. The microscopic identity of *Electro*, the detailed interaction laws, the physical causes of both reversals, the duration of the hidden legs, and the exact Electro–magnetism relationship remain unresolved. Paper II develops the reciprocal tests of inflationary necessity and single-history completeness; Paper III develops Gravity Triune dynamics; and Paper IV audits the third-leg packet reconstruction without deciding the full replacement thesis.

Series-Level Replacement Thesis and Claim-Scope Protocol

Primary replacement thesis

The Triple Bounce series retains the observed redshift–distance expansion and interprets it as the third outward leg. The proposed replacement target is not the observational statement $H > 0$ over the measured third-leg interval. The challenged target is the stronger historical reconstruction

$$\mathcal{H}_{\text{single}} = \left\{ \begin{array}{l} \text{the observable outward expansion is the complete resolved} \\ \text{directional history, with a separate primordial inflationary stage} \\ \text{required to prepare its initial state} \end{array} \right\} . \tag{1}$$

The primary series hypothesis is

$$\boxed{\begin{aligned} \mathcal{H}_{\text{TB}} = {} & \text{one singular opening followed by} \\ & \text{an outward–inward–outward } \textit{Electro} \text{ history} \end{aligned}} \tag{2}$$

with the observed expansion occupying the third leg. The series tests whether this full history supplies the causal preparation, curvature history, perturbation state, thermal handoff, and structural inheritance otherwise assigned to a separate inflationary epoch. A successful noninflationary realization would falsify the corresponding claim that inflation is necessary; it would not assert that every mathematically possible inflationary history is impossible.

Independent claim families

The framework is modular. Conceptual compatibility does not establish logical equivalence. The principal claim families are:

Claim family	Question tested	Negative result means
Pre-singularity oscillation	Can a specified oscillatory or balanced boundary state be defined consistently?	The tested boundary realization is rejected or remains incomplete; the later three-leg trajectory is not thereby rejected.
Triple directional history	Can an admissible sector satisfy $\dot{R}_E > 0 \to \dot{R}_E < 0 \to \dot{R}_E > 0$ with the stated transition rules?	The tested trajectory realization or, only at the strongest level, the directional-history claim is rejected. Horizon and flatness claims are not decided automatically.

Single-history replacement	Is observed third-leg expansion only one resolved portion of a longer history?	Historical identification may fail or the tested history may be rejected; the detector-level expansion data remain intact.
Horizon counterexample	Can retained prior-leg causal preparation satisfy the declared horizon criterion without an independent inflationary stage?	That horizon mechanism is rejected. Inflation is not thereby proved necessary, and the three-leg history is not thereby rejected.
Flatness counterexample	Can the declared boundary and transfer laws yield acceptable curvature without an independent inflationary suppression stage?	That flatness mechanism is rejected. Other claim families survive unless a dependency is derived.
Perturbation and thermal handoff	Can the central transition generate an acceptable third-leg covariance and hot state?	The tested handoff or conversion mechanism is rejected.
Inherited scaffold	Is prior structural information retained and measurably expressed?	The tested memory carrier, retention law, or historical-identification claim is rejected; absence of residue is not proof that no prior legs occurred.
Gravity Triune and GT1	Can binding, scaffolding, and chasing be implemented by one conserving, stable model?	A parameter region, mechanism, GT1 realization, or broader role architecture is rejected according to the demonstrated scope.
Packet reconstruction	Is the declared arithmetic physically selected and dynamically connected?	The physical packet interpretation may be rejected while its exact arithmetic remains true by definition.

Non-propagation and dependency rules

For distinct claim families C_i and C_j,

$$\boxed{\mathrm{Fail}(C_i) \not\Rightarrow \mathrm{Fail}(C_j), \qquad i \neq j,} \tag{3}$$

and

$$\boxed{\mathrm{Pass}(C_i) \not\Rightarrow \mathrm{Pass}(C_j).} \tag{4}$$

Propagation is permitted only when the manuscript derives a directional dependency, states the assumptions under which it holds, and identifies the exact conclusion reached. Narrative fit, shared terminology, or inclusion within the same four-paper program is not a dependency proof.

Within any one claim family, the rejection hierarchy remains

$$\boxed{\begin{aligned}&\text{parameter point} \subset \text{parameter region} \subset \text{mechanism}\\ &\qquad \subset \text{specific realization} \subset \text{model class} \subset \text{claim family}.\end{aligned}} \tag{5}$$

A result rejects the narrowest level logically reached. Architecture-level rejection requires showing that the defining postulates themselves, rather than one selected implementation, force the conflict.

Reciprocal falsification

The standard necessity claims are testable claims, not protected premises. For a function X such as horizon preparation, curvature control, or primordial-state generation, define

$$N^X_{\text{inf}}: \quad \text{an independent inflationary stage is necessary to perform } X, \tag{6}$$

and

$$T^X_{\text{TB}}: \quad \text{a frozen noninflationary Triple Bounce realization performs } X. \tag{7}$$

Then

$$\boxed{T^X_{\text{TB}} \text{ passes} \Longrightarrow N^X_{\text{inf}} \text{ is false as a necessity claim.}} \tag{8}$$

Conversely,

$$\boxed{T^X_{\text{TB}} \text{ fails} \not\Longrightarrow N^X_{\text{inf}} \text{ is proven.}} \tag{9}$$

A failed counterexample is not positive evidence that one competing explanation is uniquely necessary.

Revision lock

Claim compartmentalization is not an escape mechanism. Before a decisive test, the relevant action or equations, parameter domain, priors, transition laws, calibration data, validation data, and numerical tolerances must be frozen. A failed frozen realization remains failed. Changing those ingredients defines a new version and must be reported as such. The governing standard is therefore

$$\boxed{\text{compatible together; tested separately; linked only by demonstrated mathematics.}} \tag{10}$$

Keywords: cosmology; Triple Bounce; multi-stage cosmology; bounce cosmology; dark energy; dark matter; cosmic inflation; cosmic web; large-scale structure; early universe; cosmic horizon; spatial flatness; nonequilibrium cosmology

Contents

Notation and Terminology

The terminology introduced in this manuscript distinguishes model-specific concepts from established physical quantities. In particular, *Electro* is not used as a synonym for an ordinary electric field, an electron fluid, electromagnetic radiation, or visible light.

Definition 1 (Electro)**.** *Electro* is the provisional name assigned to the effective sector that carries the active outward–inward–outward trajectory. Its microscopic identity is unresolved. It is treated as physically distinct from ordinary light during the first and second legs, while ordinary electromagnetic behavior is proposed to become established through candidate coupling with a separate magnetic sector during the third leg.

Remark 1. The term *Electro* is deliberately provisional. It functions as a placeholder for a physical sector whose microscopic description has not yet been derived. A more precise field-theoretic name may replace it if the companion papers or subsequent work identify the underlying microphysics.

Table 2: Principal notation used in the Triple Bounce framework.

Symbol or term	**Meaning**
$a(t)$	Large-scale cosmological scale factor. It describes the evolving metric or outer cosmic volume and is not automatically identified with the radial position of *Electro*.
$H(t)$	Hubble expansion rate, $H(t) = \dot{a}(t)/a(t)$.
$R_E(t)$	Effective physical radial coordinate assigned to the active *Electro* component.
$\chi_E(t)$	Effective comoving coordinate of *Electro*, where a useful kinematic decomposition is $R_E(t) = a(t)\chi_E(t)$.
$\mathcal{W}_1(\boldsymbol{x})$	Primordial pathway pattern co-formed with the distributed dark-matter scaffold during the first outward leg.
$\mathcal{W}_3(\boldsymbol{x})$	Third-leg web occupied by electromagnetic and material structure.
Electro	A provisional effective sector representing the active outward–inward–outward component. Its microscopic identity is unresolved, and it is not assumed to be ordinary electromagnetic radiation during the first or second leg.
First leg	Initial outward propagation led by *Electro*, during which *Electro* pathways and distributed dark-matter scaffolding are proposed to co-form.
Second leg	Inward return of the active *Electro* sector while the larger cosmic volume may continue expanding and the dark-energy-like chasing role remains outward.
Third leg	Third outward propagation associated with observable cosmic history, candidate Electro–magnetism coupling, and the organization of stable ordinary matter along inherited pathways.
Gravity Triune	The proposed connected system of classical gravity, dark matter, and dark energy.
Binding	The functional role provisionally associated with classical gravity.
Scaffolding	The functional role provisionally associated with dark matter.
Chasing	The continuing outward role provisionally associated with dark energy.

1 Introduction

1.1 The cosmological problem

Modern cosmology is supported by a remarkably coherent network of observations. The expansion of the universe is inferred from the redshift–distance relation first established observationally in the early twentieth century (Hubble, 1929). The accelerated expansion of the late universe is inferred from Type Ia supernova luminosity distances (Riess et al., 1998; Perlmutter et al., 1999). The thermal history and large-scale geometry of the early observable universe are constrained by the cosmic microwave background, including its nearly blackbody spectrum, temperature anisotropies, polarization, and acoustic structure (Planck Collaboration et al., 2020). The distribution of galaxies and intergalactic matter reveals a large-scale network of filaments, clusters, walls, and voids whose statistical behavior can be compared with gravitational structure-formation models (Peebles, 1980; Springel et al., 2005; Libeskind et al., 2018).

The strength of this observational agreement does not imply that every element of the standard physical interpretation is directly observed. Several of the most important quantities in cosmology are reconstructed through a model. Distances, ages, horizon scales, density parameters, curvature bounds, and primordial conditions are inferred by fitting observations to equations that already contain assumptions about the global expansion history.

The standard homogeneous and isotropic description begins with the Friedmann–Lemaître–Robertson–Walker line element (Friedmann, 1922; Lemaître, 1927; Ellis, 1971; Weinberg, 2008),

$$\mathrm{d}s^2 = -c^2\mathrm{d}t^2 + a^2(t)\left[\frac{\mathrm{d}r^2}{1-kr^2} + r^2\mathrm{d}\Omega^2\right], \tag{11}$$

where $a(t)$ is the cosmic scale factor and k is the spatial-curvature parameter. Wherever factors of c are displayed explicitly, ρ denotes mass-equivalent energy density, $\rho = \varepsilon/c^2$. For total density ρ, pressure p, and cosmological constant Λ, the corresponding background evolution is commonly represented by

$$H^2(t) = \left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\rho - \frac{kc^2}{a^2} + \frac{\Lambda c^2}{3}, \tag{12}$$

and

$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3}\left(\rho + \frac{3p}{c^2}\right) + \frac{\Lambda c^2}{3}. \tag{13}$$

These equations provide a successful mathematical architecture for describing the observable universe. The unresolved questions concern the physical identity of the components inserted into them and whether the observable expansion necessarily represents the entirety of cosmic history.

The standard ΛCDM model assigns the dominant late-time accelerated expansion to a cosmological-constant-like contribution, while dark matter supplies most of the gravitating non-baryonic matter required by large-scale structure and many dynamical observations. Despite the model's empirical success, the microscopic nature of dark matter remains unknown, and the physical meaning of the cosmological constant remains deeply problematic (Weinberg, 1989; Peebles and Ratra, 2003).

Inflation adds another explanatory layer. It proposes an early period of accelerated expansion that can address the horizon problem, suppress observable spatial curvature, and transform microscopic fluctuations into macroscopic density perturbations (Guth, 1981; Linde, 1982; Mukhanov and Chibisov, 1981). Inflation is a broad class of models rather than a single uniquely determined mechanism. Its observational successes do not by themselves establish one particular inflaton field, potential, initial condition, or transition history.

The Triple Bounce framework begins at this interpretive boundary. It asks whether some observations attributed to a single early expansion and an inflationary stage could instead arise because the observable universe constitutes only the third leg of a longer directional history.

1.2 Observation versus reconstruction

The distinction between observation and reconstruction is central to this paper.

Astronomers observe photon frequencies, angular positions, polarization, brightnesses, spectra, galaxy correlations, lensing distortions, elemental abundances, and other detector-level quantities. Cosmological distances and elapsed times are then inferred through a model connecting those observations to the expansion function $H(z)$.

For example, the comoving radial distance to redshift z in a spatially flat background is calculated as

$$D_C(z) = c \int_0^z \frac{\mathrm{d}z'}{H(z')}. \tag{14}$$

The corresponding distance and lookback-time relations are standard cosmological constructions (Hogg, 1999; Dodelson, 2003). The lookback time is calculated differently:

$$t_L(z) = \int_0^z \frac{\mathrm{d}z'}{(1+z')H(z')}. \tag{15}$$

Consequently, a present-day distance measured in billions of light-years is not automatically equal to an elapsed duration measured in billions of years. Both quantities depend on the assumed evolution of $H(z)$.

The Triple Bounce framework does not claim that standard astronomical measurements are fictitious or carelessly obtained. Its narrower claim is that the same measurements may admit a different global history if the active primordial component does not remain comoving with the large-scale expansion at all times.

Hypothesis 1 (Incomplete-history hypothesis)**.** *The presently observable expansion corresponds primarily to the third leg of a longer outward–inward–outward energetic history. Standard cosmological reconstruction may therefore assign third-leg observables to the total age and complete dynamical history of the universe.*

This hypothesis must eventually be tested through explicit predictions for redshift, distance, causal structure, curvature evolution, and the primordial perturbation spectrum. It cannot be established by terminology or numerical coincidence alone.

2 Purpose and Scope

2.1 Purpose of the foundational paper

The purpose of Paper I is to define the Triple Bounce architecture at the level required for progressive mathematical development across the companion papers. Its immediate goal is not to provide a complete quantum theory, a particle model of dark matter, a grand unification theory, or a final derivation of the cosmological constant.

Paper I sets out five foundations.

First, it defines the outward–inward–outward sequence as three physically distinguishable legs of one complete Triple Bounce history.

Second, it separates the large-scale expansion of the cosmic volume from the effective radial motion of the active *Electro* component.

Third, it introduces the candidate hypothesis that Electro pathways and a dark-matter scaffold co-form during the first leg and remain available through the second and third legs.

Fourth, it organizes classical gravity, dark matter, and dark energy as distinct but connected members of a Gravity Triune.

Fifth, it maps candidate mechanisms onto selected problems involving expansion, inflation, causal horizons, spatial flatness, dark matter, and dark energy, while identifying the observations and equations that the framework must reproduce or improve upon.

The intended result is an architecture that can stand or fall according to its internal consistency, mathematical derivation, observational comparison, and explicit failure conditions. Paper I establishes the vocabulary and research burden; it does not claim validation.

2.2 What this paper does not attempt

The present paper does not attempt to solve every early-universe problem simultaneously. In particular, it does not provide:

1. a microscopic field theory for *Electro*;
2. a particle identity for dark matter;
3. a complete interaction Lagrangian joining classical gravity, dark matter, and dark energy;
4. a detailed theory of quantum gravity;
5. a complete entropy law for the full three-leg history;
6. a mechanism describing the end of a prior universe;
7. a galactic dark-matter halo model;
8. a final theory of baryogenesis;
9. a claim that the packet growth factor is identical to the dimensional cosmological constant Λ; or
10. a claim that the current numerical framework independently predicts the observational values from which it was partly constructed.

These exclusions are not admissions that the questions are unimportant. They prevent unresolved microphysics from being mixed prematurely with the model's central cosmological architecture.

Limitation 1. The Triple Bounce framework is presently a kinematic and effective-dynamical proposal. A complete physical theory will require field equations, conservation laws, stability analysis, perturbation equations, and observational parameter estimation.

3 Core Triple Bounce Proposition

3.1 Three real directional legs

The name "Triple Bounce" refers to one complete sequence of three physically distinguishable propagation legs. The first leg begins with the singular opening; the second and third legs begin at directional reversals of the active *Electro* component. The name therefore does not assert three singularities or three identical reversal events.

The proposed sequence is

$$\text{outward first leg} \longrightarrow \text{inward second leg} \longrightarrow \text{outward third leg.} \tag{16}$$

The first leg begins with the singular opening from an unstable, oscillatory pre-singularity state. During this leg, *Electro* is the earliest identified active outward sector and leads propagation while *Electro* pathways and a distributed dark-matter scaffold are proposed to co-form. Classical gravity contributes binding and regulation, while the dark-energy-like chasing sector supports continued outward evolution.

At an outer transition, the active *Electro* component reverses direction. Paper I leaves the physical cause of this reversal unresolved. The chasing sector is not required to reverse with *Electro*, so the larger cosmic volume need not contract.

During the second leg, *Electro* returns inward through inherited *Electro*–dark-matter pathways. The distributed dark-matter scaffold is proposed to provide containment and pathway persistence while the Gravity Triune continues to operate as a connected whole.

At a central transition, *Electro* returns to the post-singularity region or topology and again reverses direction. Paper I also leaves the physical cause of this reversal unresolved. During the third leg, *Electro* travels outward through the inherited scaffold and undergoes candidate coupling with magnetism. This leg is associated with the establishment of ordinary electromagnetic behavior, particle organization, matter stabilization, and the observable cosmic expansion.

The three legs are therefore not independent mini-theories. They are successive expressions of one complete history in which *Electro*, the dark-matter scaffold, classical gravitational binding, and dark-energy- like chasing retain connected roles while their relative expressions change.

Hypothesis 2 (Triple directional history)**.** *Cosmic history contains three successive directional legs of the active Electro component: outward propagation, inward return, and renewed outward propagation.*

3.2 Expansion without total contraction

A crucial distinction separates the Triple Bounce framework from many conventional bounce cosmologies.

In numerous bounce models, the scale factor itself changes from contraction to expansion. A cosmological bounce may then be characterized schematically by

$$H(t_b) = 0, \qquad \dot{H}(t_b) > 0. \tag{17}$$

The Triple Bounce model does not initially require such a reversal of the entire Friedmann–Lemaître–Robertson–Walker background.

Instead, the physical radial position of *Electro* may be decomposed as

$$R_E(t) = a(t)\chi_E(t). \tag{18}$$

Differentiating gives

$$\dot{R}_E(t) = H(t)R_E(t) + a(t)\dot{\chi}_E(t). \tag{19}$$

During the inward second leg, the large-scale expansion may satisfy

$$\dot{a}(t) > 0, \tag{20}$$

while *Electro* satisfies

$$\dot{R}_E(t) < 0. \tag{21}$$

For both conditions to hold simultaneously, the inward peculiar term must exceed the outward metric contribution:

$$a(t)\dot{\chi}_E(t) < -H(t)R_E(t). \tag{22}$$

This is the model's first major departure from a single-component interpretation. The universe's outer scale can continue growing while one energetic sector moves inward through it.

Proposition 1 (Sectoral reversal)**.** *A reversal of Electro does not mathematically require a reversal of the global scale factor. The two motions can be represented by distinct degrees of freedom.*

3.3 Persistent web memory

The first outward leg is proposed to co-form a spatially extended *Electro*–dark-matter pattern,

$$\mathcal{W}_1(\boldsymbol{x}), \tag{23}$$

with the dark-matter component distributed throughout the developing filamentary pathways rather than confined to an outer boundary. When the active *Electro* front reverses inward, this large-scale pattern is not assumed to be erased.

The third-leg structure may be represented provisionally as

$$\mathcal{W}_3(\boldsymbol{x}) = \alpha\,\mathcal{W}_1(\boldsymbol{x}) + \delta\mathcal{W}_{\text{int}}(\boldsymbol{x}), \tag{24}$$

where α represents the degree of large-scale pathway retention and $\delta\mathcal{W}_{\text{int}}$ represents deviations generated by collisions, interaction, secondary branching, asymmetry, and nonlinear structure formation.

The working expectation is that

$$\alpha \approx 1 \tag{25}$$

on the largest scales, without requiring perfect microscopic retracing.

This inherited-web hypothesis differs from the standard assumption that all primordial large-scale structure begins as a newly generated statistical perturbation field during the observable expansion. It does not deny gravitational growth from small density contrasts. It proposes that the dominant spatial pathways may possess a prior directional history.

4 Principal Architectural Claims and Candidate Mechanisms

Paper I advances the following limited set of architectural hypotheses and candidate mechanisms. They are not all at the same level of maturity, and none is presented here as observationally verified.

4.1 Claim 1: the visible universe represents the third leg

The approximately 13.8-billion-year conventional age scale is provisionally interpreted as an observationally anchored third-leg scale rather than as automatic proof that no earlier cosmic legs existed.

This interpretation does not establish the duration of the first or second leg, nor does it establish the full elapsed age of the Triple Bounce history. Those quantities require explicit trajectory models and matching conditions developed across the companion papers.

4.2 Claim 2: *Electro* and the scale factor are distinct

The active *Electro* component is assigned a trajectory that may differ from the average expansion of the cosmic volume. This distinction permits an inward second leg without requiring a universal Big Crunch.

4.3 Claim 3: the co-formed web persists

Electro pathways and the large-scale dark-matter scaffold are proposed to co-form during the first leg and remain available during the second and third legs. Dark matter is treated as distributed containment and scaffolding throughout the filamentary network, not merely as an outer edge or terminal capture layer. Matter later occupies this inherited structure unevenly, producing filaments, junctions, walls, and voids rather than a uniformly filled volume.

4.4 Claim 4: the chasing role remains outward

Within the framework, dark energy is treated as a distinct, volume-filling energetic sector that maintains an outward chasing role across the three-leg history. It is not restricted to a thin external shell.

The negative-pressure behavior used in standard dark-energy phenomenology is treated as potentially consistent with this continuing outward role. This is a candidate physical interpretation, not a derived equivalence. Paper I does not claim that dark energy is a literal fluid current or that it possesses a directly measured local velocity.

4.5 Claim 5: gravity is triune

Classical gravity, dark matter, and dark energy are treated as separate but dynamically connected members of one Gravity Triune:

$$\text{Gravity Triune} = \{\text{classical gravity}, \text{dark matter}, \text{dark energy}\}. \tag{26}$$

Their provisional functional assignments are

$$\begin{aligned} \text{classical gravity} &\longrightarrow \text{binding}, \\ \text{dark matter} &\longrightarrow \text{scaffolding}, \\ \text{dark energy} &\longrightarrow \text{chasing}. \end{aligned} \tag{27}$$

The term "one-third component" refers to one of three functional members. It does not mean that each component constitutes one-third of the measured mass-energy density.

These assignments apply across the complete three-leg history. Binding, scaffolding, and chasing are not sequential stages and are not confined to isolated legs. Their relative dominance and physical expression may change, but the framework treats their balance as continuous throughout the outward–inward–outward process.

4.6 Claim 6: the third leg is physically reorganizing

The third leg is not simply a repetition of the first and is not a second Big Bang. It includes the prior outward imprint, the inward return history, an unresolved central reversal, and a renewed outward flow from the post-singularity region.

The third leg is therefore proposed to be a nonequilibrium reorganization event in which:

(a) *Electro* undergoes candidate coupling with a separate magnetic sector;

(b) ordinary electromagnetic behavior may become established through a candidate mechanism whose microscopic form remains unresolved;

(c) energetic radiation and particle-like excitations may be transformed;

(d) stable ordinary matter becomes organized along the inherited web;

(e) collisions, gravity, electromagnetic effects, and local conditions may create deviations and new branches; and

(f) energetic crossings at major junctions may assemble, transform, stabilize, or disrupt energy and matter while producing rotational, circulatory, or dynamo-like tendencies.

These statements are candidate mechanisms for mathematical and observational study in the companion papers. They are not presented as completed derivations. Paper I does not determine whether all particles first appear during the third leg.

5 Relationship to Standard Cosmology

5.1 What is retained

The Triple Bounce framework does not begin by discarding general relativity or the Friedmann–Lemaître–Robertson–Walker metric.

The first mathematical program retains:

1. the Friedmann–Lemaître–Robertson–Walker background as the leading homogeneous description;
2. the Friedmann equations as the standard relationship between geometry and effective stress-energy;
3. the measured redshift–distance relation;
4. the cosmic microwave background temperature and polarization observations;
5. supernova luminosity-distance measurements;
6. baryon acoustic oscillation measurements;
7. large-scale-structure surveys;
8. light-element abundance constraints; and
9. standard conservation and covariance requirements unless a clearly defined extension is demonstrated.

The framework changes the interpretation of the component history before attempting to change the underlying gravitational field equations.

5.2 What is questioned

The model questions four common interpretive assumptions.

First, it questions whether one scale factor fully specifies the motion of every primordial component.

Second, it questions whether the earliest observable third-leg state is identical to the beginning of all cosmic history.

Third, it questions whether the large-scale structural seed must have been newly generated during the observable leg.

Fourth, it challenges the stronger claim that a separate primordial inflationary stage is necessary to produce the observed causal, geometric, and perturbative regularities.

These challenges do not deny the detector-level observations or the measured third-leg expansion. They place the standard historical interpretation, the completeness of a single-direction reconstruction, and each inflationary necessity claim into direct model comparison with a noninflationary three-leg counterexample.

5.3 Inflation as a benchmark for candidate resolutions

Inflation is not identified with the first outward *Electro* leg.

Paper I advances the full hidden first- and second-leg history, together with the central transition, as the primary noninflationary replacement hypothesis for the functions ordinarily assigned to a separate inflationary stage. The first outward *Electro* leg is not relabeled as inflation; the proposed replacement is the complete three-leg causal and dynamical architecture.

Each proposed function is nevertheless an independent counterclaim. The horizon, flatness, perturbation, thermal-handoff, and historical claims must be tested separately, and failure of one does not reject the triple directional history or any neighboring claim unless a necessary mathematical dependency has been established. The Triple Bounce model must reproduce or improve upon the relevant observable functions:

1. large-scale causal correlation;
2. near-flat spatial geometry;
3. large-scale homogeneity and isotropy;
4. a nearly scale-invariant primordial fluctuation spectrum;

5. the observed amplitude and phase structure of cosmic microwave background anisotropies; and

6. acceptable tensor, scalar, and non-Gaussian signatures.

These requirements are developed and tested in companion Paper II as parallel reciprocal contests. Their joint success would support the maximal replacement package, but no individual result is permitted to stand in for another. The three-leg history, horizon counterexample, flatness counterexample, and perturbation handoff remain technically separate claims.

5.4 Dark energy and chasing as a companion-paper test

The cosmological constant is commonly represented as a vacuum-like component with equation-of-state parameter

$$w_\Lambda = \frac{p_\Lambda}{\rho_\Lambda c^2} = -1. \tag{28}$$

This produces

$$\rho_\Lambda + \frac{3p_\Lambda}{c^2} = -2\rho_\Lambda, \tag{29}$$

which contributes positively to $\ddot{a}$ in equation (13).

The Triple Bounce interpretation provisionally treats this negative-pressure behavior as potentially consistent with the continuing outward role of the chasing member of the Gravity Triune.

However, the framework does not yet claim

$$\text{packet growth factor} = \Lambda, \tag{30}$$

because the packet growth factor is dimensionless while Λ has dimensions of inverse length squared.

Companion Paper III develops candidate Gravity Triune dynamics. Paper IV reconstructs the positive packet-derived growth factor and tests whether it has any defensible mathematical or physical relationship to negative-pressure dark-energy phenomenology. No equivalence to Λ or to an equation-of-state parameter is assumed.

6 Reciprocal Falsifiability and Claim-Scope Standard

A cosmological framework cannot be evaluated solely by whether its narrative is intuitively appealing. It must eventually generate quantitative results that can be compared with existing observations and competing models.

Falsification must be reciprocal and claim-specific. A negative result rejects only the parameter region, mechanism, realization, model class, or claim family directly reached by the test. Failure may propagate to a neighboring claim only through an explicit derived dependency. Likewise, a successful Triple Bounce counterexample may reject a standard necessity claim without proving that every competing model is impossible.

The complete research program must ultimately provide:

1. a well-defined background evolution $a(t)$;
2. a well-defined *Electro* trajectory $R_E(t)$;
3. consistent transition conditions at both reversals;
4. an effective stress-energy description for the Gravity Triune;
5. a causal-horizon calculation across the full history;
6. a curvature-evolution calculation;
7. a primordial perturbation spectrum;
8. a predicted cosmic microwave background angular power spectrum or a controlled approximation to it;
9. a third-leg distance–redshift relation;
10. a structure-growth history;
11. a stability analysis for perturbations and transition regions; and
12. at least one observation that distinguishes the framework from an appropriately fitted inflationary ΛCDM model.

Hypothesis 3 (Stand-or-fall criterion)**.** *The Triple Bounce framework should be judged by its internal consistency, mathematical derivations, and distinctive predictions rather than by the authority, reputation, or institutional position of its proposer.*

A failure to reproduce established observations would count against the framework. A successful reinterpretation must explain at least as much as the standard model in the domain where the comparison is made.

The present manuscript therefore distinguishes four broad categories of statement:

I. **Observed quantities and standard reconstructions:** detector-level measurements and values inferred within established cosmological models;

II. **Core architectural postulates and model definitions:** terms, variables, and structural commitments required to express the Triple Bounce framework;

III. **Candidate mechanisms and quantitative correspondences:** proposed explanatory links or numerical results whose interpretation remains incomplete; and

IV. **Derived predictions:** quantities that must follow from the model without being inserted as independent assumptions.

Maintaining these distinctions is especially important when discussing the approximately 13.824-billion-year third-leg scale, the approximately 46.08-billion-light-year radius-scale correspondence, the repeating three-leg factor, and the positive packet-derived growth factor near 1.028. Paper I introduces that material only briefly. Papers II and III progressively develop its definitions and physical context, while Paper IV performs the most rigorous reconstruction, dimensional audit, sensitivity analysis, and comparison with standard cosmological parameters. The terrestrial 64-million-year backstory is not required for the Paper I presentation.

7 Organization of the Remaining Paper

The remainder of Paper I develops the framework in the following order.

The next major section defines the oscillatory pre-singularity state and sets limits on what Paper I claims about its energy, geometry, time, and instability.

The first-leg section then describes the outward *Electro* release, the formation of the primordial web, the scaffolding role of dark matter, and the continuing outward role of dark energy.

The second-leg section treats the outer reversal, inward *Electro* motion, preservation of the primordial web imprint, and the distinction between an instantaneous matching boundary and a finite-duration transition.

The third-leg section treats the unresolved central reversal, nonequilibrium reorganization, candidate coupling with magnetism, possible particle-like excitations, matter organization, and development of the observable universe.

A later section introduces the binding–scaffolding–chasing grammar and applies it to the Gravity Triune.

The paper concludes with candidate consequences, limitations, falsification criteria, and a structured progression into companion Papers II–IV.

8 Methodological Commitments

The Triple Bounce framework is intended to be evaluated as a physical proposal rather than as a purely metaphorical description. Its methodology must therefore distinguish between three separate tasks:

1. preserving established observational results;
2. reinterpreting the history assigned to those observations; and
3. deriving new equations capable of distinguishing the Triple Bounce history from standard cosmology.

The framework does not begin by assuming that every unresolved cosmological observation requires a new law of physics. It begins with a narrower possibility: the known equations may have been applied to only the visible portion of a longer history.

This distinction is fundamental. A reinterpretation of cosmic history cannot simply reject the mathematical success of general relativity, the Friedmann–Lemaître–Robertson–Walker metric, recombination physics, nucleosynthesis, or the measured redshift–distance relation. It must demonstrate how those results arise within a broader sequence.

The methodological commitments of the present work are therefore:

I. retain general relativity as the baseline theory of classical gravitation;

II. retain the Friedmann–Lemaître–Robertson–Walker metric as the leading homogeneous and isotropic background description unless observations require otherwise;

III. introduce *Electro* first as an effective sector rather than as a fully specified fundamental field;

IV. distinguish global metric expansion from sector-specific motion;

V. require conservation of the total stress–energy tensor;

VI. allow energy and momentum exchange among sectors only through explicitly defined interaction terms;

VII. distinguish observed quantities from model-dependent reconstructions;

VIII. avoid assigning physical meaning to numerical residuals before a derivation supports that assignment;

IX. state unresolved mechanisms openly rather than filling them with unnecessary speculation; and

X. identify observations that could reject each named claim and, where logically reached, the core architecture.

These commitments constrain the model. They are not merely stylistic preferences.

9 General Relativity as the Baseline Theory

9.1 Einstein field equations

At the classical level, the geometry of spacetime is assumed to satisfy the Einstein field equations (Einstein, 1915; Wald, 1984),

$$G_{\mu\nu} + \Lambda_{\rm ref} g_{\mu\nu} = \frac{8\pi G}{c^4} T^{\rm tot}_{\mu\nu}, \tag{31}$$

where $G_{\mu\nu}$ is the Einstein tensor, $g_{\mu\nu}$ is the spacetime metric, $\Lambda_{\rm ref}$ is an optional reference cosmological term, and $T^{\rm tot}_{\mu\nu}$ is the total effective stress–energy tensor.

The notation $\Lambda_{\rm ref}$ is used deliberately. The Triple Bounce framework does not assume at the outset that the late-time accelerating behavior must be represented by a strictly fundamental, time-independent cosmological constant.

Two mathematically equivalent bookkeeping choices are possible.

The first places the cosmological constant on the geometric side of equation (31). The second moves it to the source side and interprets it as an effective vacuum stress–energy tensor,

$$T^{(\Lambda)}_{\mu\nu} = -\frac{\Lambda c^4}{8\pi G} g_{\mu\nu}. \tag{32}$$

The Triple Bounce framework remains initially compatible with either bookkeeping convention.

The later Gravity Triune interpretation asks whether the observed negative-pressure behavior currently represented by Λ may be an effective description of the chasing component rather than the final microscopic explanation.

Assumption 1 (Classical gravitational baseline)**.** General relativity remains the baseline description of classical spacetime geometry throughout the first stage of model development. Any modification of the Einstein field equations must be introduced explicitly and justified independently.

9.2 No gravitational fluid is inserted by definition

Classical gravity is assigned the functional role of binding within the Gravity Triune. This does not mean that classical gravity is treated as an ordinary material fluid with its own local stress–energy tensor.

In general relativity, gravitational influence is encoded primarily in spacetime geometry. A unique, generally covariant local gravitational energy-density tensor does not exist in the same manner as the stress–energy tensor of matter or radiation.

Accordingly, the Gravity Triune is not initially written as

$$T_{\mu\nu}^{\text{gravity}} + T_{\mu\nu}^{\text{DM}} + T_{\mu\nu}^{\text{DE}}, \tag{33}$$

with all three members treated as equivalent substances.

Instead:

(a) classical gravity is represented by geometric response;

(b) dark matter contributes an effective stress–energy source;

(c) dark energy contributes an effective stress–energy source or cosmological term; and

(d) the word *Triune* describes their connected functional roles within the total dynamics.

This distinction prevents the conceptual Gravity Triune from being mistaken for three identical mathematical objects.

10 Effective-Sector Decomposition

10.1 Total stress–energy content

The total effective stress–energy tensor may be decomposed schematically as

$$T_{\mu\nu}^{\text{tot}} = T_{\mu\nu}^{(b)} + T_{\mu\nu}^{(r)} + T_{\mu\nu}^{(\text{DM})} + T_{\mu\nu}^{(\text{C})} + T_{\mu\nu}^{(E)} + T_{\mu\nu}^{(\text{other})}, \tag{34}$$

where:

- $T_{\mu\nu}^{(b)}$ represents baryonic matter;
- $T_{\mu\nu}^{(r)}$ represents ordinary radiation;
- $T_{\mu\nu}^{(\text{DM})}$ represents the dark-matter scaffolding sector;

- $T_{\mu\nu}^{(\mathrm{C})}$ represents the chasing sector associated with dark-energy-like behavior;
- $T_{\mu\nu}^{(E)}$ represents the effective *Electro* sector; and
- $T_{\mu\nu}^{(\mathrm{other})}$ represents any additional sector required by a later microphysical completion.

The superscript (C) refers to *chasing*. It does not imply electric charge or the speed of light.

The decomposition in equation (34) is an organizational framework. It does not imply that each sector is already known to be fundamental, mutually independent, or describable as a perfect fluid.

10.2 Perfect-fluid approximation

At the homogeneous background level, a sector may be approximated by a perfect-fluid stress–energy tensor,

$$T_{\mu\nu}^{(i)} = \left(\rho_i + \frac{p_i}{c^2}\right) u_\mu^{(i)} u_\nu^{(i)} + p_i g_{\mu\nu}, \tag{35}$$

where ρ_i, p_i, and $u_\mu^{(i)}$ are the effective energy density, pressure, and four-velocity of sector i.

This approximation is useful but not mandatory.

A primordial sector undergoing directional reversals may require:

1. anisotropic stress;
2. nonzero energy flux;
3. a non-perfect-fluid equation of state;
4. nonlocal memory terms;
5. a scalar, vector, or tensor field description; or
6. an effective kinetic distribution rather than a single fluid velocity.

A more general decomposition relative to an observer with four-velocity u^μ is

$$T_{\mu\nu} = \rho u_\mu u_\nu + p h_{\mu\nu} + \frac{2}{c^2} u_{(\mu} q_{\nu)} + \pi_{\mu\nu}, \tag{36}$$

where

$$h_{\mu\nu} = g_{\mu\nu} + \frac{1}{c^2} u_\mu u_\nu, \tag{37}$$

q_μ is an energy-flux vector, and $\pi_{\mu\nu}$ is an anisotropic stress tensor.

The existence of an inward *Electro* trajectory during a globally expanding stage suggests that $q_\mu^{(E)}$ may be nonzero in at least one effective description.

Limitation 2. The present paper does not derive the final form of $T_{\mu\nu}^{(E)}$. It identifies the minimum mathematical properties that such a tensor or field description must possess.

10.3 The dark-matter scaffolding sector

The dark-matter-associated scaffolding role is defined operationally in the foundational model.

Its first assigned role is not a particular particle identity but distributed containment, persistence, and gravitational organization throughout the primordial filamentary scaffold.

At background level, a pressureless approximation may be written as

$$p_{\mathrm{DM}} \approx 0, \tag{38}$$

with density evolution under standard noninteracting expansion given by

$$\rho_{\mathrm{DM}} \propto a^{-3}. \tag{39}$$

The Triple Bounce framework does not yet assume that equation (39) applies unmodified throughout every leg.

If dark matter exchanges energy or momentum with the chasing or *Electro* sectors, its continuity equation may contain an interaction term.

The model therefore separates:

(a) the empirically required gravitational effects conventionally assigned to dark matter;

(b) the proposed scaffolding role in the primordial web; and

(c) the unknown microscopic identity of the dark sector.

10.4 The chasing sector

The chasing sector is provisionally associated with the continuing outward behavior attributed observationally to dark energy.

Its effective equation-of-state parameter is defined as

$$w_{\mathrm{C}} = \frac{p_{\mathrm{C}}}{\rho_{\mathrm{C}} c^2}. \tag{40}$$

A strict cosmological constant corresponds to

$$w_{\mathrm{C}} = -1, \tag{41}$$

with constant energy density.

The Triple Bounce framework does not initially fix

$$w_{\mathrm{C}}(t) = -1. \tag{42}$$

Instead, the model asks whether an effective $w_{\mathrm{C}} \approx -1$ could emerge over the observable third-leg interval from a deeper evolving process.

The present paper therefore permits

$$w_{\mathrm{C}} = w_{\mathrm{C}}(t) \tag{43}$$

or

$$w_{\mathrm{C}} = w_{\mathrm{C}}(z), \tag{44}$$

provided the resulting model remains consistent with observational constraints.

10.5 The effective *Electro* sector

The *Electro* sector must be capable of:

1. outward propagation during the first leg;
2. directional reversal at the outer transition;
3. inward propagation during the second leg;
4. directional reversal at the central transition;
5. outward propagation during the third leg;
6. retaining or interacting with a persistent spatial imprint; and
7. coupling with the magnetic sector during the third leg.

At this stage, the framework does not decide whether *Electro* is best represented by:

- a scalar field;

- a vector field;
- a radiation-like kinetic distribution;
- a collective excitation;
- a topological order parameter;
- a pre-electromagnetic field component; or
- an effective degree of freedom arising from a deeper theory.

Assumption 2 (Effective-sector minimality)**.** *Electro* is introduced only at the level necessary to represent the proposed trajectory and energy transfer. No additional field content is claimed until required by a consistent derivation.

11 Kinematic, Dynamical, and Microphysical Levels

A major source of confusion in speculative cosmology is the premature mixing of kinematics, dynamics, and microphysics.

The Triple Bounce framework separates these levels explicitly.

11.1 Kinematic level

The kinematic level describes what moves, in what direction, and with what continuity properties.

The central kinematic variables are

$$\{a(t), R_E(t), \chi_E(t), \mathcal{W}_1(\boldsymbol{x}), \mathcal{W}_3(\boldsymbol{x})\}\,. \tag{45}$$

At this level, the framework proposes:

$$\dot{R}_E \begin{cases} > 0, & \text{first leg,} \\ < 0, & \text{second leg,} \\ > 0, & \text{third leg,} \end{cases} \tag{46}$$

while allowing

$$\dot{a}(t) > 0 \tag{47}$$

throughout all three legs.

The kinematic statement does not by itself explain why either reversal occurs.

11.2 Dynamical level

The dynamical level specifies the equations producing the trajectory.

A schematic *Electro* equation may eventually take the form

$$\mathcal{D}\left[R_E, \dot{R}_E, \ddot{R}_E, a, H, \rho_i, p_i, \mathcal{W}_1\right] = 0, \tag{48}$$

where $\mathcal{D}$ is an as-yet-undetermined dynamical operator.

A simpler effective trajectory model may be written as

$$\ddot{R}_E + \Gamma_E(t)\dot{R}_E + \frac{\partial V_{\text{eff}}}{\partial R_E} = S_E(t), \tag{49}$$

where:

- $\Gamma_E(t)$ is an effective damping or transfer coefficient;
- $V_{\text{eff}}(R_E, t)$ is an effective potential;
- $S_E(t)$ is a source or driving term.

Equation (49) is not adopted as the final theory. It illustrates the minimum type of dynamical structure required to generate a finite reversal.

11.3 Microphysical level

The microphysical level identifies the fundamental degrees of freedom, symmetries, charges, interactions, and quantum states underlying the effective description.

Questions at this level include:

1. What is *Electro* microscopically?
2. What distinguishes it from an ordinary electric field?
3. How is the magnetic sector represented before third-leg coupling?
4. Which interaction produces the outer reversal?
5. Which interaction produces the central reversal?
6. How are particle–antiparticle pairs generated?
7. What mechanism preserves a matter excess?
8. What symmetry is broken during the third-leg transition?

The present paper does not answer these questions.

A kinematic model can be investigated before its complete microphysical origin is known. However, a final physical theory cannot remain permanently at the kinematic level.

Remark 2. A successful trajectory fit would not by itself prove the underlying Triple Bounce interpretation. Multiple microphysical models may generate similar effective trajectories.

12 Global Expansion and Sector-Specific Motion

12.1 Multiple velocity descriptions

In standard homogeneous cosmology, matter is commonly separated into the Hubble flow and a peculiar velocity relative to that flow.

The physical position of an object or sector may be expressed as

$$\boldsymbol{R}(t) = a(t)\boldsymbol{\chi}(t). \tag{50}$$

Its physical velocity is

$$\dot{\boldsymbol{R}} = H\boldsymbol{R} + a\dot{\boldsymbol{\chi}}. \tag{51}$$

The first term represents motion associated with metric expansion. The second represents peculiar motion relative to the comoving frame.

The Triple Bounce framework applies this distinction to the primordial *Electro* sector.

It therefore rejects the assumption

$$\dot{\chi}_E(t) = 0 \quad \text{for all cosmic times.} \tag{52}$$

During the second leg,

$$\dot{\chi}_E(t) < 0, \tag{53}$$

with sufficient magnitude to produce

$$\dot{R}_E(t) < 0. \tag{54}$$

12.2 The meaning of the outer extent

The outer extent of the cosmic volume is not assumed to be identical to the instantaneous position of the active *Electro* front.

The framework distinguishes:

$$R_{\text{out}}(t) \neq R_E(t), \tag{55}$$

where $R_{\text{out}}(t)$ is an effective measure of the evolving outer scale and $R_E(t)$ is the active *Electro* trajectory.

During the second leg, the intended ordering is

$$\dot{R}_{\text{out}}(t) > 0, \qquad \dot{R}_E(t) < 0. \tag{56}$$

The difference

$$\Delta R_{CE}(t) = R_{\text{out}}(t) - R_E(t) \tag{57}$$

may grow during the inward *Electro* return.

No physical interpretation is yet assigned to every numerical value associated with this separation.

12.3 A collective coordinate rather than a visible shell

The variable $R_E(t)$ should not automatically be interpreted as a thin luminous shell moving through ordinary empty space.

It may instead represent:

(a) the radius of maximum *Electro* energy density;

(b) the location of a propagating transition front;

(c) the expectation value of a collective radial degree of freedom;

(d) the support boundary of an effective field configuration; or

(e) a topological progression coordinate.

The exact interpretation must be fixed by a completed field theory.

This methodological flexibility is necessary because the first leg is proposed to precede ordinary matter and ordinary electromagnetic radiation.

13 Conservation and Interaction Bookkeeping

13.1 Total covariant conservation

The contracted Bianchi identity implies

$$\nabla_\mu G^{\mu\nu} = 0. \tag{58}$$

Therefore, the Einstein field equations require

$$\nabla_\mu T^{\mu\nu}_{\text{tot}} = 0. \tag{59}$$

The Triple Bounce framework retains this requirement.

Individual sectors need not be independently conserved if they exchange energy or momentum.

For each sector i, one may write

$$\nabla_\mu T^{\mu\nu}_{(i)} = Q^\nu_{(i)}, \tag{60}$$

where $Q^\nu_{(i)}$ is the interaction four-current.

Total conservation then requires

$$\sum_i Q^\nu_{(i)} = 0. \tag{61}$$

Thus, energy leaving one sector must enter another sector or the geometric bookkeeping consistently.

13.2 Background continuity equations

For a homogeneous effective sector, the time component of equation (60) may be written as

$$\dot{\rho}_i + 3H\left(\rho_i + \frac{p_i}{c^2}\right) = \mathcal{Q}_i, \tag{62}$$

where $\mathcal{Q}_i$ is the background energy-transfer rate.

The total transfer must satisfy

$$\sum_i \mathcal{Q}_i = 0. \tag{63}$$

A minimal three-sector interaction among *Electro*, dark matter, and the chasing sector may be expressed as

$$\dot{\rho}_E + 3H\left(\rho_E + \frac{p_E}{c^2}\right) = \mathcal{Q}_E, \tag{64}$$

$$\dot{\rho}_{\rm DM} + 3H\rho_{\rm DM} = \mathcal{Q}_{\rm DM}, \tag{65}$$

$$\dot{\rho}_{\rm C} + 3H\left(\rho_{\rm C} + \frac{p_{\rm C}}{c^2}\right) = \mathcal{Q}_{\rm C}, \tag{66}$$

with

$$\mathcal{Q}_E + \mathcal{Q}_{\rm DM} + \mathcal{Q}_{\rm C} = 0. \tag{67}$$

The present framework does not specify the signs or functional forms of these transfer terms.

Limitation 3. No interaction term may be selected merely because it reproduces the desired trajectory. The final functions $\mathcal{Q}_i$ must arise from a defined physical coupling or effective action.

13.3 Momentum transfer

Directional reversal requires more than background energy exchange.

The spatial components of $Q^{\nu}_{(E)}$ must permit momentum transfer sufficient to change the sign of the *Electro* radial velocity.

Relative to a chosen four-velocity u^{μ}, an interaction current may be decomposed as

$$Q^{\mu}_{(i)} = \mathcal{Q}_i u^{\mu} + \mathcal{F}^{\mu}_{(i)}, \tag{68}$$

where

$$u_{\mu}\mathcal{F}^{\mu}_{(i)} = 0. \tag{69}$$

The vector $\mathcal{F}^{\mu}_{(E)}$ represents effective momentum transfer.

A physical explanation of either bounce must eventually identify the source of this term.

14 Symmetry, Homogeneity, and the Meaning of the Center

14.1 The cosmological principle

The Friedmann–Lemaître–Robertson–Walker metric assumes spatial homogeneity and isotropy at the background level.

Homogeneity means that no spatial position is preferred in the averaged description. Isotropy means that no spatial direction is preferred.

A literal radial flow away from one ordinary spatial point appears, at first glance, to introduce a preferred center and conflict with the cosmological principle.

The Triple Bounce framework must therefore distinguish between:

1. an observable center located at one position inside the present three-dimensional universe;
2. a topological origin shared by the cosmic manifold;
3. a configuration-space origin of a collective field;
4. a boundary condition in the full higher-dimensional history; and
5. a coordinate artifact.

The foundational model adopts the second interpretation provisionally.

Definition 2 (Topological origin)**.** The topological origin is the common convergence state of the *Electro* trajectory. It is not automatically identified with an observable privileged location inside the present third-leg spatial volume.

14.2 Angularly averaged background

The first mathematical treatment may retain an Friedmann–Lemaître–Robertson–Walker background by interpreting the directional history as spherically symmetric in an effective or ensemble-averaged sense.

The background *Electro* energy density may then depend only on time and effective radius,

$$\rho_E = \rho_E(t, R), \tag{70}$$

while angular perturbations satisfy

$$\langle \delta\rho_E(t, R, \theta, \phi) \rangle_\Omega = 0. \tag{71}$$

At sufficiently large scales, the average geometry may remain close to Friedmann–Lemaître–Robertson–Walker even if the *Electro* sector contains nontrivial radial structure.

14.3 A major falsification condition

The distinction between a topological origin and an ordinary spatial center is not optional.

If the completed Triple Bounce model requires Earth, the Milky Way, or any nearby region to lie close to a unique geometric center in order to explain the observed isotropy, the framework would acquire a severe fine-tuning problem.

Hypothesis 4 (No privileged terrestrial location)**.** *The observed near-isotropy of the universe must not require the observer to occupy a specially selected central position.*

A failure to satisfy hypothesis 4 would count strongly against the framework.

15 Causality and Propagation Limits

15.1 No unrestricted superluminal claim

The qualitative statement that multiple cosmic components emerge from a common origin does not establish that they propagate with identical speeds.

In standard relativistic field theory:

- massless excitations propagate locally at c;
- massive excitations propagate below c;
- phase velocities may exceed c without carrying information superluminally;
- metric expansion can increase proper distances faster than c without representing local motion through space; and
- effective front velocities must be distinguished from signal and group velocities.

Accordingly, the Triple Bounce framework does not presently claim

$$v_{\text{gravity}} = v_{\text{DM}} = v_{\text{C}} = v_E = c \tag{72}$$

throughout all three legs.

15.2 Characteristic propagation

A completed field theory must possess well-defined characteristic surfaces.

For a generic field Ψ, the principal part of its equation may be written schematically as

$$\mathcal{K}^{\mu\nu}\nabla_\mu\nabla_\nu\Psi + \cdots = 0. \tag{73}$$

The effective metric or kinetic tensor $\mathcal{K}^{\mu\nu}$ determines the propagation cone.

A viable theory must avoid:

1. uncontrolled acausal signal propagation;
2. ghostlike kinetic terms;
3. gradient instabilities;
4. ill-posed initial-value evolution; and
5. singular characteristic transitions at the bounces.

15.3 Shared history versus local contact

The proposed candidate resolution of the horizon problem cannot rely only on the statement that all directions share a common origin.

The model must calculate whether the full three-leg conformal-time interval is sufficient to establish causal contact among regions that appear disconnected when only the third leg is included.

The relevant conformal time is

$$\eta = \int \frac{c\,\mathrm{d}t}{a(t)}. \tag{74}$$

For a three-leg history, the total available conformal interval is schematically

$$\Delta\eta_{\mathrm{full}} = \Delta\eta_1 + \Delta\eta_2 + \Delta\eta_3 + \Delta\eta_{\mathrm{transitions}}, \tag{75}$$

subject to the correct matching and time orientation.

This integral is developed in Paper II.

16 Transition and Matching Requirements

16.1 Two representations of each reversal

Each *Electro* reversal may be represented in one of two mathematically related ways.

The first is an idealized instantaneous matching boundary.

The second is a finite-duration smooth transition.

The instantaneous form is interpreted as the limiting case

$$\tau_j \to 0, \tag{76}$$

where τ_j is the characteristic duration of reversal j.

16.2 Minimal continuity conditions

For a nonsingular finite transition, the minimum desired continuity conditions are

$$\lim_{t \to t_j^-} R_E(t) = \lim_{t \to t_j^+} R_E(t), \tag{77}$$

and preferably

$$\lim_{t \to t_j^-} \dot{R}_E(t) = \lim_{t \to t_j^+} \dot{R}_E(t) = 0 \tag{78}$$

at the turning point.

The acceleration may remain finite:

$$\left| \ddot{R}_E(t_j) \right| < \infty. \tag{79}$$

For an idealized instantaneous reversal, the velocity may be joined piecewise:

$$\dot{R}_E(t_j^-) \dot{R}_E(t_j^+) < 0. \tag{80}$$

In that case, any discontinuity must be interpreted as a mathematical idealization of a narrow unresolved transition.

16.3 Geometric regularity

Because the global scale factor need not reverse, the Triple Bounce model does not automatically require

$$H(t_j) = 0. \tag{81}$$

The background may satisfy

$$H(t_j) > 0 \tag{82}$$

during an internal *Electro* reversal.

A viable solution should also avoid unphysical divergences in

$$R, \qquad R_{\mu\nu}R^{\mu\nu}, \qquad R_{\mu\nu\rho\sigma}R^{\mu\nu\rho\sigma}, \tag{83}$$

at both internal reversals. In the present framework, neither the outer nor the central reversal is a second singularity; the singular opening that begins the first leg is a separate boundary.

16.4 Independent parameterization

The outer and central reversals occur under different physical conditions, and Paper I leaves the physical cause of each unresolved.

They may nevertheless share a standardized mathematical form while retaining independent parameters.

For reversal $j \in \{\mathrm{O}, \mathrm{C}\}$, the effective velocity may be written as

$$\dot{R}_E^{(j)}(t) = \frac{v_j^- + v_j^+}{2} + \frac{v_j^+ - v_j^-}{2} \tanh\left(\frac{t - t_j}{\tau_j}\right). \tag{84}$$

The outer transition satisfies

$$v_{\mathrm{O}}^- > 0, \qquad v_{\mathrm{O}}^+ < 0, \tag{85}$$

while the central transition satisfies

$$v_{\mathrm{C}}^- < 0, \qquad v_{\mathrm{C}}^+ > 0. \tag{86}$$

The framework does not impose equal speed magnitudes, equal transition durations, or identical physical causes.

17 Observations and Model Reconstruction

17.1 Detector-level observables

The following quantities are treated as observational inputs:

1. measured photon wavelengths and frequency shifts;
2. apparent fluxes and calibrated luminosities;
3. angular positions and angular correlations;
4. polarization amplitudes and directions;
5. supernova light curves;
6. galaxy and quasar redshifts;
7. galaxy clustering statistics;
8. gravitational-lensing distortions;
9. cosmic microwave background temperature anisotropies;
10. cosmic microwave background polarization spectra;
11. light-element abundances; and
12. local and cosmological measurements of expansion-related quantities.

These observations do not depend upon the Triple Bounce interpretation.

17.2 Reconstructed quantities

The following quantities are more model dependent:

1. the age assigned to the total universe;
2. the elapsed time associated with a measured redshift;
3. the comoving distance to a source;
4. the particle-horizon distance;
5. the event-horizon distance;
6. the density parameters Ω_i;

7. the inferred curvature parameter;
8. the dark-energy equation of state;
9. the primordial power spectrum;
10. the duration and scale of inflation; and
11. conditions prior to the last-scattering surface.

For example, redshift is directly measured as

$$1 + z = \frac{\lambda_{\rm obs}}{\lambda_{\rm emit}}. \tag{87}$$

In a standard Friedmann–Lemaître–Robertson–Walker background, it is interpreted as

$$1 + z = \frac{a(t_0)}{a(t_{\rm emit})}. \tag{88}$$

The relation in equation (88) is highly successful for comoving sources in an Friedmann–Lemaître–Robertson–Walker universe.

The Triple Bounce framework does not reject it for ordinary third-leg matter.

It questions whether the same relation fully reconstructs the hidden trajectory of a non-comoving primordial sector before the observable third leg.

17.3 Luminosity and angular-diameter distance

The luminosity distance is defined by

$$F = \frac{L}{4\pi d_L^2}, \tag{89}$$

where F is the observed flux and L is the source luminosity.

The angular-diameter distance is defined by

$$d_A = \frac{\ell}{\theta}, \tag{90}$$

where ℓ is an object's transverse physical size and θ is its observed angular size.

For standard metric propagation with photon-number conservation, the Etherington distance-duality relation gives (Etherington, 1933)

$$d_L = (1 + z)^2 d_A. \tag{91}$$

A viable Triple Bounce third-leg model should preserve equation (91) unless it explicitly introduces photon nonconservation or nonmetric propagation.

17.4 What may be incomplete

The proposed incompleteness lies not in the measurement of redshift, brightness, or angular scale.

It lies in the assumption that one fitted function $H(z)$ necessarily describes:

(a) the complete age of the universe;

(b) the full history of every cosmic component;

(c) the origin of the primordial web;

(d) the entire causal history; and

(e) the only physically meaningful expansion stage.

The Triple Bounce framework must demonstrate this incompleteness quantitatively. It cannot assume it.

18 Empirical Anchoring and Parameter Discipline

18.1 Data-anchored quantities

Some values used in the packet exploration originate in existing cosmological reconstructions rather than being derived independently by the Triple Bounce framework. Paper I therefore treats them as provisional anchors rather than predictions.

The approximate third-leg time anchor is

$$T_3 \approx 13.824 \text{ Gyr}. \tag{92}$$

The corresponding large-radius model scale is

$$D_{\text{model}} \approx 46.08 \text{ Gly}. \tag{93}$$

With the conversion by c kept explicit, the model writes the structural relation

$$\frac{D_{\text{model}}}{cT_3} = \frac{10}{3} = 3.\overline{3}. \tag{94}$$

Its numerical shorthand is

$$13.824 \times 3.\overline{3} = 46.08. \tag{95}$$

This is an exploratory radius-scale correspondence obtained from approximate, partly known cosmological quantities. It is not presently classified as an independent prediction.

18.2 Brief packet sketch

Paper I uses only the coarse packet scale

$$\Delta t_{\text{packet}} = 320 \text{ Myr}. \tag{96}$$

The adopted third-leg interval therefore contains

$$N_{\text{packet}} = \frac{13.824 \text{ Gyr}}{0.320 \text{ Gyr}} = 43.2 \tag{97}$$

nominal packet intervals. Distributing the total 10/3 scale ratio as a geometric mean across those intervals gives the provisional positive factor

$$g_{\text{packet}} = \exp\left[\frac{\ln(10/3)}{43.2}\right] \approx 1.0283. \tag{98}$$

Within the Triple Bounce interpretation, this positive continued-growth factor is hypothesized to participate in the same outward behavior that standard dark-energy phenomenology represents through negative pressure. Paper I does not claim that the factor is the cosmological constant Λ, the dark-energy equation-of-state parameter w, an inflationary e-fold, or an observational measurement. The pressure-sign mapping, units, physical mechanism, and comparison target require reconstruction in the companion papers.

18.3 No retroactive assignment

The framework does not assign the residual value

$$46.08 - 3(13.824) = 4.608 \tag{99}$$

to additional elapsed cosmic time, transition latency, the age of the Earth, the age of the cosmic microwave background, dark-energy travel time, or another physical mechanism. The numerical relation remains open until a trajectory and distance calculation establishes its meaning.

Assumption 3 (Parameter discipline)**.** A quantity adopted from existing observational reconstruction must be identified as an empirical anchor. A quantity produced by the Triple Bounce equations must be identified as a derived result. The two categories must not be interchanged.

19 Hierarchy of Claims

To prevent hypothesis, correspondence, and prediction from being mixed, the framework uses the following hierarchy.

Table 3: Status categories for statements in the Triple Bounce framework.

Category	**Meaning**	**Example**
Observation	A detector-level or directly calibrated empirical result.	A measured redshift, flux, angular correlation, or polarization signal.
Standard reconstruction	A value inferred by fitting observations within an established cosmological model.	A cosmic age, comoving distance, density parameter, or curvature bound.
Model definition	A term or variable introduced to express the Triple Bounce hypothesis.	*Electro*, the chasing sector, $R_E(t)$, or the primordial web $\mathcal{W}_1$.
Working hypothesis	A proposed physical relationship not yet mathematically derived.	*Electro* pathways and dark-matter scaffolding co-form during the first leg and are reoccupied during the third leg.
Empirical correspondence	A numerical or structural similarity found after using observationally anchored inputs.	The third-leg packet growth factor near 1.0283.
Derived prediction	A result that follows from the model without being independently inserted.	A subsequently derived deviation in $H(z)$, the perturbation spectrum, or large-angle correlations.
Falsification condition	An observation or inconsistency that would count strongly against the framework.	Requirement of a privileged Earth location or failure to reproduce the cosmic microwave background spectrum.

The categories in table 3 identify the source or scientific status of a statement. Triple Bounce-specific claims also use a second, independent profile so that hybrid claims are not forced into a single maturity level.

Table 4: Two-axis profile for Triple Bounce-specific claims.

Axis	**Available classifications**	**Purpose**
Claim role	Core architectural postulate; candidate explanatory mechanism; candidate quantitative consequence; open extension.	Identifies what function the statement performs within the framework.
Development status	Conceptually defined; qualitatively motivated; mathematically derived; observationally tested.	Identifies how far the statement has progressed toward validation.

For example, the Gravity Triune is a core architectural postulate that is conceptually defined but not observationally validated as a unified system. The unstable pre-singularity oscillation is both a core starting hypothesis and a candidate trigger mechanism. The packet-derived growth factor is a candidate quantitative consequence whose present status is exploratory and reconstruction-dependent.

19.1 Language requirements

The manuscript will use different verbs for different categories.

Observed results are *measured*.

Model-dependent values are *inferred* or *reconstructed*.

Framework components are *defined*.

Unresolved mechanisms are *hypothesized*.

Numerical similarities are *compared*.

Only mathematically produced outcomes are *derived* or *predicted*.

This vocabulary is part of the scientific method of the paper.

20 Boundary Between Established Physics and Triple Bounce Hypotheses

20.1 Established framework retained

The following principles are retained unless a companion paper provides a derived and empirically justified reason for revision:

1. local Lorentz invariance;
2. general covariance;
3. the equivalence principle;
4. total stress–energy conservation;
5. metric propagation of ordinary light;
6. standard electromagnetism during the observable third leg;
7. standard nuclear and particle measurements;
8. standard recombination calculations as the baseline model;
9. standard nucleosynthesis calculations as the baseline model; and
10. the measured statistical properties of the cosmic microwave background and large-scale structure.

20.2 Triple Bounce hypotheses introduced

The framework introduces the following hypotheses:

1. the observable universe is primarily the third leg of a longer history;
2. the active *Electro* component has an outward–inward–outward trajectory;
3. the global scale factor need not reverse when *Electro* reverses;
4. dark energy continues its outward chasing role during the second leg;
5. dark matter preserves the large-scale primordial scaffold;
6. the first-leg web remains imprinted after the active front reverses;
7. the third leg largely reoccupies the inherited web;
8. the central reversal is a major nonequilibrium transition;
9. ordinary electromagnetic behavior emerges when *Electro* couples with the magnetic sector; and
10. some observations attributed to inflation may encode a longer hidden history.

20.3 Questions deliberately left open

The framework leaves the following questions unresolved:

1. the microscopic identity of *Electro*;
2. the microscopic identity of dark matter;
3. the fundamental nature of dark energy;
4. the exact cause of the outer reversal;
5. the exact cause of the central reversal;
6. the duration of either transition;
7. the complete elapsed age of the three-leg history;
8. the physical origin of the proposed packet hierarchy;
9. the interaction functions $\mathcal{Q}_i$;
10. the origin of the matter–antimatter asymmetry;
11. the quantum description of the pre-singularity state; and
12. whether the Triple Bounce belongs to a larger cyclic or plural-universe history.

These questions are not to be answered by assertion.

Proposition 2 (Methodological sufficiency)**.** *A foundational Triple Bounce paper can be scientifically meaningful without resolving all microphysics, provided it defines its variables, preserves conservation requirements, distinguishes inputs from predictions, and identifies calculations capable of falsifying the framework.*

21 Assumptions Adopted for the Foundational Model

For clarity, the first paper adopts the following provisional assumptions.

Assumption 4 (Background geometry)**.** The observable third-leg universe is described at leading order by an Friedmann–Lemaître–Robertson–Walker background with perturbations.

Assumption 5 (Continuing outer expansion)**.** The effective outer scale remains nondecreasing while the active *Electro* component undergoes its inward second leg.

Assumption 6 (Sectoral motion)**.** *Electro* possesses a sector-specific trajectory that is not always comoving with the large-scale expansion.

Assumption 7 (Persistent scaffold)**.** The principal first-leg web pattern remains encoded in the dark-matter-associated scaffold after the active *Electro* front reverses.

Assumption 8 (Third-leg inheritance)**.** The third-leg spatial organization is influenced by the inherited first-leg web but may acquire nonlinear deviations, new branches, collisions, and asymmetries.

Assumption 9 (Distinct Gravity Triune members)**.** Classical gravity, dark matter, and dark energy remain distinct but connected functional members. No complete interaction law is assumed.

Assumption 10 (No assigned total age)**.** The complete elapsed duration of the first, second, and third legs is not fixed by the approximate 46.08-billion-light-year distance scale.

Assumption 11 (Third-leg packet calculation)**.** The packet growth-factor construction is applied only to the observable third-leg interval. Paper I introduces the correspondence, Papers II and III develop its mathematical and physical context, and Paper IV performs the strongest reconstruction and testing.

21.1 Assumptions not adopted

The foundational model does not assume:

1. that all three legs have exactly equal elapsed durations;
2. that the full Triple Bounce history lasts 46.08 billion years;
3. that the 4.608 residual is transition time;
4. that dark matter is stationary;
5. that dark matter rigidly guides the inward *Electro* path;
6. that all sectors propagate at the same speed;
7. that the two reversals preserve speed magnitude;
8. that either reversal is instantaneous;
9. that the chasing sector is exactly a cosmological constant;
10. that the packet growth factor equals Λ;
11. that the first leg is standard inflation; or
12. that galactic dark-matter halos are explained in this paper.

22 Methodological Consequences for the Remaining Analysis

The commitments established in this section determine how the remainder of Paper I must be written.

The pre-singularity section may describe a concentrated, dynamically oscillatory state, but it must not claim that geometry, dimensionality, or time were absent or already understood.

The first-leg section may define outward *Electro* propagation, but it must not identify *Electro* with ordinary light.

The second-leg section may describe an inward trajectory, but it must not imply contraction of the entire universe.

The third-leg section may discuss electromagnetic coupling, particle production, and matter stabilization, but it must identify unresolved microphysics explicitly.

The Gravity Triune section may assign binding, scaffolding, and chasing roles, but it must not represent the three members as identical fluids.

The prediction section may identify possible inherited-web signatures, but it must not label an empirical anchor as an independent prediction.

The packet-growth discussion may report a numerical correspondence, but it must not claim a derivation of the dimensional cosmological constant.

These restrictions strengthen the paper. They ensure that the framework is presented in the form most capable of serious evaluation.

23 The Oscillatory Pre-Singularity State

The Triple Bounce sequence begins from an unresolved pre-singularity state proposed to be highly concentrated, dynamically active, and oscillatory rather than perfectly static.

The framework does not treat this state as a completed inventory of ordinary particles, nor does it place it as a conventional object inside a larger external universe. It also does not claim that geometry, time, or dimensionality were absent. Their exact pre-singularity form remains unresolved.

In this paper, the term *singularity* identifies the transition boundary at which the standard classical description ceases to be reliable. The first resolved post-singularity description begins with the outward *Electro* leg.

Definition 3 (Pre-singularity state)**.** The pre-singularity state is the unresolved initial configuration whose growing oscillatory instability precedes the singular opening and the first outward *Electro* leg. Paper I does not specify its microscopic identity, dimensionality, temporal character, or complete geometry.

The term *state* is used provisionally. It may ultimately correspond to:

(a) a condensed field configuration;

(b) a topological or geometric phase;

(c) a collective potential minimum or maximum;

(d) a strongly constrained configuration;

(e) a transition inherited from a larger cosmic history; or

(f) a boundary condition of a deeper physical theory.

The present paper does not choose among these possibilities.

24 Interpretive Limits of the Pre-Singularity Description

24.1 Compression without an external container

The word *compressed* ordinarily suggests a system occupying a smaller volume. In the present framework it is used more cautiously to denote an extreme concentration of effective potential or active degrees of freedom.

The pre-singularity state should therefore not be pictured automatically as an ordinary ball of matter surrounded by empty space.

The intended distinction is

$$\text{compressed} \quad \Longrightarrow \quad \text{highly concentrated effective state,} \tag{100}$$

rather than the stronger and unestablished claim

$$\text{compressed} \quad \Longrightarrow \quad \text{ordinary matter inside a tiny external container.} \tag{101}$$

This wording leaves the geometry of the pre-singularity state open.

24.2 Horizontal oscillation as a dominant orientation

The foundational picture proposes a dominant horizontal oscillation in the pre-singularity state. Here *horizontal* is a model-specific geometric description of the dominant balanced orientation. It is not claimed to be an absolute left–right axis embedded in an external coordinate system.

A useful schematic representation is

$$\Psi(q,\xi) = A(\xi)\cos\left[\omega_0\xi + \varphi\right]\Phi_0(q) + \delta\Psi(q,\xi), \tag{102}$$

where:

- q represents unresolved configuration variables;
- ξ is an unspecified evolution parameter;
- $\Phi_0(q)$ is the dominant balanced mode;
- $A(\xi)$ is its effective amplitude;
- ω_0 is an effective oscillatory scale; and
- $\delta\Psi$ represents smaller asymmetric contributions.

Equation (102) is illustrative rather than fundamental. The proposed approach to the singular opening is associated with increasing amplitude, instability, or energetic stress in the dominant mode.

The pre-singularity state is hypothesized to contain a dominant, approximately balanced horizontal oscillation whose instability grows toward the singular opening.

24.3 Possible connection to later near-flatness

The framework leaves open whether the initial oscillatory orientation contributes to the later near-flat large-scale geometry. Paper I treats this only as a candidate relationship, not as a derivation.

A schematic measure of deviation from the dominant balanced mode may be written as

$$\epsilon_{\mathrm{asym}} = \frac{\|\delta\Psi\|}{\|A\Phi_0\|}. \tag{103}$$

The working expectation is

$$0 < \epsilon_{\mathrm{asym}} \ll 1, \tag{104}$$

rather than exact symmetry,

$$\epsilon_{\text{asym}} = 0. \tag{105}$$

This permits residual curvature, anisotropy, and later structural irregularity.

Hypothesis 5 (Balanced initial ordering)**.** *The pre-singularity state contains a dominant approximately balanced oscillatory mode. A possible relationship between that ordering and later near-flatness remains to be derived and tested.*

25 Temporal Status Before the First Leg

25.1 No fixed claim about pre-singularity time

Paper I does not describe the pre-singularity state as timeless. The existence of oscillation implies ordered change in at least an effective sense, but the framework does not determine whether that ordering is measured by ordinary cosmic time, a different physical parameter, or a deeper temporal description.

The later resolved spacetime may be written using the usual proper-time relation

$$\mathrm{d}\tau^2 = -\frac{1}{c^2} g_{\mu\nu} \mathrm{d}x^\mu \mathrm{d}x^\nu, \tag{106}$$

for timelike trajectories. Paper I does not extrapolate this relation unchanged across the singular boundary.

An unresolved pre-singularity description may use a generic ordering parameter,

$$\xi_{\text{pre}}, \tag{107}$$

without identifying it with later cosmological time.

25.2 Bookkeeping origin for resolved cosmic time

For the effective model, the onset of the first resolved outward leg may be assigned

$$t = 0 \quad \text{at the onset of the first resolved post-singularity leg.} \tag{108}$$

This is a bookkeeping convention. It does not imply that no state, change, or ordering existed before $t = 0$.

A later theory may relate pre-singularity ordering to resolved cosmic time through a transition map,

$$t = \mathcal{T}\left(\xi_{\mathrm{pre}}\right), \tag{109}$$

but no such map is derived here.

Limitation 4. The present framework does not determine the temporal character of the pre-singularity state or derive the origin of cosmic time.

26 Effective Potential Before the First Resolved Leg

26.1 Why the word energy is provisional

The framework uses *energy* and *potential* as effective language for an initial state whose microscopic theory is unresolved. It does not claim that ordinary matter or familiar third-leg energy sectors already existed in their later form.

The safer foundational statement is:

> The pre-singularity state contains the effective potential and degrees of freedom from which the distinguishable large-scale sectors of the Triple Bounce emerge or become active.

A provisional total pre-singularity functional may be written as

$$\mathcal{U}_{\mathrm{pre}} = \mathcal{U}\left[\Psi, \nabla_q \Psi, \mathcal{C}_a, \lambda_b\right], \tag{110}$$

where:

- Ψ denotes unresolved pre-singularity degrees of freedom;
- ∇_q denotes variation over the chosen configuration variables;
- $\mathcal{C}_a$ denotes constraints; and
- λ_b denotes control or coupling parameters.

The later effective energy densities,

$$\rho_E, \qquad \rho_{\mathrm{DM}}, \qquad \rho_{\mathrm{C}}, \qquad \rho_r, \qquad \rho_b, \tag{111}$$

may emerge or become distinguishable through the singular transition.

26.2 Potential rather than pre-existing particles

The initial state is not assumed to contain stable electrons, protons, atoms, or photons in their ordinary third-leg form.

The model therefore begins from

$$n_{\text{stable matter}} \approx 0, \tag{112}$$

rather than from a compressed inventory of ordinary particles. This does not exclude unresolved excitations; it excludes only the claim that familiar stable matter already exists in its later form.

26.3 Earliest identified active sector

At the singular opening, *Electro* is the earliest active outward sector identified by the model. Paper I does not claim that nothing else changes or becomes active at the same transition.

The effective differentiation may be represented schematically as

$$\mathcal{U}_{\text{pre}} \longrightarrow \{\mathcal{E}_E, \mathcal{E}_{\text{DM}}, \mathcal{E}_{\text{C}}, \mathcal{E}_{\text{res}}\}, \tag{113}$$

where:

- $\mathcal{E}_E$ is the active outward *Electro* sector;
- $\mathcal{E}_{\text{DM}}$ is the scaffolding or containment sector;
- $\mathcal{E}_{\text{C}}$ is the chasing sector; and
- $\mathcal{E}_{\text{res}}$ contains unresolved remaining degrees of freedom.

The notation denotes differentiation of effective roles, not creation from nothing or a completed microscopic derivation.

27 Internal Oscillation and Instability

27.1 Dominant oscillatory behavior

The pre-singularity state is proposed to contain a dominant, approximately balanced horizontal oscillation whose amplitude or instability increases toward the singular opening.

The term *oscillation* denotes real dynamical change in the foundational picture, while its exact physical variable remains unresolved.

A generic collective coordinate Q may obey

$$\frac{\mathrm{d}^2 Q}{\mathrm{d}\tau_{\mathrm{int}}^2} + \Gamma_Q \frac{\mathrm{d}Q}{\mathrm{d}\tau_{\mathrm{int}}} + \frac{\partial U_{\mathrm{pre}}}{\partial Q} = 0, \tag{114}$$

where:

- Q represents a collective pre-singularity degree of freedom;
- Γ_Q represents effective damping or transfer; and
- $U_{\mathrm{pre}}(Q)$ is an effective potential.

Small oscillations around an effective equilibrium Q_0 satisfy

$$U_{\mathrm{pre}}(Q) \approx U_{\mathrm{pre}}(Q_0) + \frac{1}{2}\kappa_Q (Q - Q_0)^2 + \cdots , \tag{115}$$

with approximate frequency

$$\omega_Q^2 \sim \kappa_Q. \tag{116}$$

The exact normalization depends on the kinetic structure.

27.2 Growth of instability

The initial release may occur when the dominant mode becomes unstable.

An instability can be represented schematically by

$$\omega_{\mathrm{eff}}^2 < 0. \tag{117}$$

The corresponding perturbation grows approximately as

$$\delta Q \propto \exp\left(|\omega_{\mathrm{eff}}|\, \tau_{\mathrm{int}}\right). \tag{118}$$

Alternatively, the release may occur when a control parameter λ crosses a critical value:

$$\lambda > \lambda_{\mathrm{crit}}. \tag{119}$$

The framework does not presently identify the control parameter.

Possible interpretations include:

(a) an effective amplitude threshold;

(b) loss of stability of the compressed state;

(c) a phase transition;

(d) a topological transition;

(e) a critical density or curvature condition;

(f) a resonance among internal modes; or

(g) an inherited trigger from a prior cycle.

27.3 Chain-reaction analogy

The first release has been described conceptually as an uncontrolled chain reaction.

This analogy is useful only in a limited sense.

It suggests:

$$\text{local release} \longrightarrow \text{further destabilization} \longrightarrow \text{larger release.} \tag{120}$$

It does not imply nuclear fission, chemical combustion, or any known terrestrial chain-reaction mechanism.

A generic positive-feedback equation may be written as

$$\frac{\mathrm{d}f}{\mathrm{d}\tau_{\text{int}}} = \alpha f(1-f) - \beta f, \tag{121}$$

where f represents the released fraction, α is an effective amplification rate, and β is an effective suppression rate.

Release accelerates when

$$\alpha(1-f) > \beta. \tag{122}$$

Equation (121) is illustrative only.

Hypothesis 6 (Instability-triggered release)**.** *The first leg begins when the oscillatory pre-singularity configuration loses stability and the singular opening produces an active outward Electro release.*

28 The Initial *Electro* Release

28.1 Selective release

The first transition does not necessarily release every degree of freedom in the same form.

The model proposes that *Electro* is the dominant active outward component during the first leg.

This may be represented schematically as

$$f_E > f_i \tag{123}$$

for other immediately propagating sectors i, where f_E is the fraction of released effective energy participating in the active *Electro* front.

The scaffolding and chasing components are also associated with the first release, but they do not subsequently follow the same trajectory as *Electro*.

Thus,

$$R_E(t) \neq R_{\mathrm{DM}}(t) \neq R_{\mathrm{C}}(t) \tag{124}$$

in the most general case.

28.2 Radiation-like but not ordinary light

During the first leg, *Electro* is described as radiation-like because it propagates rapidly and carries energy outward.

However, ordinary electromagnetic radiation contains coupled electric and magnetic fields.

In vacuum, standard electromagnetism satisfies Maxwell's equations (Maxwell, 1865; Jackson, 1998),

$$\nabla \cdot \boldsymbol{E} = 0, \tag{125}$$

$$\nabla \cdot \boldsymbol{B} = 0, \tag{126}$$

$$\nabla \times \boldsymbol{E} = -\frac{\partial \boldsymbol{B}}{\partial t}, \tag{127}$$

$$\nabla \times \boldsymbol{B} = \frac{1}{c^2}\frac{\partial \boldsymbol{E}}{\partial t}. \tag{128}$$

A freely propagating ordinary electromagnetic wave therefore contains both electric and magnetic components.

The first-leg *Electro* state is not assumed to satisfy equations (125) to (128) in their ordinary third-leg form.

Instead, it is treated as a pre-electromagnetic precursor.

Definition 4 (Pre-electromagnetic propagation)**.** Pre-electromagnetic propagation is the first-leg transport of *Electro* before stable coupling with the magnetic sector establishes ordinary electromagnetic radiation.

28.3 Outward propagation condition

The first resolved leg satisfies

$$\dot{R}_E(t) > 0. \tag{129}$$

The corresponding acceleration may initially satisfy

$$\ddot{R}_E(t) > 0, \tag{130}$$

followed by later deceleration,

$$\ddot{R}_E(t) < 0, \tag{131}$$

before the outer reversal.

The framework does not yet specify the detailed profile.

A general first-leg trajectory may be written as

$$R_E^{(1)}(t) = R_{E,0} + \int_{t_0}^{t} v_E^{(1)}(t')\mathrm{d}t', \tag{132}$$

with

$$v_E^{(1)}(t) > 0 \tag{133}$$

throughout the outward interval.

28.4 No identification with standard inflation

The initial *Electro* release is not identified with standard inflation.

Inflation ordinarily refers to accelerated metric expansion satisfying

$$\ddot{a}(t) > 0, \tag{134}$$

often driven by a nearly homogeneous scalar field.

The first-leg hypothesis concerns the trajectory and structural action of *Electro* within the complete three-leg history.

It does not initially require that

$$R_E^{(1)}(t) \equiv a_{\text{inflation}}(t). \tag{135}$$

The relationship between the hidden first leg and observations commonly attributed to inflation is addressed separately in Paper II.

29 Earliest Resolved Post-Singularity Spacetime

29.1 From singular opening to resolved metric description

Paper I does not claim when geometry originates. It begins with the earliest resolved post-singularity spacetime and proposes that the first outward *Electro* leg organizes its filamentary structure.

An effective first-leg metric may be written as

$$g_{\mu\nu}^{(1)} = g_{\mu\nu}^{\text{background}} + \delta g_{\mu\nu}^{(1)}, \tag{136}$$

without claiming that this equation derives the origin of geometry or that stable atoms, stars, and galaxies already exist.

The model therefore distinguishes:

1. the organization of the earliest resolved filamentary scaffold during the first leg;
2. the preservation and reprocessing of that scaffold during the second leg; and
3. the visible material occupation and further branching of that scaffold during the third leg.

29.2 Scaffold before stable matter

The first-leg spacetime is proposed to be materially sparse while its filamentary organization develops.

A conceptual ordering is

$$\begin{aligned} &\text{singular opening} \longrightarrow \textit{Electro} \text{ propagation} \longrightarrow \text{filamentary scaffold organization} \\ &\qquad \longrightarrow \text{later stable matter.} \end{aligned} \tag{137}$$

The dark-matter-associated scaffold and the *Electro* pathway are proposed to co-form rather than one being added only after the other.

29.3 Origin of geometry remains unresolved

The present paper neither derives the origin of the metric nor claims that geometry first appears during the *Electro* release. A complete theory would require a well-defined action, transition conditions, and a map to the resolved metric variables.

A schematic effective action may be written as

$$S_{\text{pre}} = \int \mathcal{L}_{\text{pre}} \left(\Psi, \partial\Psi, \mathcal{C}_a\right) \mathrm{d}\mu, \tag{138}$$

but Paper I supplies no microscopic derivation from this expression.

Limitation 5. The claim that the first leg organizes the earliest resolved filamentary scaffold is a structural hypothesis. It is not a derivation of geometry or spacetime emergence.

30 Initial Omnidirectionality and Near-Isotropy

30.1 Omnidirectional release

The first outward release is proposed to occur without a preferred macroscopic direction.

In an effective spherical representation, the leading energy density may satisfy

$$\bar{\rho}_E^{(1)} = \bar{\rho}_E^{(1)}(t, R), \tag{139}$$

with angular deviations

$$\delta\rho_E^{(1)} = \delta\rho_E^{(1)}(t, R, \theta, \phi). \tag{140}$$

The angular average satisfies

$$\left\langle \delta\rho_E^{(1)} \right\rangle_\Omega = 0. \tag{141}$$

The first-leg release is therefore approximately omnidirectional but not perfectly uniform.

30.2 Common origin versus identical state

A common origin does not imply that every radial direction is exactly identical.

Small initial differences may arise from:

(a) residual asymmetry in the pre-singularity state;

(b) mode interference;

(c) local instability timing;

(d) sector-coupling variations;

(e) topological defects;

(f) quantum fluctuations; or

(g) nonlinear amplification.

The first-leg field may be expanded in angular modes:

$$\delta\rho_E^{(1)}(t,R,\theta,\phi)=\sum_{\ell=0}^{\infty}\sum_{m=-\ell}^{\ell}a_{\ell m}^{(1)}(t,R)Y_{\ell m}(\theta,\phi). \tag{142}$$

Near-isotropy requires

$$\left|a_{\ell m}^{(1)}\right|\ll\bar{\rho}_E^{(1)} \tag{143}$$

for the relevant low-order anisotropic modes.

The exact amplitudes must later be constrained by observations.

30.3 No claim of equal propagation speed

Omnidirectionality should not be confused with equal propagation speed for all sectors.

The model currently claims:

$$v_E^{(1)}(\theta,\phi)\approx\bar{v}_E^{(1)} \tag{144}$$

at leading order.

It does not claim:

$$v_E=v_{\mathrm{DM}}=v_{\mathrm{C}}=c. \tag{145}$$

31 Initial Co-Formation of the Primordial Pathway and Scaffold

31.1 Pathway emergence

As *Electro* propagates outward, it is proposed to leave behind an organized pathway.

This pathway is not initially composed of ordinary matter.

It is an energetic and geometric pattern encoded jointly in the *Electro* history and the dark-matter-associated scaffold.

A provisional path functional may be written as

$$\mathcal{W}_1(\boldsymbol{x}) = \int_{t_{\text{start}}}^{t_{\text{O}}} K\left[\boldsymbol{x}; R_E(t), \rho_E(t), \rho_{\text{DM}}(t), g_{\mu\nu}(t)\right] \mathrm{d}t, \tag{146}$$

where K is an unresolved deposition, memory, or structural-response kernel.

The first-leg web is therefore history dependent.

31.2 Distributed scaffold co-formation

The scaffolding sector is proposed to respond to or co-form with the *Electro* release.

Its density may be decomposed as

$$\rho_{\text{DM}} = \bar{\rho}_{\text{DM}} + \delta\rho_{\text{DM}}. \tag{147}$$

The structural perturbation may depend on the *Electro* passage:

$$\delta\rho_{\text{DM}} = \mathcal{S}_{\text{DM}}\left[\rho_E, q_E^{\mu}, \pi_E^{\mu\nu}, g_{\mu\nu}\right], \tag{148}$$

where $\mathcal{S}_{\text{DM}}$ is an unresolved response operator.

The model does not yet determine whether dark matter:

- pre-exists the first outward front;
- differentiates simultaneously with *Electro*;
- forms through the first-leg interaction; or
- represents a geometric response later interpreted as gravitating matter.

Its operational role is retained even while its origin remains open.

31.3 Web persistence requirement

For the web to survive the first reversal, the scaffold must possess a memory or relaxation timescale longer than the active *Electro* passage.

Let

$$\tau_{\mathrm{DM}}^{\mathrm{relax}} \tag{149}$$

denote the characteristic decay time of the structural imprint.

Persistence through the second leg requires

$$\tau_{\mathrm{DM}}^{\mathrm{relax}} \gtrsim \Delta t_2, \tag{150}$$

where Δt_2 is the second-leg duration.

A stronger form requires

$$\tau_{\mathrm{DM}}^{\mathrm{relax}} \gtrsim \Delta t_2 + \Delta t_{\mathrm{C}}, \tag{151}$$

so the imprint remains available at the onset of the third leg.

The actual values remain unknown.

Hypothesis 7 (First-leg structural memory)**.** *The first outward Electro passage produces a long-lived structural imprint within the scaffolding sector that survives the inward second leg.*

32 Initial Role of the Chasing Sector

32.1 Continuing outward tendency

The chasing sector is proposed to retain the outward tendency of the initial release.

During the first leg,

$$\dot{R}_{\mathrm{C}}(t) > 0. \tag{152}$$

At the outer *Electro* reversal, the chasing sector does not reverse with *Electro*.

Thus,

$$\dot{R}_E : + \longrightarrow -, \qquad \dot{R}_{\mathrm{C}} : + \longrightarrow +. \tag{153}$$

This directional separation is one of the defining features of the Triple Bounce framework.

32.2 Volume-filling interpretation

The chasing sector is not treated as a thin boundary shell.

Its effective density is distributed throughout the cosmic volume:

$$\rho_{\mathrm{C}} = \rho_{\mathrm{C}}(t, \boldsymbol{x}). \tag{154}$$

At leading order,

$$\rho_{\mathrm{C}}(t, \boldsymbol{x}) = \bar{\rho}_{\mathrm{C}}(t) + \delta\rho_{\mathrm{C}}(t, \boldsymbol{x}), \tag{155}$$

with

$$|\delta\rho_{\mathrm{C}}| \ll \bar{\rho}_{\mathrm{C}} \tag{156}$$

on large scales.

The paper does not presently assign the sign or magnitude of local perturbations.

32.3 Negative-pressure correspondence

If the chasing sector is represented as an effective perfect fluid, its contribution to acceleration is determined by

$$\rho_{\mathrm{C}} + \frac{3p_{\mathrm{C}}}{c^2}. \tag{157}$$

Accelerated expansion requires the total effective source to satisfy

$$\rho_{\mathrm{tot}} + \frac{3p_{\mathrm{tot}}}{c^2} < 0. \tag{158}$$

For the chasing sector alone,

$$w_{\mathrm{C}} < -\frac{1}{3} \tag{159}$$

is sufficient for an accelerating contribution.

The strict cosmological-constant value is

$$w_{\mathrm{C}} = -1. \tag{160}$$

The first-leg framework does not fix this value.

33 Absence of Stable Matter During the First Leg

33.1 No stable matter in the leading approximation

The first leg is modeled at leading order without preformed stable ordinary matter.

This means that stable third-leg matter is not yet established; it does not require every particle-like or field-like excitation to be absent.

A leading approximation is

$$\rho_b^{(1)} \approx 0, \tag{161}$$

and

$$n_{\text{atoms}}^{(1)} \approx 0. \tag{162}$$

This does not require every excitation to be nonexistent.

It means only that the first leg is not described as an outward stream of preformed ordinary matter.

33.2 No electron–positron sequence is assumed

The foundational model does not assume that the first leg consists of electrons and positrons, or that one species travels outward before the other.

Such a claim would require:

- a defined pair-production mechanism;
- charge conservation;
- a magnetic-sector description;
- a momentum-distribution calculation; and
- consistency with known particle physics.

Those requirements have not been met.

Accordingly, the first-leg *Electro* sector remains pre-stable-matter or collective in the foundational paper, without fixing the identity of any earlier excitations.

33.3 Possible particle production after the first leg

Particle and antiparticle production may become important during the second leg or at the second-to-third transition.

A generic pair-production process has the form

$$X + Y \longrightarrow P + \bar{P}, \tag{163}$$

subject to conservation of energy, momentum, angular momentum, charge, and other quantum numbers.

The foundational paper does not specify X, Y, or P.

It preserves only the stepwise possibility:

$$\begin{aligned} &\text{pre-particle energetic state} \longrightarrow \text{possible excitation-rich nonequilibrium state} \\ &\qquad\qquad \longrightarrow \text{stable matter-dominated third leg.} \end{aligned} \tag{164}$$

34 Initial Conditions for the First Leg

A completed mathematical model must specify initial data at the first resolved time t_0.

A minimal set may include

$$\mathcal{I}_0 = \left\{ a_0, H_0, R_{E,0}, \dot{R}_{E,0}, \rho_{E,0}, \rho_{\mathrm{DM},0}, \rho_{\mathrm{C},0}, \mathcal{W}_{1,0} \right\}. \tag{165}$$

The first-leg conditions are expected to satisfy

$$H_0 \geq 0, \tag{166}$$

$$\dot{R}_{E,0} > 0, \tag{167}$$

and

$$\mathcal{W}_{1,0} \approx 0, \tag{168}$$

before the web is traced.

The initial stable-matter density satisfies

$$\rho_{b,0} \approx 0. \tag{169}$$

The initial curvature and anisotropy are not fixed to exact zero.

Instead,

$$|\Omega_{k,0}| \ll 1 \tag{170}$$

may emerge from the balanced initial ordering.

This condition must eventually be derived rather than imposed.

35 Alternative Interpretations of the Initial State

The present framework permits several possible microphysical interpretations.

35.1 Effective field interpretation

A collective field χ may occupy an unstable potential, as in standard scalar-field cosmology (Mukhanov, 2005),

$$S_\chi = \int d^4x\sqrt{-g}\left[-\frac{1}{2}g^{\mu\nu}\partial_\mu\chi\partial_\nu\chi - V(\chi)\right]. \tag{171}$$

A release may occur as χ moves away from an unstable region of $V(\chi)$.

This is one possible realization.

It is not part of the minimal foundational model.

35.2 Topological transition interpretation

The pre-singularity state may involve a topological or geometric phase not captured by the later resolved metric description.

The first release may correspond to a change in topological order,

$$\mathcal{P}_{\text{pre}} \longrightarrow \mathcal{P}_{\text{post}}, \tag{172}$$

where $\mathcal{P}_{\text{post}}$ denotes the earliest resolved post-singularity phase supporting propagating sectors.

35.3 Quantum-cosmological boundary interpretation

A quantum-cosmological description may eventually be relevant, but Paper I does not adopt a wave-functional boundary condition, a universal decoherence event, or a specific quantum transition mechanism. Such interpretations remain outside the minimal architecture until a companion-paper or subsequent derivation requires them.

35.4 Open prior-history interpretation

The pre-singularity state may have a prior history, but Paper I neither requires nor derives an indefinitely recurring universe. It defines one bounded Triple Bounce history and leaves the origin of the pre-singularity state, as well as the possibility of incomplete or alternative cosmic histories, outside its minimal architecture.

36 What the First-Leg Hypothesis Must Eventually Explain

The first-leg hypothesis becomes scientifically meaningful only if it supports calculations that connect to observable third-leg quantities.

A complete first-leg model must eventually explain:

1. why the initial release is approximately isotropic;
2. why the large-scale geometry is nearly flat;
3. how the first web pattern is generated;
4. how that pattern is stored in the scaffolding sector;
5. why the chasing sector remains outward;
6. why *Electro* later reverses while the outer expansion continues;
7. how causal information is transmitted or inherited;
8. how first-leg irregularities map into third-leg perturbations;
9. how the model avoids catastrophic anisotropy;
10. how the model remains stable against uncontrolled inhomogeneous growth;
11. how the total stress–energy is conserved; and
12. which observable signatures differ from standard inflationary initial conditions.

The first paper does not claim that these tasks are complete.

It defines them as the required research program.

37 Formal Summary of the Pre-Singularity Boundary

The foundational description may be summarized through the sequence

$$\boxed{\mathcal{U}_{\rm pre} \longrightarrow \text{instability} \longrightarrow \textit{Electro}\text{ release} \longrightarrow g^{(1)}_{\mu\nu} + \mathcal{W}_1} \tag{173}$$

subject to the following conditions:

$$\rho_b^{(1)} \approx 0, \tag{174}$$

$$\dot{R}_E^{(1)} > 0, \tag{175}$$

$$\dot{R}_{\rm C}^{(1)} > 0, \tag{176}$$

$$\frac{\partial \mathcal{W}_1}{\partial t} \neq 0, \tag{177}$$

$$\frac{|\delta\rho_E|}{\bar{\rho}_E} \ll 1, \tag{178}$$

$$\nabla_\mu T^{\mu\nu}_{\rm tot} = 0. \tag{179}$$

The sequence is intentionally incomplete at the microscopic level.

Its purpose is to state the minimum effective content required for the first leg.

38 The First Outward Leg

The first leg is the initial resolved outward phase of the Triple Bounce history.

It begins after the pre-singularity configuration loses stability and an active *Electro* sector emerges into an expanding effective spacetime.

The defining directional condition is

$$\dot{R}_E^{(1)}(t) > 0, \tag{180}$$

where $R_E^{(1)}(t)$ is the effective physical radial coordinate of the active *Electro* progression during the first leg.

The first leg is not described as an ordinary explosion of matter into pre-existing empty space.

It is instead proposed to perform several connected functions:

1. establish the first effective cosmic geometry;
2. carry the active *Electro* sector outward;

3. differentiate the large-scale roles of *Electro*, dark matter, and dark energy;
4. generate the primordial Electro pathway;
5. co-form a persistent dark-matter-associated scaffold;
6. establish the large-scale directional memory later inherited by the third leg;
7. preserve approximate isotropy while allowing small asymmetries; and
8. approach an outer condition at which *Electro* reverses without forcing the entire cosmic volume to contract.

The first leg therefore functions simultaneously as a propagation stage, a geometry-forming stage, and a structure-encoding stage.

Hypothesis 8 (First-leg construction hypothesis)**.** *The first outward Electro passage establishes the dominant large-scale spatial pathways later occupied by third-leg matter and electromagnetic structure.*

39 Kinematics of the First-Leg Propagation

39.1 Separation of three effective scales

The first-leg description distinguishes at least three effective radial or volumetric scales:

$$\{R_E(t), R_\mathrm{S}(t), R_\mathrm{C}(t)\}\,, \tag{181}$$

where:

- $R_E(t)$ represents the active *Electro* progression;
- $R_\mathrm{S}(t)$ represents the effective extent of the scaffolding sector; and
- $R_\mathrm{C}(t)$ represents the effective progression of the chasing sector.

In Paper I, $R_\mathrm{C}(t)$ is a schematic progression coordinate. It is not a material radius, a cosmic edge, or a directly measured local flow velocity of dark energy. Its derivative records the sign and relative strength of the model's effective outward contribution.

The subscript S denotes scaffolding, while the subscript C denotes chasing.

The model does not require

$$R_E(t) = R_\mathrm{S}(t) = R_\mathrm{C}(t) \tag{182}$$

at all times.

During the earliest portion of the first leg, the three effective scales may remain closely coupled:

$$R_E(t) \approx R_{\rm S}(t) \approx R_{\rm C}(t). \tag{183}$$

As the first leg evolves, their dynamical roles may separate.

The active *Electro* sector traces the pathway.

The scaffolding sector records and stabilizes it.

The chasing sector preserves the outward drive of the larger volume.

39.2 Physical position and comoving position

As introduced previously,

$$R_E(t) = a(t)\chi_E(t). \tag{184}$$

Its physical velocity is

$$\dot{R}_E = HR_E + a\dot{\chi}_E. \tag{185}$$

During the first leg, both terms may contribute positively:

$$HR_E > 0, \qquad a\dot{\chi}_E \geq 0. \tag{186}$$

This allows *Electro* to propagate outward relative to the expanding background rather than simply remaining comoving with it.

A dimensionless relative-propagation parameter may be defined as

$$\beta_E(t) = \frac{a\dot{\chi}_E}{HR_E}. \tag{187}$$

Then:

$$\beta_E \begin{cases} = 0, & \textit{Electro} \text{ is comoving with the background,} \\ > 0, & \textit{Electro} \text{ propagates outward relative to the background,} \\ < 0, & \textit{Electro} \text{ moves inward relative to the background.} \end{cases} \tag{188}$$

The first leg is characterized provisionally by

$$\beta_E^{(1)} \geq 0. \tag{189}$$

The second leg will require a sufficiently negative value.

39.3 Front, peak, and distributed-field interpretations

The effective coordinate $R_E(t)$ may represent several related but nonidentical quantities.

One possibility is the radius of maximum *Electro* energy density:

$$\left.\frac{\partial \rho_E}{\partial R}\right|_{R=R_E} = 0, \qquad \left.\frac{\partial^2 \rho_E}{\partial R^2}\right|_{R=R_E} < 0. \tag{190}$$

Another possibility is a transition-front location defined by a threshold:

$$\rho_E\left(t, R_E\right) = \rho_{E,\mathrm{crit}}. \tag{191}$$

A third possibility is a collective expectation value:

$$R_E(t) = \frac{\int R\,\rho_E(t,R)\,\mathrm{d}V}{\int \rho_E(t,R)\,\mathrm{d}V}. \tag{192}$$

The foundational model remains compatible with all three.

It does not require *Electro* to occupy only one infinitesimally thin surface.

40 First-Leg Energy Distribution

40.1 Radial profile

A general spherically averaged *Electro* profile may be written as

$$\rho_E^{(1)}(t,R) = \rho_{E,\mathrm{amp}}(t) F_E\left[\frac{R - R_E(t)}{\sigma_E(t)}\right], \tag{193}$$

where:

- $\rho_{E,\mathrm{amp}}(t)$ is an effective amplitude;
- F_E is a normalized profile function;
- $R_E(t)$ is the effective propagation coordinate; and
- $\sigma_E(t)$ is the profile width.

A narrow-front limit satisfies

$$\frac{\sigma_E}{R_E} \ll 1, \tag{194}$$

while a distributed-field regime may satisfy

$$\frac{\sigma_E}{R_E} \sim \mathcal{O}(1). \tag{195}$$

The first-leg model does not yet choose between these regimes.

40.2 Energy dilution and transfer

If *Electro* behaved as ordinary noninteracting radiation, its homogeneous energy density would scale as

$$\rho_r \propto a^{-4}. \tag{196}$$

The *Electro* sector need not follow this exact law.

Its effective continuity equation is

$$\dot{\rho}_E + 3H\left(\rho_E + \frac{p_E}{c^2}\right) = \mathcal{Q}_E. \tag{197}$$

If part of the *Electro* energy is transferred into the scaffold or chasing sector, then

$$\mathcal{Q}_E < 0 \tag{198}$$

during those intervals.

Correspondingly,

$$\mathcal{Q}_{\text{DM}} + \mathcal{Q}_{\text{C}} > 0 \tag{199}$$

may hold, subject to

$$\mathcal{Q}_E + \mathcal{Q}_{\text{DM}} + \mathcal{Q}_{\text{C}} + \mathcal{Q}_{\text{other}} = 0. \tag{200}$$

The existence of a persistent web implies that at least some structural information survives even if the active *Electro* energy density later changes substantially.

40.3 Energy and structural memory are distinct

The first-leg pathway should not be understood as requiring the original *Electro* energy to remain frozen permanently at every traversed location.

The framework distinguishes:

$$\text{active energy distribution} \neq \text{stored structural imprint.} \tag{201}$$

The active *Electro* component may continue outward while its prior passage alters:

- the effective dark-matter density;
- the local metric response;
- the orientation of a field configuration;
- the coupling coefficients of later propagation;
- the effective potential encountered by the returning front; or
- the topology of the available pathway.

This distinction allows the web to persist even after the main active energy concentration has moved elsewhere.

41 Co-Formation of the Primordial Electro Web

41.1 The web as a first-leg co-formed structure

The primordial web is not introduced as an arbitrary background grid.

It is produced through the interaction of the outward *Electro* progression with the emerging scaffold.

The web may be represented by a field

$$\mathcal{W}_1 = \mathcal{W}_1(t, \boldsymbol{x}), \tag{202}$$

whose evolution obeys a schematic equation of the form

$$\frac{\partial \mathcal{W}_1}{\partial t} = \mathcal{F}_{\mathcal{W}} \left[\rho_E, q_E^\mu, T_{\mu\nu}^{(\mathrm{DM})}, g_{\mu\nu}, \mathcal{W}_1 \right]. \tag{203}$$

A minimal relaxation model is

$$\frac{\partial \mathcal{W}_1}{\partial t} = \alpha_{\mathcal{W}} \mathcal{J}_E - \frac{\mathcal{W}_1}{\tau_{\mathcal{W}}}, \tag{204}$$

where:

- $\mathcal{J}_E$ is an effective *Electro* passage or flux measure;
- $\alpha_{\mathcal{W}}$ is a deposition or structural-response coefficient; and
- $\tau_{\mathcal{W}}$ is the web relaxation timescale.

For long-term persistence,

$$\tau_{\mathcal{W}} \gg \Delta t_{\text{pass}}, \tag{205}$$

where Δt_{pass} is the local duration of the first-leg *Electro* passage.

41.2 Electro pathway and dark-matter scaffold

The primordial Electro web and the dark-matter scaffold are closely connected but should not be defined as identical.

The Electro web refers to the directional and energetic pathway.

The dark-matter scaffold refers to the persistent structuring component that supports, records, and later gravitationally influences that pathway.

A schematic coupling term may be written as

$$\mathcal{L}_{E\text{-DM}} = \lambda_{E\text{DM}} \mathcal{O}_E \mathcal{O}_{\text{DM}}, \tag{206}$$

where $\mathcal{O}_E$ and $\mathcal{O}_{\text{DM}}$ are unspecified effective operators.

Equation (206) is not adopted as a final interaction Lagrangian.

It indicates that a physical mechanism must eventually connect the two sectors.

41.3 Co-formation rather than later attachment

The dark-matter scaffold is not proposed to form as an outer accessory added after the Electro web already exists.

The working hypothesis is that the scaffold is intertwined with the pathway during its creation.

Thus,

$$\mathcal{W}_1 = \mathcal{W}_1 \left[\mathcal{E}_E, \mathcal{E}_{\text{DM}}\right], \tag{207}$$

and

$$\delta\rho_{\mathrm{DM}} = \delta\rho_{\mathrm{DM}}\left[\text{history of } \mathcal{E}_E\right]. \tag{208}$$

This co-formation is central to the later claim that third-leg matter can inherit a large-scale pathway rather than begin from an entirely new spatial arrangement.

Hypothesis 9 (Interwoven scaffold hypothesis)**.** *The dark-matter scaffold and primordial Electro pathway are co-formed during the first leg and remain structurally interwoven across later legs.*

42 Filamentary Pathway Generation

42.1 Why the first-leg structure is not uniform

An exactly homogeneous outward release would not by itself generate a filamentary web.

The first-leg model therefore requires small deviations from perfect uniformity.

Write the *Electro* density as

$$\rho_E(t, \boldsymbol{x}) = \bar{\rho}_E(t)\left[1 + \delta_E(t, \boldsymbol{x})\right], \tag{209}$$

where

$$|\delta_E| \ll 1 \tag{210}$$

initially.

The scaffold density may similarly be written as

$$\rho_{\mathrm{DM}}(t, \boldsymbol{x}) = \bar{\rho}_{\mathrm{DM}}(t)\left[1 + \delta_{\mathrm{DM}}(t, \boldsymbol{x})\right]. \tag{211}$$

A coupled perturbation system may have the schematic form

$$\ddot{\delta}_E + A_E(t)\dot{\delta}_E + B_E(t,k)\delta_E = C_{E\mathrm{DM}}(t,k)\delta_{\mathrm{DM}}, \tag{212}$$

$$\ddot{\delta}_{\mathrm{DM}} + A_{\mathrm{DM}}(t)\dot{\delta}_{\mathrm{DM}} + B_{\mathrm{DM}}(t,k)\delta_{\mathrm{DM}} = C_{\mathrm{DM}E}(t,k)\delta_E. \tag{213}$$

The coefficients remain unspecified.

The purpose of these equations is to show that filamentary organization must arise through coupled instability, anisotropic response, or mode selection. Standard gravitational accounts of anisotropic collapse and cosmic-web formation provide the comparison baseline (Zel'dovich, 1970; Bond et al., 1996).

42.2 Preferred pathways without preferred global direction

A locally preferred pathway does not require a globally preferred axis.

The model may remain statistically isotropic while containing many filaments with different orientations.

Let $\hat{\boldsymbol{n}}$ denote the local filament direction.

Statistical isotropy requires

$$\langle \hat{\boldsymbol{n}} \rangle = 0, \tag{214}$$

while local structure permits

$$\hat{\boldsymbol{n}}(\boldsymbol{x}) \neq 0. \tag{215}$$

The two-point orientation correlation may be nonzero:

$$C_n(r) = \langle \hat{\boldsymbol{n}}(\boldsymbol{x}) \cdot \hat{\boldsymbol{n}}(\boldsymbol{x} + \boldsymbol{r}) \rangle . \tag{216}$$

Such correlations could later influence the organization of third-leg matter.

42.3 Junction formation

Filaments may intersect at junctions where multiple first-leg pathways overlap.

A local junction indicator may be represented by

$$\mathcal{J}_1(\boldsymbol{x}) = \sum_{a=1}^{N_f} w_a \mathcal{W}_{1,a}(\boldsymbol{x}), \tag{217}$$

where N_f is the number of contributing filamentary channels and w_a is their relative weight.

A junction is identified when

$$\mathcal{J}_1(\boldsymbol{x}) > \mathcal{J}_{\text{crit}}. \tag{218}$$

During the first leg, such junctions are energetic and structural intersections rather than mature galaxies or clusters.

Their later importance arises because the inward and third outward legs may cross the same locations again.

42.4 Voids as unoccupied or weakly occupied regions

The web is not proposed to fill the cosmic volume uniformly with dense structure.

Regions weakly traversed or weakly scaffolded become the precursors of voids.

A first-leg void precursor may satisfy

$$\mathcal{W}_1(\boldsymbol{x}) < \mathcal{W}_{\text{threshold}}, \tag{219}$$

or

$$\delta\rho_{\text{DM}}(\boldsymbol{x}) < 0. \tag{220}$$

The later visible void does not need to be absolutely empty.

It is a region with reduced pathway occupation relative to the filamentary network.

43 The Dark-Matter Scaffolding Role During the First Leg

43.1 Operational definition

Paper I defines the dark-matter-associated scaffolding role by its large-scale structural function rather than by composition.

Its first-leg role is provisionally summarized as

$$\text{dark matter} \longrightarrow \text{persistent structural support.} \tag{221}$$

This includes:

1. responding to the outward *Electro* release;
2. retaining the large-scale path pattern;
3. supporting filament and junction persistence;
4. remaining present after the active *Electro* front reverses; and
5. providing a later gravitational environment for third-leg matter.

43.2 Scaffolding is dynamical

The term *scaffold* does not imply rigidity or absolute stationarity.

A dark-matter flow may possess four-velocity

$$u_{\mathrm{DM}}^{\mu} \tag{222}$$

and nonzero perturbation velocity

$$\boldsymbol{v}_{\mathrm{DM}} \neq 0. \tag{223}$$

The scaffolding role refers to persistence of organization, not absence of motion.

A structural displacement field may be introduced:

$$\boldsymbol{\xi}_{\mathrm{DM}} = \boldsymbol{\xi}_{\mathrm{DM}}(t, \boldsymbol{x}). \tag{224}$$

Its deformation tensor is

$$D_{ij}^{(\mathrm{DM})} = \frac{1}{2}\left(\partial_i \xi_j^{(\mathrm{DM})} + \partial_j \xi_i^{(\mathrm{DM})}\right). \tag{225}$$

The framework leaves the magnitude of dark-matter deformation open.

It requires only that the large-scale pathway not be erased.

43.3 Scaffold retention measure

A retention coefficient may be defined through the correlation of the scaffold at two times:

$$\mathcal{R}_{\mathrm{S}}(t_a, t_b) = \frac{\langle \delta\rho_{\mathrm{DM}}(t_a, \boldsymbol{x}) \delta\rho_{\mathrm{DM}}(t_b, \boldsymbol{x}) \rangle}{\sqrt{\langle \delta\rho_{\mathrm{DM}}^2(t_a, \boldsymbol{x}) \rangle \langle \delta\rho_{\mathrm{DM}}^2(t_b, \boldsymbol{x}) \rangle}}. \tag{226}$$

Perfect memory would give

$$\mathcal{R}_{\mathrm{S}} = 1, \tag{227}$$

while complete loss of correlation would give

$$\mathcal{R}_{\mathrm{S}} = 0. \tag{228}$$

The working hypothesis requires

$$\mathcal{R}_{\rm S} \approx 1 \tag{229}$$

on large scales across the first-to-third-leg interval, while permitting smaller-scale evolution.

43.4 No galactic halo claim

The first-leg scaffolding concept is cosmological.

This paper does not derive:

- individual galactic halo profiles;
- galaxy rotation curves;
- cluster-scale lensing maps;
- dark-matter subhalo abundances; or
- galaxy-by-galaxy structure formation.

Those questions are outside the scope of the foundational paper.

44 The Chasing Sector During the First Leg

44.1 Outward persistence

The chasing sector is the member of the Gravity Triune associated with continued outward drive.

During the first leg,

$$\dot{R}_{\rm C}^{(1)}(t) > 0. \tag{230}$$

Unlike *Electro*, the chasing sector is not proposed to reverse at the outer transition.

Its first-leg role may be represented as contributing to a positive large-scale expansion rate:

$$H_{\rm C}(t) > 0. \tag{231}$$

The total Hubble function is not simply equal to this one contribution, but may be decomposed effectively as

$$H^2 = H_E^2 + H_{\rm DM}^2 + H_{\rm C}^2 + H_{\rm other}^2 + H_{\rm cross}^2, \tag{232}$$

where $H_{\rm cross}^2$ represents interaction and cross-coupling terms.

Equation (232) is schematic rather than an independent Friedmann equation.

44.2 Uniform baseline with unresolved perturbations

At leading order, the chasing sector is treated as approximately homogeneous:

$$\rho_{\mathrm{C}}(t, \boldsymbol{x}) = \bar{\rho}_{\mathrm{C}}(t) + \delta\rho_{\mathrm{C}}(t, \boldsymbol{x}), \tag{233}$$

with

$$\frac{|\delta\rho_{\mathrm{C}}|}{\bar{\rho}_{\mathrm{C}}} \ll 1 \tag{234}$$

on sufficiently large scales.

The framework does not yet determine whether matter-rich or scaffold-rich regions later perturb the chasing density locally.

That question is not required for the first-leg cosmological architecture.

44.3 Residual outward drive

The chasing sector may preserve part of the original release tendency.

A phenomenological pressure may be written as

$$p_{\mathrm{C}} = w_{\mathrm{C}}\rho_{\mathrm{C}}c^2. \tag{235}$$

If

$$w_{\mathrm{C}} < -\frac{1}{3}, \tag{236}$$

the sector contributes to accelerated metric expansion.

The strict value

$$w_{\mathrm{C}} = -1 \tag{237}$$

is not imposed.

The first paper treats negative pressure as a possible effective signature of the chasing role rather than as its complete physical definition.

45 Three-Sector Co-Evolution

45.1 Coupled background system

A minimal first-leg background model may contain

$$H^2 = \frac{8\pi G}{3}\left(\rho_E + \rho_{\mathrm{DM}} + \rho_{\mathrm{C}} + \rho_{\mathrm{other}}\right) - \frac{kc^2}{a^2}, \tag{238}$$

$$\dot{\rho}_E + 3H\left(\rho_E + \frac{p_E}{c^2}\right) = \mathcal{Q}_E, \tag{239}$$

$$\dot{\rho}_{\mathrm{DM}} + 3H\left(\rho_{\mathrm{DM}} + \frac{p_{\mathrm{DM}}}{c^2}\right) = \mathcal{Q}_{\mathrm{DM}}, \tag{240}$$

$$\dot{\rho}_{\mathrm{C}} + 3H\left(\rho_{\mathrm{C}} + \frac{p_{\mathrm{C}}}{c^2}\right) = \mathcal{Q}_{\mathrm{C}}, \tag{241}$$

with

$$\mathcal{Q}_E + \mathcal{Q}_{\mathrm{DM}} + \mathcal{Q}_{\mathrm{C}} + \mathcal{Q}_{\mathrm{other}} = 0. \tag{242}$$

The *Electro* trajectory additionally satisfies an effective radial equation:

$$\ddot{R}_E + \Gamma_E \dot{R}_E + \frac{\partial V_E}{\partial R_E} = S_E. \tag{243}$$

The scaffold and chasing sectors may possess corresponding collective equations.

45.2 Functional role matrix

The first-leg functions may be summarized by the matrix

$$\mathsf{M}^{(1)}_{\mathrm{role}} = \begin{pmatrix} \textit{Electro} & \text{propagation} & \text{path formation} \\ \text{dark matter} & \text{scaffolding} & \text{structural memory} \\ \text{dark energy} & \text{chasing} & \text{continued expansion} \end{pmatrix}. \tag{244}$$

This matrix describes roles rather than equations of state.

It does not imply that each role remains unchanged in magnitude.

45.3 Connected but separate

The first-leg framework requires the three sectors to interact without being collapsed into one undifferentiated substance.

Formally,

$$T_{\mu\nu}^{(E)} \neq T_{\mu\nu}^{(\mathrm{DM})} \neq T_{\mu\nu}^{(\mathrm{C})}, \tag{245}$$

while

$$Q_E^\mu, \quad Q_{\mathrm{DM}}^\mu, \quad Q_{\mathrm{C}}^\mu \tag{246}$$

may be nonzero.

This is the mathematical form of the statement:

Separate, connected, and dynamically communicating.

46 First-Leg Asymmetry and Secondary Structure

46.1 Near symmetry rather than perfect symmetry

The first outward release is approximately isotropic but not exact.

A perfectly identical radial history in every direction would suppress the structural diversity required for later filaments and voids.

The radial coordinate may therefore depend weakly on angle:

$$R_E = R_E(t, \theta, \phi). \tag{247}$$

Write

$$R_E(t, \theta, \phi) = \bar{R}_E(t)\left[1 + \epsilon_R(t, \theta, \phi)\right], \tag{248}$$

with

$$|\epsilon_R| \ll 1. \tag{249}$$

Similarly, the local propagation velocity may be

$$v_E(t, \theta, \phi) = \bar{v}_E(t)\left[1 + \epsilon_v(t, \theta, \phi)\right]. \tag{250}$$

46.2 Mode coupling

Nonlinear interaction among perturbation modes may generate secondary structure.

In Fourier space, a perturbation may satisfy

$$\delta_E(\boldsymbol{k}, t). \tag{251}$$

A nonlinear source term can couple modes:

$$S_{\mathrm{NL}}(\boldsymbol{k}) = \int \mathrm{d}^3 q \, F\left(\boldsymbol{q}, \boldsymbol{k} - \boldsymbol{q}\right) \delta_E(\boldsymbol{q}) \delta_E(\boldsymbol{k} - \boldsymbol{q}). \tag{252}$$

Such coupling may produce:

- branching pathways;
- junction formation;
- density contrasts;
- local shear;
- vorticity-like structure;
- non-Gaussianity; and
- preferred scales.

The first-leg model does not presently calculate these effects.

It identifies them as possible origins of later structural complexity.

46.3 Collisions before stable matter

Energetic interactions during the first leg need not involve collisions between ordinary particles.

They may instead represent:

$$\text{field overlap}, \quad \text{mode crossing}, \quad \text{front interference}, \quad \text{topological interaction}, \quad \text{energy transfer}. \tag{253}$$

The term *collision* is therefore used broadly at this stage.

Stable particle collision physics becomes more relevant later.

47 Directional Memory and Path Encoding

47.1 Path history

The first-leg web is proposed to encode more than density.

It may also encode directional history.

A vectorial path-memory field may be defined as

$$\boldsymbol{\mathcal{P}}_1(\boldsymbol{x}) = \int_{t_0}^{t_{\mathrm{O}}} W(t, \boldsymbol{x}) \boldsymbol{v}_E(t, \boldsymbol{x}) \mathrm{d}t, \tag{254}$$

where W weights the local importance of each passage.

The scalar web field $\mathcal{W}_1$ records pathway strength.

The vector field $\boldsymbol{\mathcal{P}}_1$ records preferred orientation.

A tensorial memory may also be introduced:

$$\mathcal{M}_{ij}^{(1)} = \int W v_{E,i} v_{E,j} \mathrm{d}t. \tag{255}$$

This tensor can encode anisotropic structural response without requiring a globally preferred direction.

47.2 Later retracing

The third-leg tendency to follow the inherited pathway can later be expressed through an effective potential

$$V_{\text{inherit}} = V_{\text{inherit}} \left[\mathcal{W}_1, \boldsymbol{\mathcal{P}}_1, \mathcal{M}_{ij}^{(1)} \right]. \tag{256}$$

The third-leg *Electro* trajectory may then be biased toward regions satisfying

$$\nabla V_{\text{inherit}} \approx 0 \tag{257}$$

along the established pathways.

This is one possible mathematical implementation of inherited retracing.

It is not the only possibility.

47.3 Memory without deterministic repetition

Path memory does not require exact deterministic repetition.

The third-leg path may be written as

$$\boldsymbol{R}_E^{(3)}(t) = \boldsymbol{R}_{\text{inherit}}(t) + \delta\boldsymbol{R}_{\text{int}}(t), \tag{258}$$

where:

- $\boldsymbol{R}_{\text{inherit}}$ follows the dominant first-leg structure; and
- $\delta\boldsymbol{R}_{\text{int}}$ contains collision-driven and interaction-driven deviations.

Thus, inherited structure and new asymmetry are compatible.

48 The First-Leg Junction Network

48.1 Junctions as candidate multipass sites

Major first-leg junctions are locations where several energetic pathways intersect.

These junctions become important because the same regions may be encountered during:

1. the first outward passage;
2. the second inward passage; and
3. the third outward passage.

The first-leg junction state may be represented as

$$\mathcal{J}^{(1)} = \mathcal{J}\left[\mathcal{W}_1, \boldsymbol{\mathcal{P}}_1, \rho_{\text{DM}}, g_{\mu\nu}\right]. \tag{259}$$

At this stage, the junction stores the first directional history only.

The later second and third legs may add counter-directed and electromagnetically coupled contributions.

48.2 No mature dynamo in the first leg

The first-leg junction is not yet claimed to be an ordinary magnetic dynamo.

Standard dynamos require conducting matter or plasma, magnetic fields, motion, induction, and appropriate flow geometry.

The first leg precedes ordinary stable matter and ordinary electromagnetism.

Therefore, the first-leg junction is best described as a *dynamo precursor* or *candidate dynamo site*, not a mature magnetohydrodynamic dynamo.

Definition 5 (Dynamo precursor)**.** A dynamo precursor is a structurally and directionally encoded junction that may later support circulation, magnetic amplification, energy transfer, or rotational organization after electromagnetic coupling and stable matter organization become established.

48.3 Rotational bias

Intersecting pathways may generate a local circulation measure

$$\Gamma_1 = \oint_{\mathcal{C}} \boldsymbol{v}_E \cdot \mathrm{d}\boldsymbol{\ell}. \tag{260}$$

A nonzero value,

$$\Gamma_1 \neq 0, \tag{261}$$

would indicate local rotational bias.

The model does not require all junctions to possess nonzero circulation.

It permits some junctions to preserve directional imbalance later amplified during the third leg.

49 Approach to the Outer Reversal

49.1 Deceleration of the active *Electro* progression

The first leg ends when the active *Electro* sector approaches an outer turning condition.

Before reversal,

$$\dot{R}_E > 0. \tag{262}$$

Near the transition,

$$\ddot{R}_E < 0. \tag{263}$$

At a smooth turning point,

$$\dot{R}_E(t_{\rm O}) = 0. \tag{264}$$

Afterward,

$$\dot{R}_E(t > t_{\rm O}) < 0. \tag{265}$$

The cause of the deceleration remains unresolved.

49.2 Possible effective contributions

A general effective radial equation near the outer transition is

$$\ddot{R}_E = F_{\rm bind} + F_{\rm scaffold} + F_{\rm chase} + F_{\rm self} + F_{\rm other}. \tag{266}$$

The terms may represent:

- a binding contribution associated with gravity;
- a response from the dark-matter scaffold;
- continued outward influence from the chasing sector;
- self-interaction of *Electro*;
- energy exhaustion or transfer;
- an effective boundary condition; or
- an unknown interaction.

The framework does not assign dominance to any one term.

The net condition for deceleration is

$$F_{\rm bind} + F_{\rm scaffold} + F_{\rm chase} + F_{\rm self} + F_{\rm other} < 0. \tag{267}$$

49.3 Outer reversal without global contraction

The critical Triple Bounce distinction is

$$\dot{R}_E(t_\mathrm{O}) = 0, \qquad H(t_\mathrm{O}) > 0. \tag{268}$$

The active *Electro* component turns around internally while the outer cosmic volume continues expanding.

The chasing sector remains outward:

$$\dot{R}_\mathrm{C}(t_\mathrm{O}) > 0. \tag{269}$$

The scaffold remains present:

$$\rho_\mathrm{DM}(t_\mathrm{O}, \boldsymbol{x}) > 0. \tag{270}$$

The web remains imprinted:

$$\mathcal{W}_1(t_\mathrm{O}, \boldsymbol{x}) \neq 0. \tag{271}$$

49.4 Outer reversal as a transition region

The finite-duration outer transition may be represented by

$$\dot{R}_E^{(\mathrm{O})}(t) = \frac{v_\mathrm{O}^- + v_\mathrm{O}^+}{2} + \frac{v_\mathrm{O}^+ - v_\mathrm{O}^-}{2} \tanh\left(\frac{t - t_\mathrm{O}}{\tau_\mathrm{O}}\right), \tag{272}$$

with

$$v_\mathrm{O}^- > 0, \qquad v_\mathrm{O}^+ < 0. \tag{273}$$

The instantaneous idealization is recovered when

$$\tau_\mathrm{O} \to 0. \tag{274}$$

The outer transition duration remains unknown.

50 First-Leg Completion Conditions

The first leg is considered complete when the following conditions are satisfied.

50.1 Propagation condition

The active *Electro* sector has reached its maximum first-leg extent:

$$R_E(t_{\mathrm{O}}) = R_{E,\mathrm{max}}. \tag{275}$$

50.2 Web-formation condition

A persistent web has been established:

$$\mathcal{W}_1(t_{\mathrm{O}}, \boldsymbol{x}) \neq 0. \tag{276}$$

50.3 Scaffold-retention condition

The dark-matter-associated scaffold possesses a sufficiently long memory:

$$\tau_{\mathrm{S}} \gtrsim \Delta t_2. \tag{277}$$

50.4 Chasing-continuation condition

The chasing sector remains outward:

$$\dot{R}_{\mathrm{C}}(t_{\mathrm{O}}) > 0. \tag{278}$$

50.5 Matter-sparsity condition

Stable ordinary matter remains negligible:

$$\rho_b(t_{\mathrm{O}}) \approx 0. \tag{279}$$

50.6 Conservation condition

The total stress–energy remains conserved:

$$\nabla_\mu T^{\mu\nu}_{\text{tot}} = 0. \tag{280}$$

51 What the First Leg Does Not Yet Explain

The first-leg construction leaves several questions unresolved.

It does not yet explain:

1. the microscopic identity of *Electro*;
2. the microscopic identity of the scaffolding sector;
3. the fundamental origin of the chasing sector;
4. the exact field equations governing web deposition;
5. the quantitative spectrum of first-leg perturbations;
6. the exact degree of first-leg isotropy;
7. the physical origin of preferred filament scales;
8. the duration of the first leg;
9. the maximum first-leg *Electro* extent;
10. the cause of the outer reversal;
11. the amount of energy transferred among sectors;
12. the relation between first-leg structure and the observed cosmic microwave background;
13. the relation between first-leg structure and the observed matter power spectrum; or
14. the precise mapping from first-leg junctions to later dynamos, galaxies, or clusters.

These questions are reserved for companion-paper mathematical and observational development.

52 Formal Summary of the First Outward Leg

The first outward leg may be summarized schematically as

$$\boxed{\begin{aligned} \text{unstable pre-singularity potential} &\longrightarrow \textit{Electro} \text{ outward propagation} \\ &\longrightarrow \text{web–scaffold co-formation} \\ &\longrightarrow \text{outer } \textit{Electro} \text{ reversal} \end{aligned}} \tag{281}$$

with the principal directional conditions

$$\dot{R}_E^{(1)} > 0, \tag{282}$$

$$\dot{R}_{\mathrm{C}}^{(1)} > 0, \tag{283}$$

$$\dot{a}^{(1)} > 0, \tag{284}$$

the structural conditions

$$\frac{\partial \mathcal{W}_1}{\partial t} \neq 0, \tag{285}$$

$$\delta\rho_{\mathrm{DM}} = \mathcal{S}_{\mathrm{DM}}\left[\rho_E, q_E^{\mu}, g_{\mu\nu}\right], \tag{286}$$

$$\tau_{\mathrm{S}} \gtrsim \Delta t_2, \tag{287}$$

and the end condition

$$\dot{R}_E(t_{\mathrm{O}}) = 0, \qquad H(t_{\mathrm{O}}) > 0. \tag{288}$$

The first leg therefore ends not with the contraction of the universe, but with the internal reversal of the active *Electro* sector inside a still-expanding scaffold.

53 The Outer Reversal and Second Inward Leg

The second leg begins when the active *Electro* component reaches its maximum first-leg extent and reverses direction.

The defining directional change is

$$\dot{R}_E : \quad \dot{R}_E > 0 \;\longrightarrow\; \dot{R}_E < 0. \tag{289}$$

This reversal does not imply that the entire universe contracts.

The larger cosmic volume, the dark-matter-associated scaffold, and the chasing sector may continue evolving outward while the active *Electro* sector travels inward through the previously established web.

The second leg therefore contains simultaneous but oppositely directed dynamics:

$$\dot{R}_E < 0, \qquad \dot{R}_{\text{out}} > 0, \qquad \dot{R}_{\text{C}} > 0. \tag{290}$$

The active *Electro* progression returns toward the topological origin.

The chasing sector continues the outward tendency of the original release.

The scaffold remains distributed through the expanding volume and preserves the dominant first-leg pathways.

The second leg is consequently not a conventional universal contraction phase. It is an internal return phase occurring within a cosmic environment that remains globally expansive.

Hypothesis 10 (Internal-return hypothesis)**.** *The second leg is produced by the inward radial motion of the active Electro sector through a still-expanding cosmic scaffold, rather than by contraction of the full Friedmann–Lemaître–Robertson–Walker background.*

54 The Outer Reversal as a Distinct Transition

54.1 Outer turning condition

The outer transition occurs near the maximum first-leg *Electro* extent,

$$R_E(t_{\text{O}}) = R_{E,\max}. \tag{291}$$

For a smooth reversal,

$$\dot{R}_E(t_{\text{O}}) = 0, \tag{292}$$

with

$$\ddot{R}_E(t_{\text{O}}) < 0. \tag{293}$$

Immediately before the transition,

$$\dot{R}_E(t < t_{\text{O}}) > 0, \tag{294}$$

and immediately afterward,

$$\dot{R}_E(t > t_{\rm O}) < 0. \tag{295}$$

The global Hubble rate need not vanish:

$$H(t_{\rm O}) > 0. \tag{296}$$

This condition sharply distinguishes the Triple Bounce outer reversal from a standard cosmological bounce in which the scale factor itself passes from contraction to expansion.

54.2 Standardized transition profile

The outer reversal may be represented by the standardized transition equation

$$\dot{R}_E^{(\rm O)}(t) = \frac{v_{\rm O}^- + v_{\rm O}^+}{2} + \frac{v_{\rm O}^+ - v_{\rm O}^-}{2} \tanh\left[\frac{t - t_{\rm O}}{\tau_{\rm O}}\right], \tag{297}$$

where

$$v_{\rm O}^- > 0, \qquad v_{\rm O}^+ < 0. \tag{298}$$

The parameter $\tau_{\rm O}$ controls the transition width.

For

$$\tau_{\rm O} > 0, \tag{299}$$

the reversal occurs over a finite interval.

For

$$\tau_{\rm O} \to 0, \tag{300}$$

the profile approaches an effectively instantaneous sign change.

Both forms are retained as mathematical options.

54.3 No fixed physical cause

The framework does not assign a definitive physical cause to the outer reversal.

The effective acceleration may be decomposed schematically as

$$\ddot{R}_E = A_{\text{bind}} + A_{\text{scaffold}} + A_{\text{chase}} + A_{\text{self}} + A_{\text{transfer}} + A_{\text{unknown}}, \tag{301}$$

where the terms represent possible contributions from:

- the binding member of the Gravity Triune;
- the structural response of the scaffold;
- the outward influence of the chasing sector;
- *Electro* self-interaction;
- energy or momentum transfer among sectors; and
- an unresolved transition mechanism.

The net reversal condition requires

$$\ddot{R}_E < 0 \tag{302}$$

for a sufficient interval to bring $\dot{R}_E$ through zero.

The framework does not presently state that dark matter alone turns *Electro* around, that classical gravity alone causes the reversal, or that the chasing sector ceases acting outward.

55 Second-Leg Kinematics Within an Expanding Background

55.1 Physical inward motion

The *Electro* position remains

$$R_E(t) = a(t)\chi_E(t). \tag{303}$$

Differentiation gives

$$\dot{R}_E = HR_E + a\dot{\chi}_E. \tag{304}$$

During the second leg,

$$\dot{R}_E < 0. \tag{305}$$

Since

$$H > 0, \tag{306}$$

the inward comoving motion must satisfy

$$a\dot{\chi}_E < -HR_E. \tag{307}$$

Thus, *Electro* must move inward relative to the expanding background rapidly enough to overcome the outward Hubble contribution.

55.2 Relative inward-motion parameter

Define

$$\beta_E^{(2)} = \frac{a\dot{\chi}_E}{HR_E}. \tag{308}$$

Then physical inward motion requires

$$\beta_E^{(2)} < -1. \tag{309}$$

The boundary case

$$\beta_E^{(2)} = -1 \tag{310}$$

corresponds to

$$\dot{R}_E = 0. \tag{311}$$

The first leg may have

$$\beta_E^{(1)} \geq 0, \tag{312}$$

while the second leg requires a strongly negative relative motion.

This sign change is the kinematic essence of the outer reversal.

55.3 Decreasing Electro radius and increasing outer scale

Let $R_{\text{out}}(t)$ represent an effective outer-scale measure.

During the second leg,

$$\frac{\mathrm{d}R_E}{\mathrm{d}t} < 0, \qquad \frac{\mathrm{d}R_{\mathrm{out}}}{\mathrm{d}t} > 0. \tag{313}$$

Their separation is

$$\Delta R_{CE}(t) = R_{\mathrm{out}}(t) - R_E(t). \tag{314}$$

Its derivative is

$$\frac{\mathrm{d}\Delta R_{CE}}{\mathrm{d}t} = \dot{R}_{\mathrm{out}} - \dot{R}_E. \tag{315}$$

Because

$$\dot{R}_{\mathrm{out}} > 0 \quad \text{and} \quad \dot{R}_E < 0, \tag{316}$$

one obtains

$$\frac{\mathrm{d}\Delta R_{CE}}{\mathrm{d}t} > 0. \tag{317}$$

The second leg therefore increases the effective separation between the active returning *Electro* concentration and the expanding outer extent.

55.4 No direct conversion of distance into elapsed time

The growing separation in equation (314) cannot be converted into an elapsed duration without specifying:

- the full scale-factor history $a(t)$;
- the *Electro* trajectory $\chi_E(t)$;
- the transition intervals;
- the effective propagation law; and
- the relevant definition of cosmic distance.

Accordingly, no portion of the numerical 4.608 residual is assigned to second-leg travel time in this paper.

56 Persistence of the First-Leg Web

56.1 The active front departs; the pathway remains

When *Electro* reverses inward, the first-leg pathway remains encoded in the scaffold.

The framework distinguishes

$$\rho_E^{\text{active}}(t, \boldsymbol{x}) \neq \mathcal{W}_1(\boldsymbol{x}). \tag{318}$$

The active energy distribution changes position.

The web imprint remains a structural property of the cosmic scaffold.

A second-leg web evolution equation may be written as

$$\frac{\partial \mathcal{W}_1}{\partial t} = -\frac{\mathcal{W}_1}{\tau_{\mathcal{W}}} + S_{\text{return}}, \tag{319}$$

where:

- $\tau_{\mathcal{W}}$ is the structural relaxation time; and
- S_{return} represents modification caused by the inward *Electro* passage.

If

$$\tau_{\mathcal{W}} \gg \Delta t_2, \tag{320}$$

then the first-leg structure remains substantially preserved.

56.2 Return through an inherited pathway

The second-leg *Electro* trajectory is expected to remain correlated with the original pathway.

A pathway-overlap coefficient may be defined as

$$\mathcal{C}_{21} = \frac{\int \mathcal{W}_1(\boldsymbol{x})\mathcal{W}_2(\boldsymbol{x})\mathrm{d}^3x}{\sqrt{\int \mathcal{W}_1^2(\boldsymbol{x})\mathrm{d}^3x \int \mathcal{W}_2^2(\boldsymbol{x})\mathrm{d}^3x}}, \tag{321}$$

where $\mathcal{W}_2$ represents the spatial support of the inward return.

The model expects

$$\mathcal{C}_{21} \approx 1 \tag{322}$$

on large scales.

Exact microscopic retracing is not required.

56.3 The scaffold does not rigidly guide the return

The phrase *return through the inherited pathway* does not mean that dark matter acts as a rigid rail mechanically forcing every *Electro* trajectory.

The scaffold may instead:

- preserve an effective potential landscape;
- retain anisotropic susceptibility;
- maintain lower-action routes;
- preserve density corridors;
- retain directional field memory; or
- alter the probability of subsequent propagation.

The return bias may be represented schematically by

$$\boldsymbol{F}_{\text{inherit}} = -\nabla V_{\text{inherit}} \left[\mathcal{W}_1, \boldsymbol{\mathcal{P}}_1, \mathcal{M}_{ij}^{(1)} \right]. \tag{323}$$

This is one possible implementation.

The framework leaves the actual degree of dark-matter deformation and trajectory influence unresolved.

Hypothesis 11 (Second-leg pathway retention)**.** *The inward Electro return remains strongly correlated with the first-leg pathway, while allowing energetic interactions, local deviations, and modification of the stored imprint.*

57 The Chasing Sector During the Second Leg

57.1 Continued outward evolution

Within the candidate architecture, the chasing sector is proposed not to reverse with *Electro*. This is a whole-history functional assignment, not a derived local-velocity measurement.

During the second leg,

$$\dot{R}_{\text{C}}^{(2)} > 0. \tag{324}$$

The cosmic scale factor may likewise continue satisfying

$$\dot{a}^{(2)} > 0. \tag{325}$$

The Triple Bounce second leg therefore contains a directional disequilibrium:

$$\operatorname{sgn}\left(\dot{R}_E\right) = -1, \qquad \operatorname{sgn}\left(\dot{R}_{\rm C}\right) = +1. \tag{326}$$

This separation may become one source of nonequilibrium energy transfer.

57.2 Volume-filling presence

The chasing sector remains distributed throughout the cosmic volume.

Its background density is written as

$$\rho_{\rm C}(t, \boldsymbol{x}) = \bar{\rho}_{\rm C}(t) + \delta\rho_{\rm C}(t, \boldsymbol{x}). \tag{327}$$

At the present level of development, the large-scale background remains approximately homogeneous:

$$\frac{|\delta\rho_{\rm C}|}{\bar{\rho}_{\rm C}} \ll 1. \tag{328}$$

The framework does not require a thin dark-energy boundary.

It instead treats the chasing contribution as a volume-filling sector whose large-scale effect is expressed through the expansion dynamics.

57.3 Second-leg continuity equation

The chasing sector satisfies

$$\dot{\rho}_{\rm C} + 3H\left(\rho_{\rm C} + \frac{p_{\rm C}}{c^2}\right) = \mathcal{Q}_{\rm C}^{(2)}. \tag{329}$$

The interaction term $\mathcal{Q}_{\rm C}^{(2)}$ may differ from its first-leg value.

The model does not presently determine whether the returning *Electro* sector transfers energy to or from the chasing sector.

Total conservation still requires

$$\sum_i \mathcal{Q}_i^{(2)} = 0. \tag{330}$$

57.4 Negative-pressure interpretation

If the chasing sector contributes negative pressure,

$$p_{\mathrm{C}} = w_{\mathrm{C}} \rho_{\mathrm{C}} c^2, \tag{331}$$

with

$$w_{\mathrm{C}} < -\frac{1}{3}, \tag{332}$$

it can maintain accelerated expansion even while *Electro* moves inward.

The framework does not yet require

$$w_{\mathrm{C}} = -1 \tag{333}$$

throughout the hidden second leg.

58 The Scaffold During the Second Leg

58.1 Persistence without absolute stationarity

The dark-matter-associated scaffold remains dynamically present during the second leg.

It is not assumed to be motionless.

Its density and displacement fields may evolve:

$$\rho_{\mathrm{DM}} = \rho_{\mathrm{DM}}(t, \boldsymbol{x}), \tag{334}$$

and

$$\boldsymbol{\xi}_{\mathrm{DM}} = \boldsymbol{\xi}_{\mathrm{DM}}(t, \boldsymbol{x}). \tag{335}$$

The required condition is preservation of the large-scale topology and correlation of the web, not zero motion.

A coarse-grained retention condition is

$$\mathcal{R}_{\mathrm{S}}(t_{\mathrm{O}}, t) > \mathcal{R}_{\mathrm{crit}}, \tag{336}$$

for

$$t_{\rm O} < t < t_{\rm C}, \tag{337}$$

where $\mathcal{R}_{\rm crit}$ is the minimum correlation required for third-leg inheritance.

58.2 Flexing and deformation

The scaffold may deform under the combined influence of:

- the returning *Electro* flux;
- continued metric expansion;
- the chasing sector;
- gravitational binding;
- internal dark-sector stress; and
- local junction interactions.

Its deformation tensor remains

$$D_{ij}^{(\rm DM)} = \frac{1}{2}\left(\partial_i \xi_j^{(\rm DM)} + \partial_j \xi_i^{(\rm DM)}\right). \tag{338}$$

The magnitude

$$\left\| D_{ij}^{(\rm DM)} \right\| \tag{339}$$

is left unspecified.

The first paper does not determine how much the scaffold flexes.

58.3 Scaffold and Gravity Triune communication

The scaffold is interpreted as dynamically connected to both classical gravity and the chasing sector.

A schematic interaction network is

$$\text{binding} \longleftrightarrow \text{scaffolding} \longleftrightarrow \text{chasing}. \tag{340}$$

The exact interaction law remains unresolved.

The framework does not collapse these three roles into one effective substance.

59 Energetic Reprocessing During the Inward Return

59.1 Counter-directed passage

During the first leg, the dominant *Electro* passage is outward.

During the second leg, the active passage is inward.

The same large-scale pathway may therefore contain two directional histories:

$$\mathcal{H}_{12} = \{\mathcal{E}_1^{\rightarrow}, \mathcal{E}_2^{\leftarrow}\} \,. \tag{341}$$

At a given junction, the local second-leg state may be represented as

$$\mathcal{J}^{(2)} = \mathcal{J}\left[\mathcal{W}_1, \boldsymbol{\mathcal{P}}_1, \boldsymbol{\mathcal{P}}_2, \rho_E^{(2)}, \rho_{\mathrm{DM}}, g_{\mu\nu}\right] . \tag{342}$$

The inward path can therefore add:

- counter-directed momentum;
- shear;
- interference;
- compression;
- local energy concentration;
- phase reorganization; and
- new structural memory.

59.2 Effective collision measure

A local energetic-crossing measure may be defined as

$$\mathcal{X}_{12}(\boldsymbol{x}) = |\boldsymbol{\mathcal{P}}_1(\boldsymbol{x}) \times \boldsymbol{\mathcal{P}}_2(\boldsymbol{x})| + \lambda_{\parallel} \, |\boldsymbol{\mathcal{P}}_1(\boldsymbol{x}) \cdot \boldsymbol{\mathcal{P}}_2(\boldsymbol{x})| \,. \tag{343}$$

The first term measures nonparallel crossing.

The second measures aligned or counter-aligned overlap.

The coefficient $\lambda_{\parallel}$ controls their relative weight.

This expression is illustrative.

Its purpose is to show that repeated passage can produce a local state depending upon both direction and pathway geometry.

59.3 Heating and compression

The inward return may increase local energy density where pathways converge.

A local compression measure may be written as

$$\Theta_E = \nabla_\mu u_E^\mu. \tag{344}$$

Regions satisfying

$$\Theta_E < 0 \tag{345}$$

represent local convergence of the *Electro* flow.

In an effective fluid treatment, compression can raise the local temperature or energy scale.

The model does not assume monotonic cooling during the entire second leg.

Global expansion and local inward convergence may coexist.

59.4 Radiation generation

Energetic reprocessing may produce radiation-like excitations beyond the original *Electro* state.

A generic conversion may be written as

$$\textit{Electro} + \text{scaffold interaction} \longrightarrow \text{radiation-like excitations} + \text{stored structural change}. \tag{346}$$

The framework does not identify these excitations with present-day photons unless ordinary electromagnetism has already emerged.

60 Possible Pair Production During the Second Leg

60.1 Pair production as a possibility

The second leg may become energetic enough to produce particle and antiparticle pairs.

A generic process is

$$X + Y \longrightarrow P + \bar{P}, \tag{347}$$

where X and Y are high-energy excitations and P and $\bar{P}$ are a particle–antiparticle pair.

The process must satisfy

$$p_X^\mu + p_Y^\mu = p_P^\mu + p_{\bar{P}}^\mu. \tag{348}$$

The center-of-mass energy must exceed the pair-production threshold:

$$s = (p_X + p_Y)^2 \geq 4m_P^2c^2, \tag{349}$$

under the relevant unit convention.

The framework does not yet identify the produced species.

60.2 Possible radiation–pair state

If pair creation and annihilation occur rapidly, the second leg may contain a hot radiation–pair state.

A schematic reaction balance is

$$X + Y \rightleftharpoons P + \bar{P}. \tag{350}$$

Approximate symmetry implies

$$n_P \approx n_{\bar{P}}. \tag{351}$$

The state may be electrically neutral on large scales even while containing charged excitations:

$$\sum_i q_i n_i \approx 0. \tag{352}$$

This provides a more precise version of a nearly neutral energetic "goo" without requiring stable atoms or macroscopic matter.

60.3 No matter dominance yet

The existence of particle–antiparticle pairs does not imply a matter-dominated universe.

Most pairs may remain in equilibrium with radiation or annihilate.

The second-leg energy density may satisfy

$$\rho_{\text{rad}} + \rho_{\text{pair}} \gg \rho_{\text{stable matter}}. \tag{353}$$

Stable matter dominance is reserved for later third-leg evolution.

60.4 No claimed species sequence

The framework does not claim that:

- electrons form before all other particles;
- positrons represent the inward leg;
- matter and antimatter occupy separate radial shells;
- one species alone causes the central reversal; or
- ordinary photons are the only second-leg collision products.

Such claims would require a complete particle-physics model.

61 Matter–Antimatter Symmetry and Nonequilibrium

61.1 Approximately symmetric production

Standard pair-production processes generate matter and antimatter symmetrically unless an interaction violates the relevant symmetry.

The second-leg state may therefore begin with

$$n_B \approx n_{\bar{B}}, \tag{354}$$

or more generally

$$n_P \approx n_{\bar{P}}. \tag{355}$$

The corresponding asymmetry parameter is

$$\eta_P = \frac{n_P - n_{\bar{P}}}{n_P + n_{\bar{P}}}. \tag{356}$$

An approximately symmetric state has

$$|\eta_P| \ll 1. \tag{357}$$

61.2 The second-to-third transition as a symmetry-breaking opportunity

The transition from inward second-leg motion to outward third-leg motion is a strongly nonequilibrium event.

The framework therefore identifies the central transition as a possible stage at which a small matter excess may be generated or preserved.

A generic baryon-asymmetry parameter is

$$\eta_B = \frac{n_B - n_{\bar{B}}}{n_\gamma}. \tag{358}$$

A successful microscopic mechanism must satisfy the appropriate conditions for producing a nonzero asymmetry (Sakharov, 1967; Kolb and Turner, 1990; Dine and Kusenko, 2003; Riotto, 1998; Joyce et al., 1996).

The Triple Bounce framework does not specify that mechanism.

It proposes only that the second-to-third transition supplies a natural departure from equilibrium.

Hypothesis 12 (Central nonequilibrium hypothesis)**.** *The second-to-third-leg transition provides a major nonequilibrium environment in which a small matter–antimatter asymmetry may be generated or preserved.*

61.3 Electromagnetism alone is insufficient

Ordinary electromagnetic interactions treat matter and antimatter symmetrically under the relevant charge-conjugation structure.

Therefore, the emergence of electromagnetism during the third leg cannot by itself explain the observed cosmic matter excess.

A viable mechanism likely requires:

- baryon-number or lepton-number violation;
- charge-conjugation violation;
- charge-parity violation;
- departure from thermal equilibrium; or
- new physics beyond currently established interactions.

The foundational paper leaves these possibilities open.

62 Second-Pass Junctions and Counter-Imprint

62.1 Addition of the inward history

At a first-leg junction, the scaffold already stores an outward directional history.

The second-leg passage adds an inward component.

The local junction state becomes

$$\mathcal{J}_{12}(\boldsymbol{x}) = \mathcal{J}\left[\mathcal{E}_1^{\rightarrow}, \mathcal{E}_2^{\leftarrow}, \mathcal{W}_1, \rho_{\mathrm{DM}}\right]. \tag{359}$$

A vector representation is

$$\boldsymbol{\mathcal{P}}_{12} = \boldsymbol{\mathcal{P}}_1 + \boldsymbol{\mathcal{P}}_2. \tag{360}$$

If the two passages are exactly opposite and equal,

$$\boldsymbol{\mathcal{P}}_2 = -\boldsymbol{\mathcal{P}}_1, \tag{361}$$

their vector sum vanishes.

However, the tensorial memory need not vanish:

$$\mathcal{M}_{ij}^{(12)} = \mathcal{M}_{ij}^{(1)} + \mathcal{M}_{ij}^{(2)}. \tag{362}$$

Thus, opposite directional passes can cancel net vector flow while increasing stored directional structure.

62.2 Shear and circulation

Nonidentical return paths can generate shear.

For an effective velocity field v_i, define

$$\sigma_{ij} = \frac{1}{2}\left(\partial_i v_j + \partial_j v_i\right) - \frac{1}{3}\delta_{ij}\nabla \cdot \boldsymbol{v}. \tag{363}$$

The vorticity is

$$\boldsymbol{\omega} = \nabla \times \boldsymbol{v}. \tag{364}$$

At a junction,

$$\boldsymbol{\omega}_{12} \neq 0 \tag{365}$$

may arise if the inward passage is not perfectly collinear with the outward imprint.

Such locations may later act as third-leg dynamo precursors.

62.3 Counter-imprint

The second leg may create a counter-imprint,

$$\mathcal{W}_2^{\leftarrow}(\boldsymbol{x}), \tag{366}$$

without erasing the original outward imprint.

The combined structural record is

$$\mathcal{W}_{12} = \mathcal{W}_1^{\rightarrow} + \lambda_2 \mathcal{W}_2^{\leftarrow} + \delta \mathcal{W}_{12}, \tag{367}$$

where:

- λ_2 measures the retained strength of the second pass; and
- $\delta \mathcal{W}_{12}$ contains collision-induced modifications.

The third leg later adds a third directional contribution.

63 Thermal Evolution of the Second Leg

63.1 Global expansion and local heating

A globally expanding universe tends to dilute and cool freely propagating components.

However, the inward *Electro* return can produce local compression and heating.

The local temperature evolution may be represented schematically as

$$\dot{T}_E = -\alpha_H H T_E + \mathcal{H}_{\text{comp}} + \mathcal{H}_{\text{int}} - \mathcal{C}_{\text{rad}}, \tag{368}$$

where:

- $\alpha_H H T_E$ represents expansion cooling;
- $\mathcal{H}_{\text{comp}}$ represents compressional heating;

- $\mathcal{H}_{\text{int}}$ represents interaction heating; and
- $\mathcal{C}_{\text{rad}}$ represents radiative or conversion losses.

The sign of $\dot{T}_E$ need not remain fixed throughout the second leg.

63.2 No simple monotonic thermal assumption

The framework does not assume that the second leg is uniformly hotter or uniformly cooler than the first leg.

Different regions may experience:

- continued expansion cooling;
- inward-flow compression;
- junction heating;
- pair-production thresholds;
- annihilation reheating;
- energy transfer into the scaffold; and
- radiation generation.

A complete model must solve the coupled thermal and dynamical equations.

63.3 Approach to a dense central state

As *Electro* approaches the topological origin, its effective energy density may increase.

A coarse estimate is

$$\rho_E \sim \frac{E_E}{V_E}, \tag{369}$$

where V_E is the effective support volume of the returning component.

If

$$\dot{V}_E < 0, \tag{370}$$

and energy loss is not too rapid, then

$$\dot{\rho}_E > 0 \tag{371}$$

may occur near central convergence.

This increase may contribute to the conditions required for the second reversal.

64 Approach to the Topological Origin

64.1 Central convergence coordinate

The second leg approaches the same topological origin associated with the initial release.

The convergence condition is

$$R_E(t) \longrightarrow R_{\text{Cen}}, \tag{372}$$

where

$$R_{\text{Cen}} \approx 0 \tag{373}$$

in the effective radial coordinate.

The symbol R_{Cen} does not identify an ordinary observable location inside the present universe.

It denotes the common convergence state of the *Electro* trajectory.

64.2 Same origin, new dynamical state

The returning *Electro* sector reaches the same topological origin but not necessarily the identical physical state from which it first emerged.

By the end of the second leg:

- the outer cosmic volume has expanded;
- the chasing sector has continued outward;
- the scaffold remains distributed through the volume;
- the first-leg web remains imprinted;
- the inward passage has added a counter-history;
- radiation-like excitations may have formed;
- particle–antiparticle pairs may exist; and
- the central energy configuration may be highly nonequilibrium.

Therefore,

$$\mathcal{S}^{(2)}_{\text{central}} \neq \mathcal{S}_{\text{pre}}. \tag{374}$$

The topological location is recurrent.

The dynamical state is transformed.

64.3 No required pause

The framework does not require *Electro* to remain stationary at the center for a prolonged interval.

A smooth turning point satisfies

$$\dot{R}_E(t_{\text{C}}) = 0, \tag{375}$$

but the duration of near-zero velocity is controlled by the transition parameter

$$\tau_{\text{C}}. \tag{376}$$

The instantaneous limit is

$$\tau_{\text{C}} \to 0. \tag{377}$$

A finite-duration central transition has

$$\tau_{\text{C}} > 0. \tag{378}$$

Neither option is selected conclusively in Paper I.

64.4 No frame-dragging claim

The inward convergence is not described technically as frame dragging.

Frame dragging is specifically associated with rotating mass-energy and off-diagonal spacetime effects in general relativity.

The present central-return hypothesis is radial at the background level.

Local rotational effects may arise at junctions, but the overall return is better described as gravity-influenced, scaffold-interacting, or effective-potential-driven convergence.

65 Causal and Informational Continuity Across the Second Leg

65.1 Preservation of prior causal history

The second leg does not erase the first-leg causal history.

The full causal structure must include propagation during both legs.

A signal path has conformal interval

$$\Delta\eta_2 = \int_{t_\mathrm{O}}^{t_\mathrm{C}} \frac{c\,\mathrm{d}t}{a(t)}. \tag{379}$$

The combined first- and second-leg interval is

$$\Delta\eta_{12} = \Delta\eta_1 + \Delta\eta_2 + \Delta\eta_\mathrm{O}, \tag{380}$$

where $\Delta\eta_\mathrm{O}$ contains any finite outer-transition contribution.

The third-leg horizon calculation must include this inherited interval.

65.2 Structural memory as information retention

The web imprint stores information about the first-leg passage.

The second-leg counter-imprint adds further history.

An effective information functional may be written as

$$\mathcal{I}_{12} = \mathcal{I}\left[\mathcal{W}_1, \mathcal{W}_2, \boldsymbol{\mathcal{P}}_1, \boldsymbol{\mathcal{P}}_2, \mathcal{M}_{ij}^{(12)}\right]. \tag{381}$$

Paper I does not identify this quantity with thermodynamic entropy, quantum information, or a fundamental Information Triune.

It uses the word *information* only in the ordinary sense of retained structural history.

65.3 No horizon candidate resolution by assertion

The existence of two hidden legs may enlarge the available causal history.

However, a viable horizon candidate resolution requires an explicit calculation showing that the total conformal interval is sufficient to correlate the regions observed in the cosmic microwave background.

This calculation is reserved for Paper II.

66 Second-Leg Dynamical System

A minimal second-leg system may be written as

$$H^2 = \frac{8\pi G}{3}\left(\rho_E + \rho_{\mathrm{DM}} + \rho_{\mathrm{C}} + \rho_r + \rho_{\mathrm{pair}}\right) - \frac{kc^2}{a^2}, \tag{382}$$

$$\dot{\rho}_E + 3H\left(\rho_E + \frac{p_E}{c^2}\right) = \mathcal{Q}_E^{(2)}, \tag{383}$$

$$\dot{\rho}_{\mathrm{DM}} + 3H\left(\rho_{\mathrm{DM}} + \frac{p_{\mathrm{DM}}}{c^2}\right) = \mathcal{Q}_{\mathrm{DM}}^{(2)}, \tag{384}$$

$$\dot{\rho}_{\mathrm{C}} + 3H\left(\rho_{\mathrm{C}} + \frac{p_{\mathrm{C}}}{c^2}\right) = \mathcal{Q}_{\mathrm{C}}^{(2)}, \tag{385}$$

$$\dot{\rho}_r + 4H\rho_r = \mathcal{Q}_r^{(2)}, \tag{386}$$

$$\dot{\rho}_{\mathrm{pair}} + 3H\left(\rho_{\mathrm{pair}} + \frac{p_{\mathrm{pair}}}{c^2}\right) = \mathcal{Q}_{\mathrm{pair}}^{(2)}. \tag{387}$$

The interaction terms satisfy

$$\mathcal{Q}_E^{(2)} + \mathcal{Q}_{\mathrm{DM}}^{(2)} + \mathcal{Q}_{\mathrm{C}}^{(2)} + \mathcal{Q}_r^{(2)} + \mathcal{Q}_{\mathrm{pair}}^{(2)} = 0. \tag{388}$$

The *Electro* trajectory obeys

$$\ddot{R}_E + \Gamma_E^{(2)}\dot{R}_E + \frac{\partial V_E^{(2)}}{\partial R_E} = S_E^{(2)}. \tag{389}$$

During the interior second-leg interval,

$$\dot{R}_E < 0. \tag{390}$$

Near the central transition,

$$\dot{R}_E \longrightarrow 0^-. \tag{391}$$

The system is schematic.

A complete model must specify the equations of state, interaction functions, perturbations, and transition conditions.

67 Second-Leg Completion Conditions

The second leg is considered complete when the active *Electro* sector reaches the central convergence state.

67.1 Central-arrival condition

$$R_E(t_{\mathrm{C}}) = R_{\mathrm{Cen}}. \tag{392}$$

67.2 Inward-velocity termination

For a smooth transition,

$$\dot{R}_E(t_{\mathrm{C}}) = 0. \tag{393}$$

67.3 Outer-expansion persistence

$$H(t_{\mathrm{C}}) > 0. \tag{394}$$

67.4 Chasing-sector persistence

$$\dot{R}_{\mathrm{C}}(t_{\mathrm{C}}) > 0. \tag{395}$$

67.5 Scaffold-memory persistence

$$\mathcal{R}_{\mathrm{S}}(t_{\mathrm{O}}, t_{\mathrm{C}}) > \mathcal{R}_{\mathrm{crit}}. \tag{396}$$

67.6 Two-pass structural state

$$\mathcal{W}_{12} \neq 0. \tag{397}$$

67.7 Optional pair-population condition

The framework permits, but does not require,

$$\rho_{\mathrm{pair}}(t_{\mathrm{C}}) > 0. \tag{398}$$

67.8 Conservation condition

$$\nabla_\mu T^{\mu\nu}_{\text{tot}} = 0. \tag{399}$$

68 What the Second Leg Does Not Yet Explain

The second-leg framework does not yet explain:

1. the physical cause of the outer reversal;
2. the duration of the outer transition;
3. the exact second-leg *Electro* velocity profile;
4. the amount of scaffold deformation;
5. the exact strength of pathway retracing;
6. the microscopic meaning of the counter-imprint;
7. the identity of any second-leg radiation-like excitations;
8. whether particle–antiparticle pairs are actually produced;
9. which particle species form first;
10. the thermal history of the inward return;
11. the exact energy-transfer functions;
12. the origin of any matter–antimatter asymmetry;
13. the physical cause of the central reversal;
14. the duration of the central transition;
15. the complete elapsed duration of the second leg; or
16. the full causal-horizon integral.

These remain open parameters for the companion papers or subsequent research.

69 Formal Summary of the Second Inward Leg

The second leg may be summarized as

$$\boxed{\begin{aligned} \text{outer } \textit{Electro} \text{ reversal} &\longrightarrow \text{inward return through the inherited web} \\ &\longrightarrow \text{energetic reprocessing and two-pass memory} \\ &\longrightarrow \text{central convergence} \end{aligned}} \tag{400}$$

with directional conditions

$$\dot{R}_E^{(2)} < 0, \tag{401}$$

$$H^{(2)} > 0, \tag{402}$$

$$\dot{R}_{\mathrm{C}}^{(2)} > 0, \tag{403}$$

the pathway condition

$$\mathcal{C}_{21} \approx 1 \tag{404}$$

on large scales, the memory condition

$$\mathcal{W}_{12} = \mathcal{W}_1^{\rightarrow} + \lambda_2 \mathcal{W}_2^{\leftarrow} + \delta \mathcal{W}_{12}, \tag{405}$$

and the central end condition

$$R_E(t_{\mathrm{C}}) = R_{\mathrm{Cen}}, \qquad \dot{R}_E(t_{\mathrm{C}}) = 0, \qquad H(t_{\mathrm{C}}) > 0. \tag{406}$$

The second leg therefore ends not with the destruction of the scaffold, but with the return of the active *Electro* sector to a transformed central state inside a universe whose outer extent has continued expanding.

70 The Central Reversal and Third Outward Leg

The third leg begins when the inward-moving active *Electro* sector reaches the transformed central convergence state and reverses direction for a second time.

The defining directional sequence is

$$\dot{R}_E : \quad \dot{R}_E < 0 \longrightarrow \dot{R}_E = 0 \longrightarrow \dot{R}_E > 0. \tag{407}$$

The central reversal does not return the universe to its original pre-singularity condition.

By the end of the second leg, the total system already contains:

- an expanded outer cosmic volume;
- a persistent dark-matter-associated scaffold;
- a first-leg outward structural imprint;
- a second-leg inward counter-imprint;
- a continuing outward chasing sector;
- radiation-like excitations;
- possible particle–antiparticle populations;
- stored directional memory at major junctions; and
- a highly nonequilibrium central energy concentration.

The third leg therefore begins from a dynamically transformed state.

It is not a simple replay of the first outward release.

Hypothesis 13 (Third-leg transformation hypothesis)**.** *The third outward leg begins from a central convergence state containing the accumulated structural, energetic, and directional history of the first two legs.*

The third leg is identified with the cosmic interval from which the present observable universe develops.

Its earliest stage may overlap phenomenologically with the hot, dense state conventionally described by standard Big Bang cosmology, while the Triple Bounce framework assigns that state a longer hidden prehistory.

71 The Transformed Central State

71.1 Central convergence is not a reset

The active *Electro* sector returns to the same topological origin associated with the first release.

However,

$$\mathcal{S}_{\mathrm{C}}^{(2)} \neq \mathcal{S}_{\mathrm{pre}}. \tag{408}$$

The pre-singularity state precedes the first resolved co-formation of *Electro* pathways and dark-matter scaffolding.

The transformed central state exists after that inherited scaffold has developed and while the outer volume may remain expanded. It is not a second singularity and is not identified with the pre-singularity state.

The central state may be represented schematically as

$$\mathcal{S}_{\mathrm{C}}^{(2)} = \mathcal{S}\left[\rho_E, \rho_{\mathrm{pair}}, \rho_r, \mathcal{W}_{12}, \boldsymbol{\mathcal{P}}_{12}, \mathcal{M}_{ij}^{(12)}, \rho_{\mathrm{DM}}, \rho_{\mathrm{C}}, g_{\mu\nu}\right]. \tag{409}$$

The state contains both energetic concentration and inherited spatial information.

71.2 Central density enhancement

As the inward *Electro* support volume decreases, the local effective energy density may increase.

A coarse relation is

$$\rho_{E,\mathrm{C}} = \frac{E_{E,\mathrm{C}}}{V_{E,\mathrm{C}}}. \tag{410}$$

If

$$V_{E,\mathrm{C}} \ll V_E^{(2)}(t < t_{\mathrm{C}}), \tag{411}$$

then a high-density central state may form even while the total cosmic volume continues expanding.

This distinction permits:

$$\text{local } \textit{Electro} \text{ compression} \quad \text{and} \quad \text{global metric expansion} \tag{412}$$

to occur simultaneously.

71.3 High-energy nonequilibrium state

The central convergence state is expected to be far from equilibrium.

A generic departure from equilibrium may be represented by

$$f_i = f_i^{\mathrm{eq}} + \delta f_i, \tag{413}$$

where f_i is the distribution function of species or excitation i.

A strongly nonequilibrium state satisfies

$$|\delta f_i| \not\ll f_i^{\mathrm{eq}} \tag{414}$$

for at least some important degrees of freedom.

The central state may therefore support:

- rapid energy transfer;
- symmetry-changing transitions;
- particle production;
- particle annihilation;
- phase conversion;
- field recoupling;
- instability growth; and
- directional reorganization.

71.4 No ordinary singularity is required

The Triple Bounce framework does not require the central convergence to be an infinite-density curvature singularity.

A nonsingular central transition should satisfy

$$\rho_{\mathrm{tot}}(t_{\mathrm{C}}) < \infty, \tag{415}$$

and

$$|p_{\mathrm{tot}}(t_{\mathrm{C}})| < \infty. \tag{416}$$

The principal curvature invariants should also remain finite:

$$|R|, \qquad |R_{\mu\nu}R^{\mu\nu}|, \qquad |R_{\mu\nu\rho\sigma}R^{\mu\nu\rho\sigma}| < \infty. \tag{417}$$

Whether this regularity can be achieved depends on the final field equations.

72 The Central Reversal as a Dynamical Transition

72.1 Central turning condition

For a smooth reversal,

$$\dot{R}_E(t_{\mathrm{C}}) = 0, \tag{418}$$

and

$$\ddot{R}_E(t_{\mathrm{C}}) > 0. \tag{419}$$

Immediately before the transition,

$$\dot{R}_E(t < t_{\mathrm{C}}) < 0, \tag{420}$$

while immediately afterward,

$$\dot{R}_E(t > t_{\mathrm{C}}) > 0. \tag{421}$$

The outer-scale expansion may remain positive:

$$H(t_{\mathrm{C}}) > 0. \tag{422}$$

72.2 Standardized central transition profile

The same standardized transition form used for the outer reversal may be applied to the central reversal:

$$\dot{R}_E^{(\mathrm{C})}(t) = \frac{v_{\mathrm{C}}^- + v_{\mathrm{C}}^+}{2} + \frac{v_{\mathrm{C}}^+ - v_{\mathrm{C}}^-}{2} \tanh\left[\frac{t - t_{\mathrm{C}}}{\tau_{\mathrm{C}}}\right]. \tag{423}$$

The central transition satisfies

$$v_{\mathrm{C}}^{-} < 0, \qquad v_{\mathrm{C}}^{+} > 0. \tag{424}$$

The parameter τ_{C} controls the central transition width.

The instantaneous limit is

$$\tau_{\mathrm{C}} \to 0. \tag{425}$$

A finite-duration transition has

$$\tau_{\mathrm{C}} > 0. \tag{426}$$

The central and outer transitions share a mathematical form but retain independent parameters:

$$\left\{t_{\mathrm{O}}, \tau_{\mathrm{O}}, v_{\mathrm{O}}^{-}, v_{\mathrm{O}}^{+}\right\} \neq \left\{t_{\mathrm{C}}, \tau_{\mathrm{C}}, v_{\mathrm{C}}^{-}, v_{\mathrm{C}}^{+}\right\}. \tag{427}$$

72.3 Possible effective causes

The central reversal may involve a different physical mechanism from the outer reversal.

A schematic acceleration equation is

$$\ddot{R}_E = A_{\mathrm{compression}} + A_{\mathrm{self}} + A_{\mathrm{mag}} + A_{\mathrm{scaffold}} + A_{\mathrm{chase}} + A_{\mathrm{phase}} + A_{\mathrm{unknown}}. \tag{428}$$

Possible contributions include:

- pressure generated by central compression;
- *Electro* self-interaction;
- candidate coupling with the provisional Magnetism Triune sector;
- response from the inherited scaffold;
- the continuing outward chasing sector;
- a phase transition; and
- an unknown high-energy interaction.

No one contribution is selected as the established cause.

72.4 Reversal as release of accumulated imbalance

The second leg creates a directional imbalance between inward *Electro* motion and outward global expansion.

A schematic imbalance parameter may be defined as

$$\Delta_{\mathrm{dir}} = \frac{\left|\dot{R}_E - \dot{R}_{\mathrm{C}}\right|}{\left|\dot{R}_E\right| + \left|\dot{R}_{\mathrm{C}}\right|}. \tag{429}$$

Near central convergence, accumulated compression and interaction may convert this imbalance into renewed outward *Electro* propagation.

This is a working interpretation rather than a derived mechanism.

73 Third-Leg Kinematics

73.1 Renewed outward motion

The third leg satisfies

$$\dot{R}_E^{(3)}(t) > 0. \tag{430}$$

The outer scale also continues expanding:

$$\dot{a}^{(3)}(t) > 0. \tag{431}$$

The chasing sector remains outward:

$$\dot{R}_{\mathrm{C}}^{(3)}(t) > 0. \tag{432}$$

The third leg therefore contains three outward tendencies:

1. metric expansion of the cosmic background;
2. outward propagation of the active *Electro* component; and
3. continued outward influence of the chasing sector.

These three motions are not assumed to have equal speeds or identical equations.

73.2 Electro relative to the background

The *Electro* position remains

$$R_E(t) = a(t)\chi_E(t). \tag{433}$$

Its velocity is

$$\dot{R}_E = HR_E + a\dot{\chi}_E. \tag{434}$$

The third leg requires

$$HR_E + a\dot{\chi}_E > 0. \tag{435}$$

The comoving component may be positive, zero, or mildly negative, provided the total physical motion remains outward.

Define

$$\beta_E^{(3)} = \frac{a\dot{\chi}_E}{HR_E}. \tag{436}$$

Then outward motion requires

$$\beta_E^{(3)} > -1. \tag{437}$$

A strongly outward-propagating active sector may satisfy

$$\beta_E^{(3)} > 0. \tag{438}$$

The exact third-leg profile is deferred to Paper IV.

73.3 The third leg is not the first leg repeated

Although both the first and third legs move outward, they differ physically.

The first leg begins from a pre-singularity instability and organizes the initial filamentary scaffold.

The third leg begins from a transformed two-pass central state inside an already expanded scaffold. That state may be radiation-rich and may contain particle-like or pair-producing excitations, but Paper I does not require a pair-rich composition.

This distinction may be expressed as

$$\mathcal{S}^{(1)}(t_0) \neq \mathcal{S}^{(3)}(t_{\mathrm{C}}). \tag{439}$$

Similarly,

$$\mathcal{D}_1 \neq \mathcal{D}_3 \tag{440}$$

may hold for the effective dynamical operators governing the two outward stages.

74 The Magnetism Triune and *Electro*–Magnetic Coupling

74.1 A distinct but provisional magnetic domain

The Triple Bounce framework treats the Magnetism Triune as a distinct model-specific force domain that participates in the third-leg transition. This proposal must be distinguished from standard electromagnetism.

In relativistic electrodynamics, electric and magnetic fields are components of a single electromagnetic field-strength tensor (Jackson, 1998; Weinberg, 1995),

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu. \tag{441}$$

The decomposition into electric and magnetic fields depends on the observer's four-velocity. Therefore, a magnetic domain that is distinct from *Electro* before the third leg is a speculative model-specific claim requiring a Lorentz-covariant completion.

Definition 6 (Magnetism Triune)**.** The Magnetism Triune denotes the proposed threefold magnetic domain that participates in third-leg coupling and later magnetic organization. Paper I does not fix its three microscopic members or assign structural memory to any single member.

Any memory or geometric persistence associated with the coupled system is therefore treated as a candidate emergent property of the combined action of *Electro*, magnetism, gravity, inherited filamentary organization, local thermodynamics, and junction history.

Limitation 6. The foundational paper does not yet provide a covariant field theory showing how a pre-electromagnetic *Electro* degree of freedom and the provisional Magnetism Triune sector recover the standard tensor $F_{\mu\nu}$.

74.2 Provisional magnetic-sector representation

Let

$$\mathcal{B}_{\text{pre}} \tag{442}$$

denote an unresolved effective variable representing the provisional Magnetism Triune sector before ordinary electromagnetic behavior is established. It is not identified with an ordinary magnetic field in standard spacetime.

The third-leg coupling may be represented schematically as

$$(\mathit{Electro}, \mathcal{B}_{\text{pre}}) \xrightarrow{\mathcal{C}_{E\mathcal{B}}} \text{a coupled state recovering } F_{\mu\nu}. \tag{443}$$

This notation does not determine whether *Electro* is absorbed into the ordinary electromagnetic field, remains a distinguishable coupled sector, or participates through another effective relationship.

A schematic interaction term is

$$\mathcal{L}_{E\mathcal{B}} = g_{E\mathcal{B}} \mathcal{O}_E \mathcal{O}_{\mathcal{B}}, \tag{444}$$

where:

- $g_{E\mathcal{B}}$ is an effective coupling parameter;
- $\mathcal{O}_E$ is an operator associated with *Electro*; and
- $\mathcal{O}_{\mathcal{B}}$ is an operator associated with the provisional Magnetism Triune sector.

The actual operators and internal magnetic-sector decomposition are not specified.

74.3 Candidate three-contact geometry

A broader geometric picture in the framework represents the Magnetism Triune as joining the third-leg *Electro*/light-wave structure through three geometrically distinct contacts with a locally transverse or perpendicular relationship. Paper I introduces this only as a candidate geometric mechanism.

The three-contact picture is not derived from Maxwell theory, does not establish a literal microscopic three-point attachment, and is not used as evidence for the framework. Its mathematical definition and possible physical interpretation belong to the companion papers.

74.4 Coupling activation

The framework proposes that coupling becomes established during the central transition, but it does not claim that the coupling causes the central reversal. A phenomenological coupling may be written as

$$g_{E\mathcal{B}} = g_{E\mathcal{B}}\left(T, \rho_E, R_E, \mathcal{S}_{\mathrm{C}}\right). \tag{445}$$

A candidate transition condition may be

$$\mathcal{C}_{E\mathcal{B}} > \mathcal{C}_{\mathrm{crit}}, \tag{446}$$

where $\mathcal{C}_{E\mathcal{B}}$ is a collective measure of coupling strength. The framework does not yet determine the controlling variables, threshold, duration, or whether the transition is abrupt or continuous.

74.5 Ordinary electromagnetism as the low-energy requirement

A successful completion must recover the Maxwell action at observable third-leg energies:

$$S_{\mathrm{EM}} = -\frac{1}{4\mu_0}\int F_{\mu\nu}F^{\mu\nu}\sqrt{-g}\,\mathrm{d}^4x. \tag{447}$$

It must also recover the standard field equations,

$$\nabla_{[\lambda}F_{\mu\nu]} = 0, \tag{448}$$

and

$$\nabla_\mu F^{\mu\nu} = \mu_0 J^\nu. \tag{449}$$

Any Triple Bounce microphysics that fails to reproduce ordinary electromagnetism in the observable third leg would be unacceptable.

75 Emergence of Ordinary Electromagnetic Behavior

75.1 From precursor to coupled radiation

Once the effective *Electro* and provisional Magnetism Triune sectors enter the proposed coupled state, radiation may propagate in the standard electromagnetic form. Paper I does not determine the post-coupling microscopic identity of *Electro*.

The transition may be summarized as

$$\text{pre-electromagnetic transport} \longrightarrow \text{coupled electromagnetic transport.} \tag{450}$$

The resulting radiation field carries:

- energy;
- momentum;
- polarization;
- phase;
- electric and magnetic field components; and
- interactions with charged particles.

75.2 Propagation speed requirement

In the standard low-energy limit, electromagnetic waves must propagate locally at the invariant speed c in vacuum.

The characteristic condition is

$$g_{\mu\nu}k^{\mu}k^{\nu} = 0, \tag{451}$$

where k^{μ} is the wave four-vector.

The Triple Bounce framework does not claim that the first-leg *Electro* precursor necessarily obeys the same dispersion relation.

It does require standard electromagnetic propagation after the third-leg coupling becomes established.

75.3 Charge and current

Ordinary electromagnetic interactions require a conserved current,

$$\nabla_{\mu}J^{\mu} = 0. \tag{452}$$

The emergence of stable charged particles must therefore be compatible with charge conservation.

A generic current is

$$J^{\mu} = \sum_i q_i n_i u_i^{\mu}. \tag{453}$$

The framework does not derive the values of the charges q_i.

It requires the final theory to reproduce the observed charge spectrum and gauge structure.

75.4 Electromagnetic coupling is not baryogenesis

The establishment of ordinary electromagnetism does not by itself produce a matter–antimatter excess.

Electromagnetic interactions conserve baryon number and treat particles and antiparticles according to charge-conjugate dynamics.

The model therefore distinguishes:

$$\text{electromagnetic emergence} \neq \text{baryogenesis mechanism}. \tag{454}$$

The two processes may occur in the same broad transition era without being physically identical.

76 Third-Leg Particle and Radiation Reorganization

76.1 Possible radiation–excitation mixture

The third leg may begin with a dense nonequilibrium mixture containing:

- *Electro* energy;
- newly established electromagnetic radiation;
- possible particle-like or particle–antiparticle excitations;
- dark-matter-associated structure;
- the chasing sector; and
- other unresolved high-energy degrees of freedom.

A provisional density bookkeeping relation is

$$\rho_{\text{tot}}^{(3)} = \rho_E + \rho_\gamma + \rho_{\text{exc}} + \rho_{\text{DM}} + \rho_{\text{C}} + \rho_{\text{other}}, \tag{455}$$

where ρ_{exc} may include pair populations if they are physically produced. A radiation- or excitation-dominated condition,

$$\rho_\gamma + \rho_{\text{exc}} \gg \rho_{\text{stable matter}}, \tag{456}$$

is permitted but not required by the architecture.

76.2 Reaction network

The early third leg may contain reactions of the generic form

$$\gamma + \gamma \rightleftharpoons P + \bar{P}, \tag{457}$$

$$P + \gamma \rightleftharpoons P + \gamma, \tag{458}$$

$$P + \bar{P} \rightleftharpoons \gamma + \gamma, \tag{459}$$

$$X \rightleftharpoons Y + Z. \tag{460}$$

The exact species and cross sections depend on the microphysical theory.

The number density of species i satisfies a Boltzmann equation,

$$\frac{\partial f_i}{\partial t} - Hp\frac{\partial f_i}{\partial p} = C_i[f], \tag{461}$$

where $C_i[f]$ is the collision operator.

A complete model must recover the successful thermal history of standard particle cosmology.

76.3 Thermalization

If interaction rates exceed the Hubble expansion rate,

$$\Gamma_{\text{int}} > H, \tag{462}$$

the relevant species may approach thermal equilibrium.

When

$$\Gamma_{\text{int}} < H, \tag{463}$$

a species may decouple or freeze out.

The Triple Bounce framework does not replace these standard kinetic criteria.

It places them within the third leg.

76.4 Entropy production

Nonequilibrium reactions may produce entropy.

For entropy current s^μ,

$$\nabla_\mu s^\mu \geq 0. \tag{464}$$

The central transition may contribute a finite entropy increase:

$$\Delta S_{\mathrm{C}} \geq 0. \tag{465}$$

The complete entropy accounting across all three legs remains open.

77 Matter–Antimatter Imbalance in the Third Leg

77.1 A small asymmetry

A matter-dominated third leg requires a small excess of matter over antimatter before widespread annihilation is complete.

The baryon asymmetry may be written as

$$\eta_B = \frac{n_B - n_{\bar{B}}}{n_\gamma}. \tag{466}$$

The Triple Bounce framework proposes that the central transition may be the stage at which this asymmetry is generated or preserved.

It does not derive the value of η_B.

77.2 Minimum requirements

A viable mechanism must include the necessary nonequilibrium and symmetry conditions.

Schematically,

$$\text{matter excess} \Longrightarrow \begin{cases} \text{number-changing interactions,} \\ \text{charge-conjugation asymmetry,} \\ \text{charge-parity asymmetry,} \\ \text{departure from equilibrium} \end{cases} \tag{467}$$

or an alternative mechanism producing an equivalent observable outcome.

The central reversal naturally supplies a departure from equilibrium, but the remaining ingredients require explicit particle physics.

77.3 Generation versus preservation

The third-leg framework leaves open two possibilities.

First, the asymmetry may be generated at the central transition:

$$\eta_B^{\text{before}} \approx 0, \qquad \eta_B^{\text{after}} \neq 0. \tag{468}$$

Second, an earlier asymmetry may be preserved through the transition:

$$\eta_B^{\text{after}} = \mathcal{P}_B \eta_B^{\text{before}}, \tag{469}$$

where $\mathcal{P}_B$ is a survival factor.

The framework does not yet choose between these possibilities.

77.4 Annihilation and surviving matter

After pair annihilation, the surviving net matter density is approximately determined by the initial asymmetry.

Schematically,

$$n_{\text{surviving}} \sim n_B - n_{\bar{B}}. \tag{470}$$

Most particle–antiparticle pairs may annihilate into radiation, while the small excess remains.

This provides a route from a nearly symmetric central state to a matter-dominated observable universe without claiming that the initial state contained only matter.

78 Matter Stabilization

78.1 Meaning of stabilization

Matter stabilization refers to the progression from short-lived, high-energy excitations toward persistent particles, nuclei, atoms, and larger structures. Particle-like excitations may exist before the third leg; Paper I claims only that stable ordinary matter becomes organized or established during the third leg.

The conceptual sequence is

$$\text{high-energy excitations} \longrightarrow \text{particle populations} \longrightarrow \text{stable matter excess} \\ \longrightarrow \text{nuclei} \longrightarrow \text{atoms} \longrightarrow \text{large-scale structure.} \quad (471)$$

The foundational paper does not replace the standard nuclear and atomic physics governing the later steps.

78.2 Expansion and cooling

As the third leg expands, the temperature of a radiation-dominated component approximately scales as

$$T \propto a^{-1} \quad (472)$$

under adiabatic expansion.

A matter component dilutes approximately as

$$\rho_m \propto a^{-3}, \quad (473)$$

while radiation dilutes as

$$\rho_r \propto a^{-4}. \quad (474)$$

These standard relations remain the baseline for the observable third leg unless interaction terms modify them.

78.3 Nuclear formation

As the temperature decreases, stable nuclei may form through standard nuclear reactions.

The Triple Bounce framework must remain consistent with observed light-element abundances.

This requires reproducing an acceptable relationship among:

- the expansion rate;
- the baryon density;
- the neutron–proton ratio;
- reaction cross sections;

- neutrino behavior; and
- the thermal history.

The model cannot arbitrarily alter the early third-leg expansion without testing these consequences.

78.4 Atomic formation

Within the conventional downstream chronology, electrons and nuclei later combine into neutral atoms.

The free-electron fraction

$$x_e = \frac{n_e}{n_{\mathrm{H}}} \tag{475}$$

decreases during recombination.

Photons then propagate with greatly reduced scattering, producing the radiation observed as the cosmic microwave background. Paper I does not assign the origin of the earlier opaque plasma era to the Triple Bounce mechanism; it treats that downstream thermal history as a compatibility requirement rather than a claimed derivation.

Remark 3. The cosmic microwave background is electromagnetic radiation. It is not identified with dark energy or with the chasing sector.

79 Occupation of the Inherited Web

79.1 Third-leg return to the first-leg pathways

The third outward *Electro* progression expands through a scaffold that already contains the first- and second-leg history.

The inherited structural field is

$$\mathcal{W}_{12} = \mathcal{W}_1^{\rightarrow} + \lambda_2 \mathcal{W}_2^{\leftarrow} + \delta\mathcal{W}_{12}. \tag{476}$$

The third-leg pathway may then be written as

$$\mathcal{W}_3 = \alpha_3 \mathcal{W}_{12} + \delta\mathcal{W}_3, \tag{477}$$

where:

- α_3 measures large-scale inheritance; and

- $\delta\mathcal{W}_3$ contains new third-leg structure.

The working expectation is

$$\alpha_3 \approx 1 \tag{478}$$

on the largest scales.

79.2 Matter follows the inherited scaffold

Matter does not need to fill the entire cosmic volume uniformly.

The local matter density may respond to the inherited scaffold:

$$\delta\rho_m = \mathcal{G}_m\left[\mathcal{W}_{12}, \rho_{\mathrm{DM}}, \Phi, \boldsymbol{v}_m\right], \tag{479}$$

where Φ is the gravitational potential and $\mathcal{G}_m$ is an effective growth operator.

At the linear level, matter perturbations may satisfy

$$\ddot{\delta}_m + 2H\dot{\delta}_m - 4\pi G\rho_{\mathrm{eff}}\delta_m = S_{\mathrm{inherit}}, \tag{480}$$

where S_{inherit} represents the inherited-web contribution.

In standard structure formation,

$$S_{\mathrm{inherit}} = 0 \tag{481}$$

unless initial conditions encode an equivalent effect.

The Triple Bounce framework permits

$$S_{\mathrm{inherit}} \neq 0. \tag{482}$$

79.3 Large-scale retracing with local divergence

The third-leg structure is not expected to reproduce the first-leg path exactly at all scales.

The local deviation may be written as

$$\delta\boldsymbol{R}_3 = \boldsymbol{R}_E^{(3)} - \boldsymbol{R}_{\mathrm{inherit}}. \tag{483}$$

The deviation may arise from:

- particle collisions;
- electromagnetic forces;
- pressure gradients;
- gravitational nonlinearities;
- junction interactions;
- scaffold deformation;
- asymmetric central release; and
- stochastic fluctuations.

The model therefore predicts structural inheritance without perfect geometric duplication.

Hypothesis 14 (Inherited occupation hypothesis)**.** *Third-leg radiation and matter preferentially organize along pathways established and preserved during the first two legs.*

80 Three-Pass Junctions

80.1 Accumulated directional history

A major junction may experience:

1. first-leg outward passage;
2. second-leg inward passage; and
3. third-leg outward electromagnetic and material passage.

The three-pass junction state is

$$\mathcal{J}_{123} = \mathcal{J}\left[\mathcal{E}_1^{\rightarrow}, \mathcal{E}_2^{\leftarrow}, \mathcal{E}_3^{\rightarrow}, \mathcal{W}_{12}, F_{\mu\nu}, \rho_m, \rho_{\mathrm{DM}}\right]. \tag{484}$$

Its directional-memory vector is

$$\boldsymbol{\mathcal{P}}_{123} = \boldsymbol{\mathcal{P}}_1 + \boldsymbol{\mathcal{P}}_2 + \boldsymbol{\mathcal{P}}_3. \tag{485}$$

Its tensorial memory is

$$\mathcal{M}_{ij}^{(123)} = \sum_{n=1}^{3} \mathcal{M}_{ij}^{(n)} + \delta\mathcal{M}_{ij}^{\mathrm{int}}. \tag{486}$$

80.2 Dynamo-junction hypothesis

The third passage differs from the first two because ordinary electromagnetic behavior and charged matter may now be present.

A previously encoded junction can therefore become a candidate site of:

- circulation, vorticity, and current formation;
- magnetic-field amplification or dissipation;
- energy storage and transfer;
- matter assembly, transformation, stabilization, or disruption;
- angular-momentum transfer and plasma organization;
- structural persistence or geometric reorganization; and
- entropy production.

Definition 7 (Dynamo junction)**.** A dynamo junction is a candidate multipass electromagnetic interaction site within the inherited filamentary web where accumulated directional history and third-leg flow may support energy transfer, structural persistence, matter transformation, rotational organization, or structural breakdown.

The term does not imply that every cosmic junction operates as a standard astrophysical dynamo, that it only creates matter, or that its activity necessarily reinforces existing structure. Local balance and history may instead stabilize, reorganize, or disrupt the junction.

80.3 Current and circulation

Once charged particles are present, a local current may form:

$$\boldsymbol{J} = \sum_i q_i n_i \boldsymbol{v}_i. \tag{487}$$

The circulation is

$$\Gamma_3 = \oint_{\mathcal{C}} \boldsymbol{v} \cdot \mathrm{d}\boldsymbol{\ell}. \tag{488}$$

The magnetic flux is

$$\Phi_B = \int_{\Sigma} \boldsymbol{B} \cdot \mathrm{d}\boldsymbol{A}. \tag{489}$$

A complete model would need to determine whether the inherited geometry produces statistically distinctive current, circulation, or magnetic patterns.

80.4 No direct galaxy claim

Paper I does not claim that each three-pass junction maps directly to a specific observed galaxy, galaxy cluster, or black hole.

Such a mapping would require:

- a calibrated length scale;
- a third-leg perturbation calculation;
- gravitational collapse modeling;
- baryonic cooling;
- feedback physics;
- magnetohydrodynamics; and
- comparison with large-scale surveys.

The junction hypothesis remains cosmological and structural.

81 The Chasing Sector During the Third Leg

81.1 Continuation across all three legs

The chasing sector is proposed to retain its outward role throughout the full directional history.

Its sign does not reverse when *Electro* reverses:

$$\dot{R}_{\mathrm{C}}^{(1)} > 0, \qquad \dot{R}_{\mathrm{C}}^{(2)} > 0, \qquad \dot{R}_{\mathrm{C}}^{(3)} > 0. \tag{490}$$

The strength of its contribution may change.

The framework does not require its density, pressure, or equation of state to remain identical through all three legs.

81.2 Third-leg effective equation of state

During the observable third leg,

$$p_C = w_C(z)\rho_C c^2. \tag{491}$$

The standard cosmological-constant limit is

$$w_C = -1. \tag{492}$$

The Triple Bounce framework permits a near-constant effective behavior over the measured interval without assuming that $w_C = -1$ is the fundamental microphysical identity.

81.3 Third-leg acceleration

The acceleration equation is

$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3}\sum_i \left(\rho_i + \frac{3p_i}{c^2}\right). \tag{493}$$

The chasing sector contributes outward acceleration when

$$\rho_C + \frac{3p_C}{c^2} < 0. \tag{494}$$

For a positive density, this requires

$$w_C < -\frac{1}{3}. \tag{495}$$

The packet-growth correspondence developed across Papers I–IV is compared with this observable third-leg behavior only, with the strongest reconstruction reserved for Paper IV.

81.4 No identification with photons

The chasing sector is not identified with the cosmic microwave background, ordinary photons, or the electromagnetic radiation produced during the third leg.

The model distinguishes

$$\rho_C \neq \rho_\gamma. \tag{496}$$

Photons propagate through spacetime whose expansion is influenced by the chasing sector.

They are not the chasing sector itself.

82 The Gravity Triune During the Third Leg

82.1 Binding

Classical gravity provides the binding role.

At the perturbative Newtonian level,

$$\nabla^2\Phi = 4\pi G a^2 \delta\rho_{\rm grav}, \tag{497}$$

where $\delta\rho_{\rm grav}$ includes all gravitating density perturbations.

Binding acts to:

- amplify overdensities;
- slow local expansion;
- produce collapse;
- retain matter in structures; and
- organize later stars, galaxies, and clusters.

82.2 Scaffolding

Dark matter retains the scaffolding role.

Its third-leg functions include:

- preserving large-scale pathway structure;
- providing gravitational wells;
- supporting filament growth;
- linking junctions;
- maintaining low-density void regions; and
- guiding later matter organization statistically.

The framework does not require the scaffold to remain unchanged.

It may evolve gravitationally and dynamically during the third leg.

82.3 Chasing

Dark energy retains the chasing role.

Its effect is expressed through continued large-scale expansion and late-time acceleration.

The Gravity Triune may therefore be summarized as

$$\begin{aligned} \text{binding} &\longrightarrow \text{local retention and collapse,} \\ \text{scaffolding} &\longrightarrow \text{large-scale structural organization,} \\ \text{chasing} &\longrightarrow \text{continued outward expansion.} \end{aligned} \tag{498}$$

These roles operate simultaneously rather than sequentially.

82.4 Competing scales

At smaller scales, binding and scaffolding may dominate.

At sufficiently large scales, chasing may dominate the expansion.

A schematic scale-dependent balance is

$$\mathcal{B}(L) + \mathcal{S}(L) - \mathcal{C}(L), \tag{499}$$

where:

- $\mathcal{B}(L)$ is the effective binding contribution;
- $\mathcal{S}(L)$ is the scaffolding contribution; and
- $\mathcal{C}(L)$ is the chasing contribution.

The framework does not yet derive the crossover scale.

83 The Beginning of Observable Cosmic History

83.1 Third-leg observational accessibility

The observable universe develops within the third leg.

This does not mean that every moment of the third leg is directly visible.

Electromagnetic observations are limited by:

- the opacity of the early plasma;
- the last-scattering surface;

- the finite speed of light;
- the expansion history;
- the particle horizon;
- the sensitivity of detectors; and
- foreground contamination.

The earliest directly observable electromagnetic radiation is the cosmic microwave background, not the central reversal itself.

83.2 Standard hot-state physics as the third-leg baseline

The Triple Bounce framework retains standard hot-state cosmology as the baseline description after ordinary particle physics and electromagnetism become established.

This includes:

1. a hot radiation-rich plasma;
2. particle reactions and freeze-out;
3. light-element formation;
4. matter–radiation evolution;
5. recombination;
6. photon decoupling;
7. growth of density perturbations;
8. formation of stars and galaxies; and
9. late-time accelerated expansion.

The proposed change concerns the origin and hidden prehistory of the initial conditions.

83.3 The third leg and the conventional cosmic age

The conventional cosmic age scale is treated in this framework as an empirical anchor for the observable third leg.

Paper IV uses

$$T_3 \approx 13.824 \text{ Gyr} \tag{500}$$

as the selected third-leg time scale.

This does not by itself determine:

- the first-leg duration;
- the second-leg duration;
- the outer-transition duration;
- the central-transition duration; or
- the total elapsed Triple Bounce history.

83.4 The visible beginning is not necessarily the absolute beginning

The earliest reconstructable hot state of the third leg may appear, within a one-leg model, to be the beginning of the entire universe.

The Triple Bounce interpretation instead proposes

$$t_{\text{observable beginning}} \neq t_{\text{total beginning}}. \tag{501}$$

This is the central incomplete-history claim.

It must ultimately be tested through quantitative predictions rather than asserted conceptually.

84 The Cosmic Microwave Background in the Third-Leg Framework

84.1 Radiation from recombination

The cosmic microwave background consists of photons released from frequent scattering when the primordial plasma became sufficiently neutral (Hu and Sugiyama, 1996; Seager et al., 2000; Dodelson, 2003).

Its present temperature, angular anisotropy spectrum, polarization spectrum, and acoustic structure contain information about the third-leg plasma, geometry, composition, and perturbations.

The photon energy density scales approximately as

$$\rho_\gamma \propto a^{-4}. \tag{502}$$

The photon temperature scales approximately as

$$T_\gamma \propto a^{-1}. \tag{503}$$

84.2 The CMB is not a dark-energy boundary

The cosmic microwave background is not treated as the physical edge of the chasing sector.

It is also not treated as the total distance dark energy has traveled.

The observed last-scattering surface is an electromagnetic visibility boundary.

The chasing sector is modeled as volume filling and dynamically active throughout the third-leg geometry.

Thus,

$$\text{cosmic microwave background last-scattering surface} \neq \text{dark-energy boundary}. \tag{504}$$

84.3 Inherited-history signatures

If the third leg inherits structure from earlier legs, that history may influence the initial perturbations entering the standard recombination calculation.

A generic primordial curvature spectrum may be written as

$$\mathcal{P}_\mathcal{R}(k) = \mathcal{P}_\mathcal{R}^{\text{standard}}(k) + \Delta\mathcal{P}_\mathcal{R}^{\text{inherit}}(k). \tag{505}$$

Possible inherited contributions could affect:

- large-angle correlations;
- power-spectrum features;
- phase relationships;
- statistical isotropy;
- non-Gaussianity;
- polarization; and
- cross-correlations with large-scale structure.

No specific signature is derived in Paper I.

84.4 Requirement to reproduce acoustic physics

Any successful Triple Bounce model must reproduce the observed acoustic peak structure, whose standard treatment couples primordial perturbations, photon–baryon dynamics, and recombination (Ma and Bertschinger, 1995; Hu and Sugiyama, 1996; Mukhanov, 2005).

That requires an acceptable third-leg calculation of:

- the sound horizon;
- baryon loading;
- photon diffusion;
- gravitational driving;
- recombination;
- projection to angular scales; and
- late-time lensing and reionization.

A hidden prehistory does not remove these requirements.

85 Third-Leg Effective Dynamical System

A minimal third-leg background system may be written as

$$H^2 = \frac{8\pi G}{3}\left(\rho_E + \rho_\gamma + \rho_b + \rho_{\rm DM} + \rho_{\rm C} + \rho_{\rm other}\right) - \frac{kc^2}{a^2}, \tag{506}$$

$$\dot\rho_E + 3H\left(\rho_E + \frac{p_E}{c^2}\right) = \mathcal{Q}_E^{(3)}, \tag{507}$$

$$\dot\rho_\gamma + 4H\rho_\gamma = \mathcal{Q}_\gamma^{(3)}, \tag{508}$$

$$\dot\rho_b + 3H\rho_b = \mathcal{Q}_b^{(3)}, \tag{509}$$

$$\dot\rho_{\rm DM} + 3H\left(\rho_{\rm DM} + \frac{p_{\rm DM}}{c^2}\right) = \mathcal{Q}_{\rm DM}^{(3)}, \tag{510}$$

$$\dot\rho_{\rm C} + 3H\left(\rho_{\rm C} + \frac{p_{\rm C}}{c^2}\right) = \mathcal{Q}_{\rm C}^{(3)}. \tag{511}$$

Total conservation requires

$$\mathcal{Q}_E^{(3)} + \mathcal{Q}_\gamma^{(3)} + \mathcal{Q}_b^{(3)} + \mathcal{Q}_{\rm DM}^{(3)} + \mathcal{Q}_{\rm C}^{(3)} + \mathcal{Q}_{\rm other}^{(3)} = 0. \tag{512}$$

The active *Electro* trajectory satisfies

$$\ddot{R}_E + \Gamma_E^{(3)} \dot{R}_E + \frac{\partial V_E^{(3)}}{\partial R_E} = S_E^{(3)}, \tag{513}$$

with

$$\dot{R}_E > 0. \tag{514}$$

The inherited web evolves according to

$$\frac{\partial \mathcal{W}_3}{\partial t} = \mathcal{F}_3 \left[\mathcal{W}_{12}, \rho_E, F_{\mu\nu}, \rho_m, \rho_{\rm DM}, g_{\mu\nu}\right]. \tag{515}$$

The system remains schematic until the equations of state, interaction terms, and perturbation equations are specified.

86 Third-Leg Perturbation Requirements

86.1 Density perturbations

Each sector may contain a background and perturbation:

$$\rho_i(t, \boldsymbol{x}) = \bar{\rho}_i(t) \left[1 + \delta_i(t, \boldsymbol{x})\right]. \tag{516}$$

A complete theory must evolve the coupled set

$$\{\delta_E, \delta_\gamma, \delta_b, \delta_{\rm DM}, \delta_{\rm C}\}. \tag{517}$$

The inherited web may enter as an initial condition or source term.

86.2 Metric perturbations

In conformal Newtonian gauge, the perturbed metric may be written as

$$\mathrm{d}s^2 = a^2(\eta) \left[-(1 + 2\Psi)c^2 \mathrm{d}\eta^2 + (1 - 2\Phi)\delta_{ij} \mathrm{d}x^i \mathrm{d}x^j\right]. \tag{518}$$

The potentials Ψ and Φ must be solved consistently with the sector perturbations.

An inherited anisotropic stress could produce

$$\Phi \neq \Psi. \tag{519}$$

The model must ensure that any such effect remains observationally acceptable.

86.3 Initial-condition map

The central transition must map the two-leg inherited state into third-leg perturbation initial data:

$$\left\{\mathcal{W}_{12}, \boldsymbol{\mathcal{P}}_{12}, \mathcal{M}_{ij}^{(12)}, \mathcal{S}_{\mathrm{C}}\right\} \longrightarrow \{\delta_i, \theta_i, \Phi, \Psi\}_{t=t_{\mathrm{C}}^{+}}, \tag{520}$$

where θ_i denotes the velocity-divergence perturbation of sector i.

This mapping is one of the principal unsolved mathematical problems of the framework.

87 Third-Leg Observable Requirements

The third-leg model must reproduce or account for:

1. the observed redshift–distance relation;
2. the present expansion rate;
3. supernova luminosity distances;
4. baryon acoustic oscillation distance scales;
5. the cosmic microwave background temperature spectrum;
6. the cosmic microwave background polarization spectrum;
7. light-element abundances;
8. the matter power spectrum;
9. large-scale structure growth;
10. gravitational lensing;
11. the observed near-flat geometry;
12. the matter–radiation transition;
13. late-time acceleration; and
14. the statistical isotropy of the observable universe.

The model should also produce at least one distinctive signature that is not merely obtained by fitting additional free parameters.

Potential classes of signatures include:

- large-scale inherited correlations;
- specific departures in the third-leg expansion history;
- nonstandard but controlled curvature evolution;
- multipass junction statistics;
- primordial magnetic correlations;
- phase structure in the perturbation spectrum; and
- cross-correlations between large-scale matter and magnetic structure.

No one signature is selected as established in Paper I.

88 Third-Leg Continuation Conditions

Unlike the first and second legs, the third leg has not yet reached a known terminal reversal within the observable history.

Its present continuation conditions are:

88.1 Outward Electro condition

$$\dot{R}_E^{(3)} > 0. \tag{521}$$

88.2 Expanding background condition

$$H^{(3)} > 0. \tag{522}$$

88.3 Chasing-sector condition

$$\rho_{\mathrm{C}} > 0, \tag{523}$$

with an effective accelerating contribution compatible with observation.

88.4 Scaffold condition

$$\rho_{\mathrm{DM}} > 0. \tag{524}$$

88.5 Inherited-web condition

$$\mathcal{C}_{3,12} > \mathcal{C}_{\rm crit} \tag{525}$$

on the largest relevant scales, where $\mathcal{C}_{3,12}$ is the correlation between third-leg structure and the inherited two-pass web.

88.6 Electromagnetic recovery condition

$$\mathcal{L}_{\rm effective} \longrightarrow \mathcal{L}_{\rm Maxwell} \tag{526}$$

at ordinary electromagnetic energies.

88.7 Conservation condition

$$\nabla_\mu T^{\mu\nu}_{\rm tot} = 0. \tag{527}$$

89 What the Third Leg Does Not Yet Explain

The third-leg framework does not yet explain:

1. the physical cause of the central reversal;
2. the duration of the central transition;
3. the microphysical identity and internal structure of the Magnetism Triune sector;
4. the Lorentz-covariant origin of ordinary electromagnetism from the proposed precursor sectors;
5. the particle species present at the beginning of the third leg;
6. the mechanism generating or preserving the matter–antimatter asymmetry;
7. the complete thermalization history;
8. the detailed transition from *Electro* energy into ordinary radiation;
9. the quantitative inherited-web source term;
10. the primordial perturbation spectrum;
11. the cosmic microwave background angular power spectrum;
12. the full matter power spectrum;
13. the statistical distribution of dynamo junctions;

14. the exact third-leg expansion function $H(z)$;
15. the microscopic nature of the chasing sector;
16. the future endpoint of the third leg; or
17. whether another reversal occurs after the present observable era.

These questions define the companion-paper mathematical and observational program.

90 Formal Summary of the Third Outward Leg

The third leg may be summarized as

$$\boxed{\begin{aligned} \text{central } \textit{Electro} \text{ reversal} &\longrightarrow \text{nonequilibrium outward re-expansion} \\ &\longrightarrow \textit{Electro}\text{–magnetic coupling} \\ &\longrightarrow \text{electromagnetic radiation and matter stabilization} \\ &\longrightarrow \text{occupation of the inherited web} \end{aligned}} \tag{528}$$

with directional conditions

$$\dot{R}_E^{(3)} > 0, \tag{529}$$

$$H^{(3)} > 0, \tag{530}$$

$$\dot{R}_{\mathrm{C}}^{(3)} > 0, \tag{531}$$

the central transition condition

$$\dot{R}_E(t_{\mathrm{C}}^-) < 0, \qquad \dot{R}_E(t_{\mathrm{C}}) = 0, \qquad \dot{R}_E(t_{\mathrm{C}}^+) > 0, \tag{532}$$

the electromagnetic recovery condition

$$\textit{Electro} + \mathcal{B}_{\mathrm{pre}} \longrightarrow F_{\mu\nu}, \tag{533}$$

the inherited-web condition

$$\mathcal{W}_3 = \alpha_3 \mathcal{W}_{12} + \delta\mathcal{W}_3, \tag{534}$$

and the Gravity Triune functions

$$\boxed{\text{binding} + \text{scaffolding} + \text{chasing}} \tag{535}$$

operating simultaneously during observable cosmic evolution.

The third leg is therefore not merely an outward release of energy.

It is the visible reorganization of a system containing the accumulated history of two prior directional passes.

91 Three-Leg Architectural Summary

The complete Triple Bounce sequence may now be represented as

$$\boxed{\begin{aligned} \text{First leg:} \quad & \text{outward } \textit{Electro} \text{ release} + \text{web formation}, \\ \text{Second leg:} \quad & \text{inward } \textit{Electro} \text{ return} + \text{counter-imprint}, \\ \text{Third leg:} \quad & \text{outward electromagnetic reorganization} + \text{matter occupation.} \end{aligned}} \tag{536}$$

The directional history is

$$\textit{Electro}: \quad \rightarrow \quad \leftarrow \quad \rightarrow . \tag{537}$$

The chasing history is

$$\text{chasing sector}: \quad \rightarrow \quad \rightarrow \quad \rightarrow . \tag{538}$$

The scaffold history is

$$\text{scaffold}: \quad \text{formation} \longrightarrow \text{retention} \longrightarrow \text{occupation and evolution.} \tag{539}$$

The web history is

$$\mathcal{W}_1 \longrightarrow \mathcal{W}_{12} \longrightarrow \mathcal{W}_3. \tag{540}$$

The matter history is

$$\text{no stable matter} \longrightarrow \text{possible particle-like excitation state} \longrightarrow \text{stable matter excess.} \tag{541}$$

This architecture provides the conceptual foundation for the remaining sections of Paper I.

92 Matter and Inherited Structure

The Triple Bounce framework proposes that the large-scale organization of third-leg matter does not begin on a structurally blank background.

Instead, the third leg develops inside a cosmic scaffold already shaped by:

1. the first outward *Electro* passage;
2. the second inward *Electro* passage;
3. persistent dark-matter-associated structural memory;
4. the continuing outward evolution of the chasing sector; and
5. the transformed central transition that initiates the observable leg.

Matter therefore emerges into an inherited environment.

The framework does not claim that every galaxy, filament, wall, or void is predetermined before the third leg.

It proposes a more limited relationship:

$$\text{large-scale pathway inheritance} + \text{local third-leg evolution} = \text{observable structure.} \tag{542}$$

The inherited web supplies a spatial bias.

Third-leg gravity, radiation pressure, electromagnetic interaction, particle collisions, fluid flow, and nonlinear instability then alter that bias.

Hypothesis 15 (Inherited-structure hypothesis)**.** *The statistical organization of third-leg matter is influenced by a persistent large-scale web established before ordinary stable matter formed.*

93 Structural Retracing

93.1 Meaning of retracing

Structural retracing does not mean that the third outward leg follows every first-leg trajectory with exact microscopic precision.

It means that third-leg propagation and matter organization remain correlated with the dominant pre-existing pathways.

Let

$$\mathcal{W}_1(\boldsymbol{x}) \tag{543}$$

represent the first-leg pathway field,

$$\mathcal{W}_2(\boldsymbol{x}) \tag{544}$$

represent the second-leg inward support field, and

$$\mathcal{W}_3(\boldsymbol{x}) \tag{545}$$

represent the third-leg occupied structure.

The inherited two-pass field is

$$\mathcal{W}_{12} = \mathcal{W}_1 + \lambda_2 \mathcal{W}_2 + \delta\mathcal{W}_{12}, \tag{546}$$

where λ_2 weights the retained second-pass contribution.

The third-leg structure is then written as

$$\mathcal{W}_3 = \alpha_3 \mathcal{W}_{12} + \delta\mathcal{W}_{\mathrm{branch}} + \delta\mathcal{W}_{\mathrm{grav}} + \delta\mathcal{W}_{\mathrm{EM}} + \delta\mathcal{W}_{\mathrm{stoch}}, \tag{547}$$

where:

- α_3 is the large-scale inheritance coefficient;
- $\delta\mathcal{W}_{\mathrm{branch}}$ represents collision-driven branching;
- $\delta\mathcal{W}_{\mathrm{grav}}$ represents nonlinear gravitational evolution;
- $\delta\mathcal{W}_{\mathrm{EM}}$ represents electromagnetic reorganization; and
- $\delta\mathcal{W}_{\mathrm{stoch}}$ represents stochastic deviations.

93.2 Large-scale and small-scale limits

The inheritance coefficient may depend on scale:

$$\alpha_3 = \alpha_3(k), \tag{548}$$

where k is comoving wavenumber.

The framework expects stronger inheritance at large scales:

$$\alpha_3(k \to 0) \approx 1, \tag{549}$$

while smaller scales may exhibit greater divergence:

$$\alpha_3(k \to k_{\mathrm{NL}}) < \alpha_3(k \to 0), \tag{550}$$

where k_{NL} marks the onset of substantial nonlinear structure formation.

The framework therefore predicts scale-dependent structural memory rather than perfect repetition.

93.3 Path preference

Matter may preferentially accumulate where the inherited pathway strength exceeds a threshold:

$$\mathcal{W}_{12}(\boldsymbol{x}) > \mathcal{W}_{\mathrm{crit}}. \tag{551}$$

A phenomenological matter-response relation may be written as

$$\rho_m(t, \boldsymbol{x}) = \bar{\rho}_m(t) \left[1 + b_{\mathcal{W}}(t)\mathcal{W}_{12}(\boldsymbol{x}) + \delta_m^{\mathrm{new}}(t, \boldsymbol{x})\right], \tag{552}$$

where:

- $b_{\mathcal{W}}(t)$ is an inherited-web response coefficient; and
- δ_m^{new} represents third-leg structure generated after the central reversal.

Equation (552) is a phenomenological starting point rather than a completed structure formation law.

94 Web Retention Coefficients

94.1 Two-time retention

The persistence of the scaffold can be quantified through a two-time correlation.

Define

$$\mathcal{R}_{\mathcal{W}}(t_a, t_b) = \frac{\langle \mathcal{W}(t_a, \boldsymbol{x}) \mathcal{W}(t_b, \boldsymbol{x}) \rangle}{\sqrt{\langle \mathcal{W}^2(t_a, \boldsymbol{x}) \rangle \langle \mathcal{W}^2(t_b, \boldsymbol{x}) \rangle}}. \tag{553}$$

The first-to-second-leg retention is

$$\mathcal{R}_{12} = \mathcal{R}_{\mathcal{W}}(t_{\mathrm{O}}, t_{\mathrm{C}}), \tag{554}$$

while the first-to-third-leg retention is

$$\mathcal{R}_{13} = \mathcal{R}_{\mathcal{W}}(t_{\mathrm{O}}, t_3). \tag{555}$$

A strong large-scale memory hypothesis requires

$$\mathcal{R}_{12} \approx 1, \qquad \mathcal{R}_{13} \approx 1 \tag{556}$$

after coarse graining over sufficiently large scales.

94.2 Scale-dependent retention

In Fourier space, define the cross-power spectrum

$$\left\langle \widetilde{\mathcal{W}}_a(\boldsymbol{k}) \widetilde{\mathcal{W}}_b^*(\boldsymbol{k}') \right\rangle = (2\pi)^3 \delta_D(\boldsymbol{k} - \boldsymbol{k}') P_{ab}(k), \tag{557}$$

where δ_D is the Dirac delta distribution.

A scale-dependent correlation coefficient is

$$r_{ab}(k) = \frac{P_{ab}(k)}{\sqrt{P_{aa}(k) P_{bb}(k)}}. \tag{558}$$

For large-scale structural inheritance,

$$r_{13}(k) \to 1 \tag{559}$$

as k approaches the large-scale regime.

On smaller scales,

$$r_{13}(k) < 1 \tag{560}$$

may result from nonlinear evolution and new third-leg branching.

94.3 Amplitude retention versus topological retention

The web may retain its topology even if its density amplitude changes.

The framework distinguishes:

$$\text{amplitude retention} \neq \text{topological retention}. \tag{561}$$

Amplitude retention concerns the magnitude of structural contrasts.

Topological retention concerns the persistence of:

- filament connectivity;
- junction positions;
- void boundaries;
- pathway orientation;
- network hierarchy; and
- large-scale adjacency relations.

A topological retention measure may be defined schematically as

$$\mathcal{T}_{13} = 1 - \frac{d_{\text{top}}\left(\mathfrak{W}_1, \mathfrak{W}_3\right)}{d_{\text{top,max}}}, \tag{562}$$

where:

- $\mathfrak{W}_1$ and $\mathfrak{W}_3$ are network representations of the first- and third-leg webs;
- d_{top} is a topological distance measure; and
- $d_{\text{top,max}}$ is a normalization.

The completed framework must determine an appropriate topology statistic.

95 Three-Pass Structural Memory

95.1 Accumulation of directional history

The first, second, and third passages contribute different directional records.

Let

$$\boldsymbol{\mathcal{P}}_1, \qquad \boldsymbol{\mathcal{P}}_2, \qquad \boldsymbol{\mathcal{P}}_3 \tag{563}$$

denote the directional memory fields for the three legs.

The total vector memory is

$$\boldsymbol{\mathcal{P}}_{123} = w_1\boldsymbol{\mathcal{P}}_1 + w_2\boldsymbol{\mathcal{P}}_2 + w_3\boldsymbol{\mathcal{P}}_3, \tag{564}$$

where w_i are retention weights.

Because the first and second passes may be approximately opposed,

$$\boldsymbol{\mathcal{P}}_2 \approx -\boldsymbol{\mathcal{P}}_1, \tag{565}$$

the vector memory can be smaller than the total directional activity.

However, the tensor memory remains additive:

$$\mathcal{M}_{ij}^{(123)} = \sum_{n=1}^{3} w_n \mathcal{M}_{ij}^{(n)} + \delta\mathcal{M}_{ij}^{\text{int}}. \tag{566}$$

This allows a junction to retain a strong multipass history even when the net vector direction partially cancels.

95.2 Memory state at a junction

A three-pass junction may be assigned a state vector

$$\boldsymbol{\mathcal{S}}_{\mathcal{J}} = \Big(\mathcal{W}_{123}, \boldsymbol{\mathcal{P}}_{123}, \mathcal{M}_{ij}^{(123)}, \rho_{\text{DM}}, \rho_m, \boldsymbol{J}, \boldsymbol{B}, \boldsymbol{\omega}\Big). \tag{567}$$

The entries represent:

- total pathway strength;
- net directional memory;
- tensorial directional memory;

- scaffold density;
- ordinary matter density;
- electric current;
- magnetic field; and
- vorticity.

The state vector is intended as an organizational device.

It does not imply that all quantities are independently conserved.

95.3 Memory hierarchy

The framework distinguishes three levels of memory:

I. **Path memory:** the location and strength of previously traversed channels;

II. **Directional memory:** the orientation and sequence of earlier passages; and

III. **Interaction memory:** persistent changes produced by collisions, shear, compression, or coupling at repeated junctions.

The total memory field may be written schematically as

$$\mathcal{M}_{\text{total}} = \mathcal{M}_{\text{path}} + \mathcal{M}_{\text{direction}} + \mathcal{M}_{\text{interaction}}. \tag{568}$$

A completed field theory must identify which physical variables carry each form of memory.

96 Filament Formation in the Third Leg

96.1 Inherited filament seeds

The inherited web provides anisotropic seed structure before ordinary matter becomes gravitationally nonlinear.

A filament-seed field may be constructed from the Hessian of the inherited potential:

$$\mathcal{H}_{ij} = \partial_i \partial_j \Phi_{\text{inherit}}, \tag{569}$$

where

$$\nabla^2\Phi_{\text{inherit}} = 4\pi G a^2 \delta\rho_{\text{inherit}}. \tag{570}$$

The eigenvalues of $\mathcal{H}_{ij}$ may classify local structure into collapse directions.

A filamentary region may contain two dominant collapse directions and one extended direction.

The Triple Bounce framework does not require the standard cosmic-web classification to be abandoned.

It proposes that the initial field entering such a classification may contain inherited structure from prior legs.

96.2 Matter flow along filaments

Matter velocity may decompose into components parallel and perpendicular to the inherited filament:

$$\boldsymbol{v}_m = v_\parallel \hat{\boldsymbol{n}} + \boldsymbol{v}_\perp, \tag{571}$$

where $\hat{\boldsymbol{n}}$ is the local filament direction.

Preferential flow along the inherited pathway corresponds to

$$\left|v_\parallel\right| > |\boldsymbol{v}_\perp| \tag{572}$$

during at least some stages of formation.

This flow can transport matter toward junctions and overdense nodes.

96.3 Gravitational amplification

Once matter perturbations are present, classical gravity amplifies the inherited seed.

In a simplified pressureless regime,

$$\ddot{\delta}_m + 2H\dot{\delta}_m - 4\pi G\rho_m\delta_m = S_{\mathcal{W}}, \tag{573}$$

where $S_{\mathcal{W}}$ is the inherited-web source.

If the inherited field is encoded entirely in the initial conditions, then

$$S_{\mathcal{W}} = 0 \tag{574}$$

during later evolution, while

$$\delta_m(t_{\mathrm{init}}, \boldsymbol{x}) = \delta_m^{\mathrm{inherit}}(\boldsymbol{x}) + \delta_m^{\mathrm{new}}(\boldsymbol{x}). \tag{575}$$

If the scaffold remains dynamically coupled, then

$$S_{\mathcal{W}} \neq 0. \tag{576}$$

The paper leaves both implementations open.

96.4 Filament thickness and branching

A filament need not remain a one-dimensional path.

Its transverse profile may be modeled as

$$\rho_f(r_\perp) = \rho_{f,0} F_f \left(\frac{r_\perp}{R_f} \right), \tag{577}$$

where:

- $r_\perp$ is perpendicular distance from the filament axis;
- R_f is a characteristic width; and
- F_f is a profile function.

Third-leg pressure, collisions, and gravity may broaden or split the original pathway.

97 Void Formation and Persistence

97.1 Inherited low-pathway regions

Void precursors correspond to regions in which the inherited web is weak.

A void-seed condition may be written as

$$\mathcal{W}_{12}(\boldsymbol{x}) < \mathcal{W}_{\mathrm{void}}. \tag{578}$$

Such regions may also contain a negative scaffold perturbation:

$$\delta_{\mathrm{DM}}(\boldsymbol{x}) < 0. \tag{579}$$

Matter then preferentially flows away from these regions toward filaments and junctions.

97.2 Void expansion

A local void scale factor $a_v(t)$ may expand faster than the background average:

$$H_v = \frac{\dot{a}_v}{a_v}, \tag{580}$$

with

$$H_v > H \tag{581}$$

during suitable stages.

The chasing sector may further support the growth of low-density regions.

The framework does not claim that dark energy exists only in voids.

It treats the chasing sector as volume filling while allowing voids to respond differently because binding and scaffolding are weaker there.

97.3 Void boundaries

Void boundaries form where low-pathway regions meet filaments or walls.

A boundary may be identified by a rapid spatial gradient:

$$|\nabla \mathcal{W}_{12}| > G_{\mathrm{crit}}. \tag{582}$$

Matter accumulation near the boundary may produce walls and sheets.

The inherited framework therefore permits a connected hierarchy:

$$\text{void} \longrightarrow \text{wall} \longrightarrow \text{filament} \longrightarrow \text{junction}. \tag{583}$$

97.4 Voids are not absolute emptiness

A void may contain:

- diffuse matter;
- dark matter;
- radiation;
- the chasing sector;
- weak filaments;

- small galaxies; and
- residual fields.

The term *void* refers to relative underdensity, not absence of all physical content.

98 Collision-Driven Branching

98.1 Third-leg departures from the inherited path

The third leg contains stable charged particles, electromagnetic radiation, pressure gradients, and gravitationally interacting matter.

It therefore has more available mechanisms for path deviation than the first leg.

A local third-leg trajectory may be written as

$$\boldsymbol{x}_3(t) = \boldsymbol{x}_{\text{inherit}}(t) + \delta\boldsymbol{x}_{\text{coll}} + \delta\boldsymbol{x}_{\text{EM}} + \delta\boldsymbol{x}_{\text{grav}} + \delta\boldsymbol{x}_{\text{press}}. \tag{584}$$

98.2 Branching criterion

A new branch may form when the transverse force exceeds the restoring bias of the inherited pathway.

Let

$$\boldsymbol{F}_{\perp}^{\text{tot}} = \boldsymbol{F}_{\perp}^{\text{coll}} + \boldsymbol{F}_{\perp}^{\text{EM}} + \boldsymbol{F}_{\perp}^{\text{grav}} + \boldsymbol{F}_{\perp}^{\text{press}}. \tag{585}$$

Let

$$\boldsymbol{F}_{\text{inherit}} = -\nabla_{\perp} V_{\text{inherit}}. \tag{586}$$

Branching becomes possible when

$$\left|\boldsymbol{F}_{\perp}^{\text{tot}}\right| > \left|\boldsymbol{F}_{\text{inherit}}\right|. \tag{587}$$

This condition is schematic.

It expresses the competition between pathway memory and new third-leg interactions.

98.3 Branch survival

A temporary deviation does not necessarily become a persistent branch.

A new branch must acquire sufficient matter, field strength, or scaffolding support to survive.

Define a branch-amplification parameter

$$\mathcal{A}_{\mathrm{br}} = \frac{\text{growth rate of branch support}}{\text{decay rate of branch support}}. \tag{588}$$

Persistent branching requires

$$\mathcal{A}_{\mathrm{br}} > 1. \tag{589}$$

Branches with

$$\mathcal{A}_{\mathrm{br}} < 1 \tag{590}$$

fade back into the dominant inherited structure.

98.4 Asymmetric branching

Branching need not occur symmetrically.

Local asymmetries may arise from:

- unequal collision angles;
- unequal current densities;
- magnetic deflection;
- density gradients;
- scaffold deformation;
- vorticity;
- unequal particle populations; and
- statistical fluctuations.

The third-leg web may therefore become increasingly asymmetric while retaining large-scale ancestry.

99 Junction Hierarchies

99.1 Junction order

Not all junctions have equal structural importance.

Define the order of a junction as the number of significant connected pathways:

$$N_{\mathcal{J}} = \text{number of major incident branches.} \tag{591}$$

A low-order junction may satisfy

$$N_{\mathcal{J}} = 2 \quad \text{or} \quad 3, \tag{592}$$

while a major network node may have

$$N_{\mathcal{J}} \gg 1. \tag{593}$$

The total junction strength may be defined as

$$S_{\mathcal{J}} = \sum_{a=1}^{N_{\mathcal{J}}} w_a \mathcal{W}_a + \lambda_\rho \rho_{\mathrm{DM}} + \lambda_M \operatorname{Tr} \mathcal{M}^{(123)}. \tag{594}$$

99.2 Primary, secondary, and tertiary junctions

The framework distinguishes:

I. **Primary junctions:** major multipass intersections inherited from the first-leg network;

II. **Secondary junctions:** intersections produced through third-leg branching from primary pathways; and

III. **Tertiary junctions:** later nonlinear intersections generated by gravitational and electromagnetic evolution.

The distinction is historical rather than purely geometric.

Two junctions may appear similar in the third leg while possessing different inherited histories.

99.3 Junction ancestry

A junction ancestry indicator may be defined as

$$\mathcal{A}_{\mathcal{J}} = \frac{S_{\mathcal{J}}^{\mathrm{inherit}}}{S_{\mathcal{J}}^{\mathrm{total}}}. \tag{595}$$

A primary inherited junction has

$$\mathcal{A}_{\mathcal{J}} \approx 1, \tag{596}$$

while a newly formed third-leg junction may have

$$\mathcal{A}_{\mathcal{J}} \ll 1. \tag{597}$$

A dedicated simulation could test whether such ancestry leaves measurable statistical differences.

99.4 Junction mass accumulation

Matter flowing along connected filaments accumulates at junctions.

A junction mass-growth equation may be written schematically as

$$\frac{\mathrm{d}M_{\mathcal{J}}}{\mathrm{d}t} = \sum_a \dot{M}_a^{\mathrm{in}} - \dot{M}_{\mathcal{J}}^{\mathrm{out}} - \dot{M}_{\mathcal{J}}^{\mathrm{loss}}. \tag{598}$$

The inflow rates depend on:

- filament density;
- velocity along each branch;
- gravitational potential;
- pressure;
- magnetic forces; and
- feedback from later astrophysical processes.

Paper I does not model the later baryonic feedback.

100 Dynamo Precursors and Magnetic Organization

100.1 Multipass origin of rotational bias

The first outward, second inward, and third outward passes need not be perfectly collinear.

Their combination may generate local shear and circulation.

The total vorticity may be decomposed as

$$\boldsymbol{\omega}_{123} = \boldsymbol{\omega}_1 + \boldsymbol{\omega}_2 + \boldsymbol{\omega}_3 + \boldsymbol{\omega}_{\text{int}}. \tag{599}$$

The first two terms represent inherited directional effects.

The third term represents third-leg flow.

The interaction term represents nonlinear coupling among passes.

100.2 Magnetic induction

Once ordinary electromagnetism and conducting plasma exist, magnetic fields evolve through an induction equation; standard dynamo theory provides the relevant amplification baseline (Brandenburg and Subramanian, 2005).

In magnetohydrodynamic form,

$$\frac{\partial \boldsymbol{B}}{\partial t} = \nabla \times (\boldsymbol{v} \times \boldsymbol{B}) + \eta_m \nabla^2 \boldsymbol{B}, \tag{600}$$

where η_m is magnetic diffusivity.

A dynamo requires the flow term to overcome diffusive decay over the relevant interval.

A magnetic Reynolds number is

$$\text{Rm} = \frac{VL}{\eta_m}. \tag{601}$$

Efficient magnetic-field advection and amplification generally require

$$\text{Rm} \gg 1. \tag{602}$$

The Triple Bounce framework does not replace standard dynamo physics.

It proposes that inherited junction geometry may provide favorable initial conditions for later dynamo action.

100.3 Seed-field problem

A dynamo requires a nonzero seed magnetic field. Cosmological magnetic fields and observational limits on primordial contributions provide the comparison context (Ryu et al., 2008; Planck Collaboration et al., 2016).

The framework permits several possibilities:

1. the *Electro*–magnetic coupling directly generates seed fields;
2. charge separation at three-pass junctions generates seed currents;
3. vorticity and plasma effects generate seed magnetism;
4. high-energy phase transitions generate primordial fields; or
5. a provisional magnetic-sector degree of freedom persists into the third leg.

No mechanism is selected as established.

100.4 Junction magnetic-memory tensor

A magnetic-memory tensor may be defined as

$$\mathcal{B}_{ij}^{\mathrm{mem}} = \int_{t_{\mathrm{C}}}^{t} B_i(t', \boldsymbol{x}) B_j(t', \boldsymbol{x}) \mathrm{d}t'. \tag{603}$$

This tensor records persistent directional magnetic organization.

A correlation with the inherited structural tensor may be measured by

$$\mathcal{C}_{B\mathcal{M}} = \frac{\left\langle \mathcal{B}_{ij}^{\mathrm{mem}} \mathcal{M}_{ij}^{(123)} \right\rangle}{\sqrt{\left\langle \mathcal{B}_{ij}^{\mathrm{mem}} \mathcal{B}_{ij}^{\mathrm{mem}} \right\rangle \left\langle \mathcal{M}_{ij}^{(123)} \mathcal{M}_{ij}^{(123)} \right\rangle}}. \tag{604}$$

A strong nonrandom alignment would be a possible signature of inherited junction structure.

Hypothesis 16 (Dynamo-precursor hypothesis)**.** *Multipass junctions provide inherited geometric and directional conditions that may enhance later circulation, current formation, and magnetic-field amplification.*

101 Matter Distribution Relative to the Scaffold

101.1 Matter and dark matter are not identical

Ordinary matter occupies the scaffold but is not identified with it.

The density fields satisfy

$$\rho_m(t, \boldsymbol{x}) \neq \rho_{\rm DM}(t, \boldsymbol{x}). \tag{605}$$

Their cross-correlation may nevertheless be strong:

$$r_{m,\rm DM}(k) = \frac{P_{m,\rm DM}(k)}{\sqrt{P_m(k) P_{\rm DM}(k)}}. \tag{606}$$

The Triple Bounce framework expects

$$r_{m,\rm DM}(k) \approx 1 \tag{607}$$

on large scales after sufficient gravitational evolution.

101.2 Bias

Visible matter may trace the scaffold with a scale-dependent bias:

$$\delta_m(k) = b_m(k)\delta_{\rm DM}(k) + \epsilon_m(k), \tag{608}$$

where:

- $b_m(k)$ is the matter-to-scaffold bias; and
- $\epsilon_m(k)$ represents stochastic or non-scaffold contributions.

The bias may change with time:

$$b_m = b_m(k, t). \tag{609}$$

101.3 Incomplete occupation

Not every inherited pathway must contain equal visible matter.

Occupation depends upon:

- local matter supply;
- temperature;
- pressure;
- ionization state;
- gravitational potential;
- magnetic fields;
- feedback;
- branch connectivity; and
- later mergers.

Thus,

$$0 \leq f_{\mathrm{occ}}(\boldsymbol{x}, t) \leq 1, \tag{610}$$

where f_{occ} is the fraction of an inherited path visibly occupied by matter.

A structurally real pathway may therefore remain weakly luminous.

102 Candidate Observable Consequences

The inherited-web hypothesis must eventually produce observable consequences distinguishable from ordinary structure formation with suitably chosen initial conditions.

Paper I does not derive those consequences fully.

It identifies candidate classes of tests.

102.1 Large-scale phase correlations

A pre-existing web may generate phase relationships not expected from a purely random Gaussian initial field.

Write the density mode as

$$\delta(\boldsymbol{k}) = |\delta(\boldsymbol{k})|\, e^{i\phi(\boldsymbol{k})}. \tag{611}$$

The inherited model may produce nontrivial correlations of the form

$$\left\langle e^{i[\phi(\boldsymbol{k}_1)+\phi(\boldsymbol{k}_2)-\phi(\boldsymbol{k}_3)]} \right\rangle \neq 0 \tag{612}$$

for selected mode configurations.

Such correlations would appear through higher-order statistics.

102.2 Non-Gaussianity

A three-pass structural history may generate non-Gaussian features.

The bispectrum is defined by

$$\langle \delta(\boldsymbol{k}_1)\delta(\boldsymbol{k}_2)\delta(\boldsymbol{k}_3)\rangle = (2\pi)^3 \delta_D\left(\boldsymbol{k}_1 + \boldsymbol{k}_2 + \boldsymbol{k}_3\right) B\left(k_1, k_2, k_3\right). \tag{613}$$

A distinctive inherited contribution may be written as

$$B = B_{\text{standard}} + B_{\text{inherit}}. \tag{614}$$

The shape and amplitude of B_{inherit} must be derived before comparison with observations.

102.3 Topology and connectivity

Standard cosmic-web analyses quantify filament, wall, void, and halo environments using complementary classification and catalogue methods (Hahn et al., 2007; Cautun et al., 2014; Tempel et al., 2014; Libeskind et al., 2018). Against that baseline, the inherited model may affect:

- filament-length distributions;
- junction-degree distributions;
- void-connectivity statistics;
- network persistence;
- alignment across large separations; and
- the topology of overdense excursion sets.

A network-degree distribution may be written as

$$P(N_{\mathcal{J}}), \tag{615}$$

while a filament-length distribution is

$$P(L_f). \tag{616}$$

The Triple Bounce model must predict these quantities rather than merely noting their existence.

102.4 Magnetic alignment

If three-pass junctions influence magnetic organization, one may search for correlations between magnetic-field orientation and large-scale filament structure.

Define an alignment statistic

$$\mathcal{A}_{Bf} = \left\langle \left| \hat{\boldsymbol{B}} \cdot \hat{\boldsymbol{n}}_f \right| \right\rangle, \tag{617}$$

where $\hat{\boldsymbol{n}}_f$ is the filament direction.

For random orientations in three dimensions, the statistic has a standard null expectation.

A significant scale-dependent excess would require interpretation, including comparison with standard tidal-torque and cosmic-web alignment predictions (Codis et al., 2015).

The inherited framework would need to predict the sign, scale, and magnitude of the effect.

102.5 Junction rotational statistics

A multipass history may affect the distribution of local vorticity.

A junction-vorticity statistic may be defined as

$$P\left(|\boldsymbol{\omega}_{\mathcal{J}}| \mid N_{\mathcal{J}}, S_{\mathcal{J}}\right). \tag{618}$$

A distinctive model might predict that high-order inherited junctions have systematically different rotational properties from newly formed junctions.

No such prediction is derived here.

102.6 Cross-correlation with the cosmic microwave background

If inherited structure influences primordial perturbations, it may produce cross-correlations between large-scale matter structure and features in the cosmic microwave background.

A generic angular cross-spectrum is

$$C_\ell^{Xg} = \left\langle a_{\ell m}^{X} a_{\ell m}^{g*} \right\rangle, \tag{619}$$

where X may represent temperature or polarization and g represents a large-scale-structure tracer.

The standard cosmological effects contributing to such correlations must be modeled before attributing any residual to inherited structure.

103 Distinguishing Inheritance from Standard Initial Conditions

103.1 The degeneracy problem

A major challenge is that any observed third-leg structure can, in principle, be represented as an initial condition at the beginning of the third leg.

Therefore,

$$\text{hidden inherited web} \quad \text{and} \quad \text{chosen third-leg initial field} \tag{620}$$

may generate similar observable outcomes.

A viable Triple Bounce test must identify a feature that cannot be reproduced naturally by an ordinary one-leg model without additional fine tuning.

103.2 Required consistency across observables

The inherited model must predict one underlying structure that appears consistently in several independent observables.

For example, one inherited parameter set should jointly determine:

- matter clustering;
- filament topology;
- void structure;
- magnetic alignment;
- junction statistics;
- cosmic microwave background correlations; and
- possibly the third-leg expansion history.

The model should not introduce a separate arbitrary correction for each dataset.

103.3 Predictive compression

A useful model explains multiple observations with fewer independent assumptions than a purely phenomenological fit.

Let

$$\mathcal{L}_{\text{model}} \tag{621}$$

represent an effective description length, including parameters and assumptions.

The Triple Bounce framework gains evidential value only if

$$\mathcal{L}_{\text{Triple Bounce}} < \mathcal{L}_{\text{independent corrections}} \tag{622}$$

for comparable explanatory accuracy.

This is a methodological criterion rather than a literal final likelihood equation.

103.4 Parameter estimation requirement

A complete inherited-web model must be fit to data through a parameter set such as

$$\boldsymbol{\theta}_{\mathcal{W}} = \{\alpha_3, \lambda_2, \tau_{\mathcal{W}}, b_{\mathcal{W}}, A_{\text{br}}, L_{\text{corr}}, S_{\mathcal{J}}, \ldots\}\,. \tag{623}$$

The posterior distribution is

$$P\left(\boldsymbol{\theta}_{\mathcal{W}} \mid \mathcal{D}\right) \propto P\left(\mathcal{D} \mid \boldsymbol{\theta}_{\mathcal{W}}\right) P\left(\boldsymbol{\theta}_{\mathcal{W}}\right), \tag{624}$$

where $\mathcal{D}$ is the observational dataset.

The model must be compared with standard cosmology using matched data and transparent priors.

104 Claim-Specific Test Outcomes for Inherited Structure

The following outcomes apply specifically to the inherited-web claim family. They do not automatically reject the triple directional history, the pre-singularity hypothesis, or the independent horizon and flatness mechanisms.

104.1 No viable retention mechanism

If no physically consistent field or scaffold can preserve large-scale structure across the second leg, then

$$\mathcal{R}_{13} \to 0, \tag{625}$$

and the inheritance hypothesis fails.

104.2 Excessive anisotropy

If the inherited web necessarily produces large-scale directional anisotropy exceeding observational limits, the model is unacceptable.

A viable model requires

$$\epsilon_{\text{anis}} \ll 1 \tag{626}$$

on the largest observed scales.

104.3 Failure to reproduce the matter power spectrum

The predicted matter power spectrum must remain consistent with observations:

$$P_m^{\text{TB}}(k) = P_m^{\text{obs}}(k) + \Delta P_m(k), \tag{627}$$

with residuals remaining within acceptable uncertainty after a complete fit.

A large unavoidable mismatch would reject the tested inherited-web matter-power realization.

104.4 Failure to reproduce the cosmic microwave background

Any inherited perturbation contribution must preserve the observed acoustic structure.

If

$$C_\ell^{\text{TB}} \tag{628}$$

cannot reproduce the measured temperature and polarization spectra, the tested inherited-perturbation and CMB-recovery realization is rejected. That verdict does not, by itself, reject the existence of prior legs.

104.5 No distinctive prediction

If every inherited-web effect is exactly degenerate with arbitrary third-leg initial conditions, then the hypothesis may remain unfalsifiable.

A scientifically useful theory must identify at least one measurable quantity satisfying

$$\mathcal{O}_{\mathrm{TB}} \neq \mathcal{O}_{\Lambda\mathrm{CDM}} \tag{629}$$

after both models are fit fairly.

104.6 Requirement of observer centrality

If the inherited network requires the observer to occupy a privileged location to explain isotropy, that inherited-network realization is strongly disfavored.

105 Required Simulation Program

The inherited-structure hypothesis requires numerical development.

A minimum simulation program contains five stages.

105.1 Stage I: inherited field generation

Construct a first-leg pathway field

$$\mathcal{W}_1(\boldsymbol{x}) \tag{630}$$

from a specified *Electro* propagation and scaffold-response law.

105.2 Stage II: second-leg evolution

Evolve the inward *Electro* passage while allowing:

- scaffold deformation;
- counter-imprint formation;
- junction reprocessing;
- local compression; and
- continued outer expansion.

The output is

$$\mathcal{W}_{12}(\boldsymbol{x}). \tag{631}$$

105.3 Stage III: central matching

Apply the central transition map:

$$\mathcal{M}_{\mathrm{C}} : \mathcal{W}_{12} \longrightarrow \{\delta_i, \theta_i, \Phi, \Psi, \boldsymbol{B}, \boldsymbol{J}\}_{t_{\mathrm{C}}^{+}} . \tag{632}$$

105.4 Stage IV: third-leg structure growth

Evolve:

- radiation;
- baryonic matter;
- dark matter;
- the chasing sector;
- electromagnetic fields;
- gravity; and
- the inherited pathway field.

The output includes

$$\{P_m(k), B(k_1, k_2, k_3), P(N_{\mathcal{J}}), P(L_f), P(R_v), \mathcal{A}_{Bf}, C_\ell\} . \tag{633}$$

105.5 Stage V: model comparison

Compare the Triple Bounce outputs with:

- standard ΛCDM simulations;
- inflationary initial-condition models;
- large-scale-structure surveys;

- weak-lensing maps;
- cosmic microwave background data;
- magnetic-field observations; and
- void and filament catalogs.

The comparison must include parameter penalties and uncertainty propagation.

106 Formal Summary of Matter and Inherited Structure

The matter-structure proposal may be summarized as

$$\boxed{\begin{aligned}\text{first-leg pathway} &\longrightarrow \text{second-leg counter-history}\\ &\longrightarrow \text{persistent two-pass scaffold}\\ &\longrightarrow \text{third-leg matter occupation}\\ &\longrightarrow \text{nonlinear branching and junction growth}\end{aligned}} \tag{634}$$

The structural decomposition is

$$\mathcal{W}_3 = \alpha_3 \mathcal{W}_{12} + \delta\mathcal{W}_{\text{branch}} + \delta\mathcal{W}_{\text{grav}} + \delta\mathcal{W}_{\text{EM}} + \delta\mathcal{W}_{\text{stoch}}. \tag{635}$$

The large-scale retention condition is

$$r_{13}(k \to 0) \approx 1. \tag{636}$$

The matter response is

$$\rho_m = \bar{\rho}_m \left[1 + b_{\mathcal{W}} \mathcal{W}_{12} + \delta_m^{\text{new}}\right]. \tag{637}$$

The three-pass memory is

$$\mathcal{M}_{ij}^{(123)} = \sum_{n=1}^{3} w_n \mathcal{M}_{ij}^{(n)} + \delta\mathcal{M}_{ij}^{\text{int}}. \tag{638}$$

The branching condition is

$$\left|\boldsymbol{F}_{\perp}^{\text{tot}}\right| > \left|\boldsymbol{F}_{\text{inherit}}\right|. \tag{639}$$

The junction hierarchy is characterized by

$$N_{\mathcal{J}}, \qquad S_{\mathcal{J}}, \qquad \mathcal{A}_{\mathcal{J}}. \tag{640}$$

The dynamo-precursor hypothesis requires a measurable relationship among

$$\mathcal{M}_{ij}^{(123)}, \qquad \boldsymbol{\omega}, \qquad \boldsymbol{J}, \qquad \boldsymbol{B}. \tag{641}$$

The inherited-web hypothesis becomes scientifically meaningful only if these quantities lead to distinctive predictions that cannot be reproduced through arbitrary third-leg initial conditions.

107 The Triune Dynamical Grammar

The Triple Bounce framework uses the term *Triune* to describe a system containing three distinct functional members that remain dynamically connected.

A Triune is not defined merely by the number three.

It requires:

1. three distinguishable members;
2. a nonredundant functional role for each member;
3. interaction or mutual dependence among the members;
4. a collective behavior not reducible to any one member alone; and
5. a domain in which the three-member organization produces a useful physical description.

The foundational example is the Gravity Triune:

$$\mathfrak{G} = \{\mathcal{G}_{\text{bind}}, \mathcal{G}_{\text{scaf}}, \mathcal{G}_{\text{chase}}\}, \tag{642}$$

where:

- $\mathcal{G}_{\text{bind}}$ represents classical gravitational binding;
- $\mathcal{G}_{\text{scaf}}$ represents dark-matter-associated scaffolding; and
- $\mathcal{G}_{\text{chase}}$ represents dark-energy-associated outward chasing.

The three functions may be summarized as

$$\boxed{\text{binding} \;+\; \text{scaffolding} \;+\; \text{chasing}} \tag{643}$$

within one effective cosmological architecture.

Definition 8 (Triune)**.** A Triune is a connected three-member functional system in which each member remains distinguishable, each performs a nonidentical role, and the complete dynamics depend upon their coordinated interaction.

Remark 4. The term *Triune* is a model-organizing concept. It does not by itself establish a new symmetry group, particle multiplet, gauge structure, or fundamental law.

108 Functional Roles Versus Physical Identities

108.1 Role is not substance

The functions binding, scaffolding, and chasing should not be confused with complete microscopic identities.

For example,

$$\text{dark matter} \longrightarrow \text{scaffolding} \tag{644}$$

does not specify whether dark matter consists of:

- weakly interacting particles;
- axion-like fields;
- hidden-sector matter;
- primordial compact objects;
- superfluid or condensate behavior;
- modified gravitational phenomena; or
- another unknown physical sector.

Similarly,

$$\text{dark energy} \longrightarrow \text{chasing} \tag{645}$$

does not determine whether the observed acceleration arises from:

- a cosmological constant;
- vacuum energy;
- a scalar field;

- a modified-gravity effect;
- an interacting dark sector;
- emergent spacetime dynamics; or
- another mechanism.

The functional assignment is therefore weaker than a microscopic identification.

108.2 Physical identity may carry several functions

A physical sector may perform more than one function.

Dark matter may scaffold structure while also contributing to binding through its stress–energy.

The chasing sector may influence expansion while also altering structure growth.

Classical gravity binds matter but also responds to every stress–energy component.

Thus, the Triune roles should not be interpreted as mutually exclusive labels.

A role-weight matrix may be introduced:

$$\mathsf{R} = \begin{pmatrix} r_{\mathrm{bind},G} & r_{\mathrm{bind},DM} & r_{\mathrm{bind},C} \\ r_{\mathrm{scaf},G} & r_{\mathrm{scaf},DM} & r_{\mathrm{scaf},C} \\ r_{\mathrm{chase},G} & r_{\mathrm{chase},DM} & r_{\mathrm{chase},C} \end{pmatrix}, \tag{646}$$

where each coefficient measures the contribution of one physical member to one functional role.

The minimal Triple Bounce interpretation expects the approximate ordering

$$r_{\mathrm{bind},G} > r_{\mathrm{bind},DM}, r_{\mathrm{bind},C}, \tag{647}$$

$$r_{\mathrm{scaf},DM} > r_{\mathrm{scaf},G}, r_{\mathrm{scaf},C}, \tag{648}$$

$$r_{\mathrm{chase},C} > r_{\mathrm{chase},G}, r_{\mathrm{chase},DM}, \tag{649}$$

without requiring the subdominant entries to vanish.

108.3 One-third does not mean equal abundance

Each member is one of three functional components.

This does not imply

$$\Omega_G = \Omega_{\mathrm{DM}} = \Omega_{\mathrm{C}} = \frac{1}{3}. \tag{650}$$

The measured energy-density fractions may remain highly unequal.

The Triune classification is organizational and dynamical, not an equal division of cosmic mass-energy.

109 Binding

109.1 Classical gravitational binding

Binding is the tendency of mass-energy and spacetime curvature to retain, focus, orbit, collapse, or assemble physical systems.

In general relativity, binding is not represented as a separate material substance.

It emerges from the metric response governed by

$$G_{\mu\nu} + \Lambda_{\mathrm{ref}} g_{\mu\nu} = \frac{8\pi G}{c^4} T^{\mathrm{tot}}_{\mu\nu}. \tag{651}$$

At weak field and low velocity, the Newtonian potential satisfies

$$\nabla^2 \Phi = 4\pi G \rho_{\mathrm{grav}}. \tag{652}$$

The acceleration of a test particle is approximately

$$\boldsymbol{a} = -\nabla \Phi. \tag{653}$$

109.2 Binding is scale dependent

Binding is most evident where local overdensity and gravitational potential dominate over expansion.

A characteristic gravitational timescale is

$$t_{\mathrm{ff}} \sim \frac{1}{\sqrt{G\rho}}. \tag{654}$$

A local region can collapse or remain gravitationally bound when its internal dynamical timescale is sufficiently short relative to the cosmological expansion timescale,

$$t_{\mathrm{ff}} \lesssim H^{-1}. \tag{655}$$

This relation is schematic and depends on geometry, pressure, angular momentum, and environment.

109.3 Binding across the three legs

The binding role may change across the directional history.

During the first leg, binding may:

- contribute to the geometry established by the released sectors;
- respond to the developing scaffold;
- oppose unlimited local dispersal; and
- participate in the approach to the outer reversal.

During the second leg, binding may:

- support inward convergence;
- increase local compression;
- act through the scaffold;
- amplify junction concentration; and
- contribute to the central high-density state.

During the third leg, binding may:

- amplify inherited density contrasts;
- form stable structures;
- retain matter at filament junctions;
- produce gravitational collapse; and
- oppose large-scale dilution locally.

The framework does not claim that classical gravity reverses direction as a whole.

It responds to the evolving stress–energy and geometry throughout all three legs.

109.4 Binding operator

A schematic binding operator may be introduced as

$$\mathcal{B}\left[g_{\mu\nu}, T^{\rm tot}_{\mu\nu}\right] = G_{\mu\nu} - \frac{8\pi G}{c^4} T^{\rm tot}_{\mu\nu}. \quad (656)$$

Physical solutions satisfy

$$\mathcal{B} = 0 \quad (657)$$

after inclusion of any cosmological reference term.

This notation does not introduce new gravitational dynamics.

It labels the binding response within the Triune grammar.

110 Scaffolding

110.1 Structural persistence

Scaffolding is the function of maintaining large-scale organization throughout the three-leg history.

The scaffold is proposed to:

1. co-form with the first outward *Electro* web;
2. retain the first-leg pathway after the active front passes;
3. survive the outer reversal;
4. remain present during the inward return;
5. record the second-leg counter-history;
6. survive the central transition; and
7. influence the third-leg distribution of matter and radiation.

The scaffold is associated primarily with dark matter because dark matter already occupies the dominant nonluminous structural role in standard cosmology.

110.2 Scaffold field

A generalized scaffold field may be written as

$$\mathcal{S} = \mathcal{S}\left(t, \boldsymbol{x}\right). \tag{658}$$

It may contain:

$$\mathcal{S} = \left\{\rho_{\mathrm{DM}}, \boldsymbol{v}_{\mathrm{DM}}, D_{ij}^{(\mathrm{DM})}, \mathcal{W}, \boldsymbol{\mathcal{P}}, \mathcal{M}_{ij}\right\}. \tag{659}$$

The components represent:

- dark-matter density;
- dark-matter velocity;
- scaffold deformation;
- pathway strength;
- directional memory; and
- tensorial structural memory.

110.3 Scaffold evolution operator

The scaffold may obey an effective equation

$$\mathcal{D}_{\mathcal{S}}\mathcal{S} = \mathcal{J}_E + \mathcal{J}_G + \mathcal{J}_C + \mathcal{J}_m, \tag{660}$$

where:

- $\mathcal{J}_E$ is the source from *Electro* passage;
- $\mathcal{J}_G$ is the response to gravitational binding;
- $\mathcal{J}_C$ is the interaction with the chasing sector; and
- $\mathcal{J}_m$ is the later response to ordinary matter.

The operator $\mathcal{D}_{\mathcal{S}}$ remains undefined.

The equation expresses the requirement that the scaffold be dynamical rather than a fixed external grid.

110.4 Memory and relaxation

The scaffold must possess a sufficiently long memory timescale:

$$\tau_{\mathcal{S}} \gtrsim \Delta t_2 + \tau_{\mathrm{C}}. \tag{661}$$

A simple memory kernel may be written as

$$\mathcal{S}(t) = \int_{t_0}^{t} K_{\mathcal{S}}(t,t')\mathcal{J}_E(t')\mathrm{d}t', \tag{662}$$

where the kernel may decay as

$$K_{\mathcal{S}}(t,t') \propto \exp\left[-\frac{t-t'}{\tau_{\mathcal{S}}}\right]. \tag{663}$$

Long-lived memory requires large $\tau_{\mathcal{S}}$.

110.5 Scaffolding is not rigid determinism

The scaffold biases later development but does not uniquely determine every local outcome.

The third-leg matter state may be written as

$$\mathcal{M}_3 = \mathcal{F}\left[\mathcal{S}_{12}, \mathcal{I}_3, \mathcal{N}_3\right], \tag{664}$$

where:

- $\mathcal{S}_{12}$ is the inherited scaffold;
- $\mathcal{I}_3$ contains third-leg interactions; and
- $\mathcal{N}_3$ contains nonlinear and stochastic contributions.

The scaffold is therefore constraining but not absolutely deterministic.

111 Chasing

111.1 Definition of chasing

Chasing is the persistent outward function associated with the dark-energy-like sector.

The word does not imply that dark energy literally pursues matter as an ordinary object. It denotes the continuing outward tendency that:

- survives the first *Electro* reversal;
- remains active during the inward second leg;
- contributes to continued expansion of the cosmic volume; and
- is proposed to have a late-time third-leg expression in accelerated expansion.

A chasing field may be denoted by

$$\mathcal{C} = \mathcal{C}\left(t, \boldsymbol{x}\right). \tag{665}$$

At the homogeneous level,

$$\mathcal{C} \longrightarrow \left\{\rho_{\mathrm{C}}(t), p_{\mathrm{C}}(t)\right\}. \tag{666}$$

111.2 Chasing and negative pressure

The effective equation of state is

$$w_{\mathrm{C}} = \frac{p_{\mathrm{C}}}{\rho_{\mathrm{C}} c^2}. \tag{667}$$

The chasing sector contributes to acceleration when

$$\rho_{\mathrm{C}} + \frac{3 p_{\mathrm{C}}}{c^2} < 0. \tag{668}$$

For positive density,

$$w_{\mathrm{C}} < -\frac{1}{3}. \tag{669}$$

The cosmological-constant limit is

$$w_{\mathrm{C}} = -1. \tag{670}$$

The Triple Bounce framework allows the possibility that this standard negative-pressure phenomenology is an effective third-leg manifestation rather than the final microscopic description.

111.3 Chasing across the three legs

Under the schematic progression-coordinate convention, the effective functional sign remains outward:

$$\operatorname{sgn}\left(\dot{R}_{\mathrm{C}}^{(1)}\right) = \operatorname{sgn}\left(\dot{R}_{\mathrm{C}}^{(2)}\right) = \operatorname{sgn}\left(\dot{R}_{\mathrm{C}}^{(3)}\right) = +1. \tag{671}$$

Equation (671) is a model bookkeeping statement. It does not assign a directly measured radial velocity to dark energy or describe a fluid shell moving through space.

The magnitude may vary:

$$\left|\dot{R}_{\mathrm{C}}^{(1)}\right| \neq \left|\dot{R}_{\mathrm{C}}^{(2)}\right| \neq \left|\dot{R}_{\mathrm{C}}^{(3)}\right|. \tag{672}$$

The equation of state may also vary:

$$w_{\mathrm{C}} = w_{\mathrm{C}}^{(j)}(t), \qquad j \in \{1,2,3\}. \tag{673}$$

No equality across the legs is imposed.

111.4 Chasing is not a boundary shell

The chasing sector is modeled as volume filling.

Its local density may be written as

$$\rho_{\mathrm{C}}(t,\boldsymbol{x}) = \bar{\rho}_{\mathrm{C}}(t) + \delta\rho_{\mathrm{C}}(t,\boldsymbol{x}). \tag{674}$$

The foundational model assumes large-scale smoothness:

$$|\delta\rho_{\mathrm{C}}| \ll \bar{\rho}_{\mathrm{C}} \tag{675}$$

at sufficiently large scales.

It does not claim that the chasing sector is located only at the cosmic edge.

111.5 Chasing operator

A schematic chasing operator may be defined as

$$\mathcal{C}_{\mathrm{op}}\left[\rho_{\mathrm{C}}, p_{\mathrm{C}}, g_{\mu\nu}\right] = -\frac{4\pi G}{3}\left(\rho_{\mathrm{C}} + \frac{3p_{\mathrm{C}}}{c^2}\right). \tag{676}$$

An outward accelerating contribution corresponds to

$$\mathcal{C}_{\mathrm{op}} > 0. \tag{677}$$

This notation labels the acceleration contribution.

It does not replace the Friedmann acceleration equation.

112 The Gravity Triune as a Coupled System

112.1 Triune state vector

The Gravity Triune may be represented by the state vector

$$\boldsymbol{\mathcal{G}} = (\mathcal{B}, \mathcal{S}, \mathcal{C})^{\mathsf{T}}, \tag{678}$$

where:

- $\mathcal{B}$ is the binding state;
- $\mathcal{S}$ is the scaffolding state; and
- $\mathcal{C}$ is the chasing state.

Their coupled evolution may be written schematically as

$$\frac{\mathrm{d}}{\mathrm{d}t}\boldsymbol{\mathcal{G}} = \mathsf{A}_{\mathcal{G}}\boldsymbol{\mathcal{G}} + \boldsymbol{\mathcal{J}}_{\mathcal{G}}, \tag{679}$$

where $\mathsf{A}_{\mathcal{G}}$ is a coupling matrix and $\boldsymbol{\mathcal{J}}_{\mathcal{G}}$ contains sources from other sectors.

The matrix is

$$\mathsf{A}_{\mathcal{G}} = \begin{pmatrix} A_{BB} & A_{BS} & A_{BC} \\ A_{SB} & A_{SS} & A_{SC} \\ A_{CB} & A_{CS} & A_{CC} \end{pmatrix}. \tag{680}$$

The off-diagonal elements represent communication among the roles.

112.2 Separate but connected

The phrase *separate but connected* requires

$$\mathcal{B} \neq \mathcal{S} \neq \mathcal{C}, \tag{681}$$

and at least some nonzero cross-couplings:

$$A_{ij} \neq 0 \tag{682}$$

for selected $i \neq j$.

A completely diagonal system,

$$A_{ij} = 0 \qquad \text{for all } i \neq j, \tag{683}$$

would represent three unrelated sectors rather than a connected Triune.

A completely degenerate system,

$$\mathcal{B} = \mathcal{S} = \mathcal{C}, \tag{684}$$

would erase their distinct functions.

The intended model lies between these limits.

112.3 Interaction energy

A schematic effective interaction energy may be written as

$$U_{\mathfrak{G}} = U_B(\mathcal{B}) + U_S(\mathcal{S}) + U_C(\mathcal{C}) + U_{BS} + U_{SC} + U_{CB}, \tag{685}$$

where the cross terms represent pairwise interactions.

A possible three-way term is

$$U_{BSC} = \lambda_{BSC}\mathcal{B}\mathcal{S}\mathcal{C}. \tag{686}$$

No such specific interaction is adopted as physical law.

The equation demonstrates the mathematical difference between separate member energies and collective coupling.

112.4 Total conservation

If the dark sectors exchange energy, their continuity equations may be

$$\dot{\rho}_{\rm DM} + 3H\left(\rho_{\rm DM} + \frac{p_{\rm DM}}{c^2}\right) = \mathcal{Q}_{\rm DM}, \tag{687}$$

$$\dot{\rho}_{\rm C} + 3H\left(\rho_{\rm C} + \frac{p_{\rm C}}{c^2}\right) = \mathcal{Q}_{\rm C}, \tag{688}$$

while geometric response remains encoded through the Einstein equations.

Any dark-sector transfer must satisfy

$$\mathcal{Q}_{\rm DM} + \mathcal{Q}_{\rm C} + \mathcal{Q}_{\rm other} = 0 \tag{689}$$

when all receiving sectors are included.

113 Competition and Cooperation Within the Gravity Triune

113.1 Local competition

Binding and chasing may produce opposite large-scale tendencies.

Binding promotes local retention and collapse.

Chasing promotes continued expansion.

A schematic net radial acceleration is

$$a_{\rm net}(R) = a_{\rm bind}(R) + a_{\rm scaf}(R) + a_{\rm chase}(R). \tag{690}$$

The signs may satisfy

$$a_{\rm bind} < 0, \qquad a_{\rm chase} > 0, \tag{691}$$

while the scaffolding term may support either local retention or large-scale pathway organization depending on context.

113.2 Cooperation in structure formation

Binding and scaffolding cooperate in structure formation.

The scaffold supplies an organized density field.

Binding amplifies it.

A simplified matter-growth equation is

$$\ddot{\delta}_m + 2H\dot{\delta}_m - 4\pi G\rho_{\text{eff}}\delta_m = S_{\mathcal{S}}, \tag{692}$$

where $S_{\mathcal{S}}$ represents the scaffold contribution.

Chasing affects this growth indirectly through $H(t)$ and possibly through interactions.

113.3 Cooperation in large-scale separation

During the second leg, the scaffold and chasing sector may jointly permit an inward *Electro* return without global contraction.

The scaffold preserves the path.

Chasing preserves the outward evolution of the volume.

Binding may contribute to inward concentration.

The second-leg architecture may therefore be summarized as

$$\boxed{\text{binding inward influence} + \text{scaffold retention} + \text{chasing outward expansion}} \tag{693}$$

acting while

$$\dot{R}_E < 0. \tag{694}$$

113.4 Scale-dependent dominance

Define effective strengths

$$\mathcal{B}(L,t), \qquad \mathcal{S}(L,t), \qquad \mathcal{C}(L,t), \tag{695}$$

at physical scale L.

The dominant role is

$$\mathcal{D}(L,t) = \arg\max \left\{|\mathcal{B}|, |\mathcal{S}|, |\mathcal{C}|\right\}. \tag{696}$$

The model expects:

- binding dominance in strongly bound local systems;
- scaffolding importance in large-scale network organization; and

- chasing dominance in sufficiently large-scale accelerated expansion.

The transitions among these regimes must be derived quantitatively.

114 Gravity Triune State Changes Across the Three Legs

114.1 First-leg state

During the first leg, the Gravity Triune state may be summarized as

$$\boldsymbol{\mathcal{G}}_1 = (\mathcal{B}_1, \mathcal{S}_1, \mathcal{C}_1)\,. \tag{697}$$

Its dominant functions are:

$$\mathcal{B}_1 : \text{binding, regulation, and geometric response,} \tag{698}$$

$$\mathcal{S}_1 : \text{distributed containment, web co-formation, and path persistence,} \tag{699}$$

$$\mathcal{C}_1 : \text{continued outward drive.} \tag{700}$$

114.2 Second-leg state

During the second leg,

$$\boldsymbol{\mathcal{G}}_2 = (\mathcal{B}_2, \mathcal{S}_2, \mathcal{C}_2)\,. \tag{701}$$

Its dominant functions become:

$$\mathcal{B}_2 : \text{inward concentration and convergence,} \tag{702}$$

$$\mathcal{S}_2 : \text{retention and counter-imprint support,} \tag{703}$$

$$\mathcal{C}_2 : \text{continued outward cosmic expansion.} \tag{704}$$

114.3 Third-leg state

During the third leg,

$$\boldsymbol{\mathcal{G}}_3 = (\mathcal{B}_3, \mathcal{S}_3, \mathcal{C}_3)\,. \tag{705}$$

Its dominant functions become:

$$\mathcal{B}_3 : \text{matter retention and gravitational collapse,} \tag{706}$$

$$\mathcal{S}_3 : \text{inherited-web occupation and structure growth,} \tag{707}$$

$$\mathcal{C}_3 : \text{continued expansion and late acceleration.} \tag{708}$$

114.4 Role continuity with state change

The functional identities remain recognizable while their physical expressions change. This section does not divide the Triple Bounce into three independent mechanisms; it tracks one connected Gravity Triune through three successive directional regimes.

This may be written as

$$\mathcal{G}_i^{(1)} \neq \mathcal{G}_i^{(2)} \neq \mathcal{G}_i^{(3)}, \tag{709}$$

while

$$\text{Role}\left(\mathcal{G}_i^{(1)}\right) = \text{Role}\left(\mathcal{G}_i^{(2)}\right) = \text{Role}\left(\mathcal{G}_i^{(3)}\right) \tag{710}$$

at the broad functional level.

Thus, the members evolve without losing their defining roles.

115 The Electricity Triune

115.1 Provisional three-member organization

The Triple Bounce framework also permits a provisional Electricity Triune.

Unlike the Gravity Triune, its three members are less fully defined.

A minimal organizational form is

$$\mathfrak{E} = \{\mathcal{E}_{\text{potential}}, \mathcal{E}_{\text{propagation}}, \mathcal{E}_{\text{interaction}}\} . \tag{711}$$

The members may be interpreted provisionally as:

- stored electrical or pre-electrical potential;
- active *Electro* propagation; and
- charge-mediated electromagnetic interaction after coupling.

This formulation is deliberately cautious.

It does not claim three newly discovered electrical particles or fields.

115.2 pre-singularity potential member

The first member is associated with the unresolved pre-singularity potential from which *Electro* emerges.

Denote it by

$$\mathcal{E}_0. \tag{712}$$

It is not ordinary electrostatic potential

$$V_{\text{electric}} \tag{713}$$

defined relative to a pre-existing charge distribution.

It is a precursor degree of freedom.

115.3 Propagation member

The second member is the active *Electro* component:

$$\mathcal{E}_1 = \textit{Electro}. \tag{714}$$

Its defining directional history is

$$\mathcal{E}_1 : \quad \rightarrow \quad \leftarrow \quad \rightarrow . \tag{715}$$

115.4 Interaction member

The third member is the ordinary electromagnetic charge-and-current sector that becomes established during the third leg.

Denote it by

$$\mathcal{E}_2. \tag{716}$$

Its low-energy description includes:

$$\{J^\mu, F_{\mu\nu}, q_i, \boldsymbol{E}, \boldsymbol{B}\}. \tag{717}$$

The proposed progression is

$$\boxed{\mathcal{E}_0 \longrightarrow \mathcal{E}_1 \longrightarrow \mathcal{E}_2} \tag{718}$$

from potential, through propagation, to stabilized electromagnetic interaction.

115.5 No standard-theory replacement

The Electricity Triune is not proposed as a replacement for quantum electrodynamics.

A viable completion must recover:

- $U(1)$ gauge invariance;
- charge conservation;
- the Maxwell equations;
- the observed fine-structure constant;
- the electron and positron charge relation;
- Lorentz covariance; and
- quantum electrodynamic scattering results.

Until those requirements are met, the Electricity Triune remains a functional cosmological grammar rather than a complete field theory.

116 The Magnetism Triune

116.1 Magnetism as a distinct organizational domain

The framework treats magnetism as a distinct Triune domain while recognizing that ordinary electric and magnetic fields are unified in the electromagnetic tensor. The existence of a threefold magnetic domain is an architectural proposal; its microscopic decomposition is not fixed in Paper I.

Let

$$\mathfrak{M} = \{\mathcal{M}_a, \mathcal{M}_b, \mathcal{M}_c\} \tag{719}$$

denote three unresolved functional positions within the Magnetism Triune. These symbols are placeholders, not identified fields.

Attraction, repulsion, orientation, persistence, and geometric memory remain candidate magnetic functions, but Paper I does not assign any one of them to a unique member. Structural memory may instead emerge from the combined action of the entire force process.

116.2 Expression across the third leg

The sequence

$$\boxed{\text{provisional magnetic sector} \longrightarrow \text{candidate coupling} \longrightarrow \text{magnetic organization}} \tag{720}$$

describes stages of expression across the third leg. It does not define the three members of the Magnetism Triune.

The effective pre-coupling representation remains

$$\mathcal{B}_{\text{pre}}, \tag{721}$$

whose microscopic identity is unresolved. The candidate coupling is represented by

$$\mathcal{C}_{E\mathcal{B}}, \tag{722}$$

and the later magnetic expression may include currents, vorticity, induction, plasma flow, magnetic tension, field amplification, dissipation, and dynamo-junction behavior.

116.3 No fixed memory member

Paper I does not define structural memory or geometric persistence as one specific member of the Magnetism Triune. Those behaviors may arise from cross-coupling among magnetism, *Electro*, gravity, the inherited scaffold, thermodynamic history, and matter.

116.4 Lorentz-covariance requirement

In standard relativity, electric and magnetic fields transform into each other under changes of inertial frame. Therefore, any separate pre-coupling description must eventually explain how Lorentz covariance is recovered.

A viable completion must produce

$$F_{\mu\nu} \tag{723}$$

as the low-energy covariant object. Without such a derivation, the pre-coupling distinction between *Electro* and the provisional Magnetism Triune sector remains speculative.

117 Relationships Among the Three Triunes

117.1 Three functional domains

The framework distinguishes:

$$\{\mathfrak{G}, \mathfrak{E}, \mathfrak{M}\}, \tag{724}$$

where:

- $\mathfrak{G}$ is the Gravity Triune;
- $\mathfrak{E}$ is the Electricity Triune; and
- $\mathfrak{M}$ is the Magnetism Triune.

These domains are not isolated.

Their interactions shape the three-leg history.

117.2 Cross-Triune coupling network

A schematic coupling network is

$$\mathfrak{G} \longleftrightarrow \mathfrak{E} \longleftrightarrow \mathfrak{M}, \qquad \mathfrak{M} \longleftrightarrow \mathfrak{G}. \tag{725}$$

The principal proposed interactions include:

1. the Gravity Triune shapes the geometry through which *Electro* propagates;
2. *Electro* co-forms the scaffold;
3. the scaffold retains the *Electro* pathway;
4. binding contributes to inward convergence;
5. chasing preserves outward expansion during the inward leg;
6. the provisional Magnetism Triune sector enters candidate coupling with *Electro* during the central transition;
7. electromagnetic fields influence third-leg matter organization; and
8. matter and electromagnetic energy contribute back to gravitational geometry.

117.3 Cross-Triune state vector

A combined state vector may be written as

$$\boldsymbol{\mathcal{T}} = \begin{pmatrix} \boldsymbol{\mathcal{G}} \\ \boldsymbol{\mathcal{E}} \\ \boldsymbol{\mathcal{M}} \end{pmatrix}. \tag{726}$$

Its evolution is schematically

$$\frac{\mathrm{d}}{\mathrm{d}t}\boldsymbol{\mathcal{T}} = \mathsf{A}_{\mathcal{T}}\boldsymbol{\mathcal{T}} + \boldsymbol{\mathcal{J}}_{\mathcal{T}}. \tag{727}$$

The block matrix is

$$\mathsf{A}_{\mathcal{T}} = \begin{pmatrix} \mathsf{A}_{GG} & \mathsf{A}_{GE} & \mathsf{A}_{GM} \\ \mathsf{A}_{EG} & \mathsf{A}_{EE} & \mathsf{A}_{EM} \\ \mathsf{A}_{MG} & \mathsf{A}_{ME} & \mathsf{A}_{MM} \end{pmatrix}. \tag{728}$$

The diagonal blocks govern internal evolution.

The off-diagonal blocks govern cross-Triune coupling.

No numerical form is assigned in Paper I.

117.4 No nine-fold fundamental claim

Three Triunes contain nine functional positions.

The framework does not claim that nature contains exactly nine fundamental substances or nine elementary forces.

The organization is a research grammar, not a completed particle classification.

118 Triune State Transitions Across the Triple Bounce

118.1 Initial differentiation

At the first release, the pre-singularity potential differentiates into effective roles:

$$\mathcal{U}_{\mathrm{pre}} \longrightarrow \{\mathfrak{G}_1, \mathfrak{E}_1, \mathfrak{M}_1\}\,. \tag{729}$$

The Gravity Triune begins scaffolding, binding response, and chasing.

The Electricity Triune enters its active propagation phase.

The Magnetism Triune remains primarily precursor-like.

118.2 Outer-transition reconfiguration

At the outer reversal,

$$\{\mathfrak{G}_1, \mathfrak{E}_1, \mathfrak{M}_1\} \longrightarrow \{\mathfrak{G}_2, \mathfrak{E}_2, \mathfrak{M}_2\}\,. \tag{730}$$

The active *Electro* direction reverses.

The scaffold persists.

The chasing sector continues outward.

The magnetic domain remains unresolved but may participate in energy reprocessing.

118.3 Central-transition reconfiguration

At the central reversal,

$$\{\mathfrak{G}_2, \mathfrak{E}_2, \mathfrak{M}_2\} \longrightarrow \{\mathfrak{G}_3, \mathfrak{E}_3, \mathfrak{M}_3\}\,. \tag{731}$$

The third-leg transition includes:

- renewed outward *Electro* motion;
- ordinary electromagnetic coupling;
- particle and radiation reorganization;
- matter stabilization;
- third-pass occupation of the inherited web; and
- continued operation of the Gravity Triune.

118.4 Transition maps

Define the outer transition map

$$\mathcal{T}_{\mathrm{O}} : \boldsymbol{\mathcal{T}}_1 \longrightarrow \boldsymbol{\mathcal{T}}_2, \tag{732}$$

and the central transition map

$$\mathcal{T}_{\mathrm{C}} : \boldsymbol{\mathcal{T}}_2 \longrightarrow \boldsymbol{\mathcal{T}}_3. \tag{733}$$

The complete three-leg map is

$$\boldsymbol{\mathcal{T}}_3 = \mathcal{T}_{\mathrm{C}} \circ \mathcal{U}_2 \circ \mathcal{T}_{\mathrm{O}} \circ \mathcal{U}_1 \left[\boldsymbol{\mathcal{T}}_0\right], \tag{734}$$

where $\mathcal{U}_1$ and $\mathcal{U}_2$ are the first- and second-leg evolution operators.

The third-leg evolution is then

$$\boldsymbol{\mathcal{T}}(t) = \mathcal{U}_3 \left[\boldsymbol{\mathcal{T}}_3\right]. \tag{735}$$

These operators remain formal placeholders.

119 Triune Coupling and Effective Action

119.1 Schematic action

A field-theoretic completion may begin from an action

$$S_{\text{tot}} = S_{\text{GR}} + S_{\text{DM}} + S_{\text{C}} + S_E + S_M + S_{\text{matter}} + S_{\text{int}}. \tag{736}$$

The gravitational term is

$$S_{\text{GR}} = \frac{c^3}{16\pi G} \int (R - 2\Lambda_{\text{ref}}) \sqrt{-g} \mathrm{d}^4 x. \tag{737}$$

The interaction action may contain

$$S_{\text{int}} = \int \mathcal{L}_{\text{int}} (\Phi_{\text{DM}}, \Phi_{\text{C}}, \Psi_E, \Psi_M, g_{\mu\nu}) \sqrt{-g} \mathrm{d}^4 x, \tag{738}$$

where the fields remain provisional.

119.2 Minimum consistency requirements

A viable effective action must satisfy:

1. general covariance;
2. well-posed equations of motion;
3. absence of ghostlike kinetic terms;
4. acceptable propagation speeds;
5. total stress–energy conservation;
6. stable background solutions;
7. stable perturbations;
8. recovery of general relativity in tested regimes;
9. recovery of standard electromagnetism in tested regimes; and
10. compatibility with observed cosmological evolution.

119.3 Variation and equations of motion

The metric equation follows from

$$\frac{\delta S_{\text{tot}}}{\delta g^{\mu\nu}} = 0. \tag{739}$$

The dark-matter field equation is

$$\frac{\delta S_{\text{tot}}}{\delta \Phi_{\text{DM}}} = 0. \tag{740}$$

The chasing-field equation is

$$\frac{\delta S_{\text{tot}}}{\delta \Phi_{\text{C}}} = 0. \tag{741}$$

The *Electro* equation is

$$\frac{\delta S_{\text{tot}}}{\delta \Psi_E} = 0. \tag{742}$$

The magnetic-precursor equation is

$$\frac{\delta S_{\text{tot}}}{\delta \Psi_M} = 0. \tag{743}$$

Paper I does not specify these fields or their Lagrangians.

119.4 Interaction currents from the action

Once an interaction action is defined, the sector transfer currents must follow from the equations rather than being inserted arbitrarily.

The interaction currents satisfy

$$\sum_i Q_i^\mu = 0. \tag{744}$$

This requirement provides a route from the qualitative Triune grammar to a testable effective theory.

120 Triune Balance Conditions

120.1 Dynamic balance

A Triune does not require static equilibrium.

Its members may remain in dynamic balance while their magnitudes evolve.

Define the effective balance functional

$$\mathcal{F}_{\mathfrak{G}} = w_B \mathcal{B} + w_S \mathcal{S} - w_C \mathcal{C}, \tag{745}$$

where the sign convention treats chasing as outward relative to local binding.

A balanced state may satisfy

$$\mathcal{F}_{\mathfrak{G}} \approx 0. \tag{746}$$

A binding-dominated state satisfies

$$\mathcal{F}_{\mathfrak{G}} > 0, \tag{747}$$

while a chasing-dominated state satisfies

$$\mathcal{F}_{\mathfrak{G}} < 0. \tag{748}$$

The exact sign convention depends on the physical definition adopted.

120.2 First-leg balance

During the first leg, outward release dominates the active *Electro* trajectory.

The Gravity Triune may nevertheless maintain a partial balance among:

- outward chasing;
- emerging scaffold support; and
- binding response.

The approach to the outer reversal may correspond to a change in this balance.

120.3 Second-leg balance

During the second leg,

$$\dot{R}_E < 0, \qquad \dot{R}_{\mathrm{C}} > 0. \tag{749}$$

The system is not directionally balanced in the ordinary sense.

Its stability depends upon the scaffold preserving structure while binding and chasing act in opposite directions.

120.4 Third-leg balance

During the observable third leg, local binding and large-scale chasing coexist.

The transition from matter-dominated deceleration to accelerated expansion reflects a changing cosmic balance.

In a standard effective description,

$$\ddot{a}: \quad \ddot{a} < 0 \longrightarrow \ddot{a} > 0. \tag{750}$$

The Triple Bounce framework interprets this as a change in relative Triune dominance within the third leg.

121 Triune Symmetry and Asymmetry

121.1 No exact three-fold symmetry is assumed

The existence of three members does not imply an exact permutation symmetry among them.

The framework does not assume

$$\mathfrak{G} \sim S_3 \tag{751}$$

or any other specific symmetry group.

Binding, scaffolding, and chasing are physically asymmetric roles.

121.2 Functional complementarity

The three functions are complementary because none alone describes the observed cosmic behavior.

Binding alone would not explain accelerated expansion.

Chasing alone would not explain bound structure.

Scaffolding alone would not explain either metric attraction or late-time acceleration.

The complete functional relation may be written as

$$\mathcal{O}_{\text{cosmos}} = \mathcal{F}\left[\mathcal{B}, \mathcal{S}, \mathcal{C}\right], \tag{752}$$

where $\mathcal{O}_{\text{cosmos}}$ denotes the observable cosmic state.

121.3 Triune imbalance as an evolutionary driver

Transitions may occur when the relative strengths change.

Define normalized fractions

$$f_B = \frac{|\mathcal{B}|}{\Sigma}, \qquad f_S = \frac{|\mathcal{S}|}{\Sigma}, \qquad f_C = \frac{|\mathcal{C}|}{\Sigma}, \tag{753}$$

where

$$\Sigma = |\mathcal{B}| + |\mathcal{S}| + |\mathcal{C}|. \tag{754}$$

Then

$$f_B + f_S + f_C = 1. \tag{755}$$

A change in the dominant fraction may mark a dynamical phase transition.

These fractions are functional measures, not cosmological density parameters.

122 Candidate Observable Consequences of the Triune Framework

122.1 Background expansion

The Gravity Triune must produce an effective Hubble function

$$H_{\mathfrak{G}}(z) \tag{756}$$

consistent with measured third-leg distances and expansion rates.

A distinctive model may predict

$$H_{\mathfrak{G}}(z) = H_{\Lambda\text{CDM}}(z) + \Delta H_{\mathfrak{G}}(z). \tag{757}$$

The deviation must be derived from Triune dynamics rather than added as an arbitrary function.

122.2 Structure growth

The growth rate

$$f(a) = \frac{\mathrm{d}\ln D}{\mathrm{d}\ln a} \tag{758}$$

may differ if scaffolding and chasing interact.

A model-specific growth index may satisfy

$$f(a) \approx \Omega_m(a)^{\gamma}. \tag{759}$$

The Triune framework may predict a modified γ or a scale-dependent growth function.

122.3 Gravitational slip

If the effective sectors generate anisotropic stress, the metric potentials may differ:

$$\Phi - \Psi \neq 0. \tag{760}$$

A slip parameter may be defined as

$$\eta_{\text{slip}} = \frac{\Phi}{\Psi}. \tag{761}$$

A viable model must remain consistent with lensing and structure-growth constraints.

122.4 Dark-sector interaction signatures

An interaction between scaffolding and chasing may alter:

- the background density evolution;
- structure-growth rates;
- the integrated Sachs–Wolfe effect;
- weak lensing;
- cluster abundance;
- the matter power spectrum; and

- the redshift dependence of acceleration.

A specific interaction model might take

$$\mathcal{Q} = \xi H \rho_{\mathrm{C}}, \tag{762}$$

or

$$\mathcal{Q} = \xi H \rho_{\mathrm{DM}}. \tag{763}$$

These forms are examples only. Interacting and dynamical dark-energy models provide the established comparison literature (Copeland et al., 2006; Amendola and Tsujikawa, 2010).

Paper I does not adopt either.

122.5 Cross-Triune electromagnetic signatures

If the central transition connects the Electricity and Magnetism Triunes, possible observable consequences may include:

- primordial magnetic-field correlations;
- large-scale current patterns;
- nonrandom field alignment with the cosmic web;
- multipass-junction magnetic enhancement; and
- distinctive polarization or Faraday-rotation statistics.

These signatures must be separated from ordinary astrophysical magnetic processes.

123 Claim-Specific Test Outcomes for the Triune Interpretation

The Triune interpretation would lose scientific value if it remained only a vocabulary for already known phenomena.

It must eventually satisfy explicit tests.

123.1 No distinct mathematical content

If binding, scaffolding, and chasing cannot be represented by variables, equations, or measurable quantities, then the Triune framework remains descriptive rather than physical.

123.2 No connected dynamics

If the three members evolve independently,

$$A_{ij} = 0 \qquad \text{for all } i \neq j, \tag{764}$$

then the system is not dynamically Triune.

123.3 Complete redundancy

If the Triune model produces no result beyond a relabeling of standard equations, it does not constitute an independent physical framework.

A useful model must produce

$$\mathcal{P}_{\mathfrak{G}} \neq \mathcal{P}_{\text{standard}} \tag{765}$$

for at least one falsifiable prediction $\mathcal{P}$.

123.4 Violation of established local physics

The tested Gravity Triune realization is rejected if it necessarily violates:

- local Lorentz invariance;
- charge conservation;
- tested general relativity;
- standard electromagnetic propagation;
- laboratory particle physics; or
- well-established conservation laws

without strong independent evidence.

123.5 Instability

A completed theory is unacceptable if it contains unavoidable:

- ghost instabilities;
- gradient instabilities;
- runaway energy transfer;
- negative physical energy densities without consistent interpretation;
- singular transition behavior; or
- ill-posed evolution equations.

123.6 Uncontrolled parameter freedom

If every observation requires a separately adjusted Triune parameter, the framework loses predictive power.

A viable model must use a constrained parameter set across multiple datasets.

124 Formal Limits of the Triune Interpretation

The Triune framework is intentionally limited.

It does not presently establish:

1. a fundamental three-fold symmetry of nature;
2. three equal energy-density fractions;
3. three new elementary particles;
4. a completed quantum theory of gravity;
5. a microscopic dark-matter model;
6. a microscopic dark-energy model;
7. a Lorentz-covariant precursor theory of electricity and magnetism;
8. a complete interaction Lagrangian;
9. a proven mechanism for either *Electro* reversal;

10. a derivation of the cosmological constant;
11. a derivation of matter–antimatter asymmetry;
12. an explanation of all galactic dark-matter phenomena;
13. an exact magnetic-field prediction; or
14. a final unified theory of all forces.

The Triune grammar serves three narrower purposes:

I. to distinguish physically nonidentical cosmological functions;
II. to organize the Triple Bounce sequence consistently across all three legs; and
III. to define the variables and couplings required for later mathematical testing.

Limitation 7. The Triune framework remains an effective organizational architecture until its members and couplings are derived from a mathematically consistent action or equivalent dynamical theory.

125 Formal Summary of the Triune Dynamical Grammar

The Gravity Triune is

$$\boxed{\mathfrak{G} = \{\text{binding}, \text{scaffolding}, \text{chasing}\}}. \tag{766}$$

Its principal physical associations are

$$\boxed{\begin{aligned} \text{classical gravity} &\longrightarrow \text{binding}, \\ \text{dark matter} &\longrightarrow \text{scaffolding}, \\ \text{dark energy} &\longrightarrow \text{chasing}. \end{aligned}} \tag{767}$$

The three members remain distinct:

$$\mathcal{B} \neq \mathcal{S} \neq \mathcal{C}, \tag{768}$$

but connected:

$$A_{ij} \neq 0 \tag{769}$$

for at least some cross-couplings.

Their roles across the legs are

$$\begin{array}{|c|c|c|c|}
\text{Leg} & \text{Binding} & \text{Scaffolding} & \text{Chasing} \\
\hline
1 & \text{geometric response} & \text{web formation} & \text{outward drive} \\
2 & \text{convergence} & \text{memory retention} & \text{continued expansion} \\
3 & \text{structure binding} & \text{matter organization} & \text{late acceleration}
\end{array} \tag{770}$$

The provisional Electricity Triune is

$$\boxed{\text{potential} \longrightarrow \textit{Electro}\text{ propagation} \longrightarrow \text{electromagnetic interaction}}. \tag{771}$$

The provisional Magnetism Triune has unresolved internal members. Its third-leg expression is summarized as

$$\boxed{\text{provisional magnetic sector} \longrightarrow \text{candidate coupling} \longrightarrow \text{magnetic organization}}. \tag{772}$$

This sequence describes stages of expression rather than the three members themselves.

The combined architecture is

$$\boxed{\mathfrak{G} \longleftrightarrow \mathfrak{E} \longleftrightarrow \mathfrak{M}} \tag{773}$$

inside the complete Triple Bounce history.

The scientific burden is to convert this grammar into:

- defined fields;
- conserved currents;
- stable equations;
- transition maps;
- background solutions;
- perturbation predictions; and
- observable differences from standard cosmology.

126 Predictions, Reciprocal Tests, and Claim-Specific Rejection

The Triple Bounce framework becomes a scientific cosmology only when its qualitative architecture is converted into quantitative predictions.

A narrative involving three directional legs, an inherited scaffold, and distinct Triune functions is not sufficient by itself.

The framework must demonstrate that it can:

1. produce a self-consistent background expansion history;
2. reproduce established third-leg observations;
3. remain dynamically stable across both reversals;
4. preserve conservation laws;
5. generate acceptable primordial perturbations;
6. explain the observed large-scale geometry;
7. account for the cosmic microwave background temperature and polarization spectra;
8. produce acceptable matter and structure-growth histories;
9. derive at least one observable consequence not freely inserted as an initial condition; and
10. identify clear conditions under which the model fails.

The scientific standard is not whether the Triple Bounce interpretation can be made compatible with observations after unrestricted adjustment.

The standard is whether one constrained dynamical system can explain several independent observations simultaneously.

Hypothesis 17 (Predictive burden)**.** *The Triple Bounce framework is viable only if its hidden first and second legs lead to calculable third-leg consequences that survive comparison with standard cosmology under matched observational and statistical standards.*

127 Hierarchy of Predictions

The framework distinguishes four levels of predictive development.

127.1 Level I: consistency predictions

Consistency predictions determine whether the mathematical structure is internally possible.

They include:

- existence of a globally expanding solution with an inward *Electro* trajectory;
- regular outer and central transitions;
- finite stress–energy and curvature quantities;
- total covariant conservation;
- stable perturbation evolution;
- causal propagation; and
- recovery of standard third-leg electromagnetism.

A Level I failure rejects the tested realization before observational fitting begins. It reaches the core architecture only when the conflict is shown to follow from the defining postulates across every admissible realization.

127.2 Level II: recovery predictions

Recovery predictions determine whether the framework reproduces well-established results.

These include:

- the measured third-leg distance–redshift relation;
- the conventional hot-plasma thermal sequence;
- light-element abundances;
- recombination;
- the cosmic microwave background acoustic structure;
- matter clustering;
- gravitational lensing; and

- late-time accelerated expansion.

A hidden prehistory does not excuse failure to recover these results.

127.3 Level III: reinterpretive predictions

Reinterpretive predictions show how observations ordinarily assigned to one-leg cosmology arise from a longer three-leg history.

These include:

- a larger full conformal-time interval;
- near-flatness inherited from balanced pre-singularity ordering;
- third-leg initial conditions generated by the prior two legs;
- an inherited structural source for the cosmic web; and
- a third-leg growth-factor correspondence built from empirical anchors.

127.4 Level IV: distinctive predictions

Distinctive predictions separate the Triple Bounce model from a well-fitted inflationary ΛCDM model.

Possible classes include:

- specific large-scale phase correlations;
- a characteristic scale dependence in inherited-web retention;
- nonstandard but controlled curvature evolution;
- a calculable departure in $H(z)$;
- multipass junction statistics;
- primordial magnetic alignment with the large-scale web;
- specific non-Gaussian signatures;
- cross-correlations among matter, magnetic structure, and the cosmic microwave background; and
- a constrained packet-scale modulation in third-leg expansion.

The framework achieves scientific distinctiveness only at Level IV.

128 Background Expansion Requirements and Candidate Branches

The equations in this section are compatibility requirements, not a replacement retelling of standard downstream chronology. Their purpose is to identify what a quantitative Triple Bounce realization must reproduce before the proposed hidden history can be evaluated against observations.

128.1 Piecewise three-leg background

The full history may be represented by a piecewise background solution,

$$a(t) = \begin{cases} a_1(t), & t_0 \le t < t_{\mathrm{O}}, \\ a_{\mathrm{O}}(t), & t_{\mathrm{O}} - \Delta t_{\mathrm{O}}/2 \le t \le t_{\mathrm{O}} + \Delta t_{\mathrm{O}}/2, \\ a_2(t), & t_{\mathrm{O}} < t < t_{\mathrm{C}}, \\ a_{\mathrm{C}}(t), & t_{\mathrm{C}} - \Delta t_{\mathrm{C}}/2 \le t \le t_{\mathrm{C}} + \Delta t_{\mathrm{C}}/2, \\ a_3(t), & t > t_{\mathrm{C}}. \end{cases} \tag{774}$$

The framework permits

$$H_j(t) = \frac{\dot{a}_j}{a_j} > 0 \tag{775}$$

throughout all three legs.

This globally expanding branch is permitted by the architecture but is not derived in Paper I. Companion Papers III and IV must determine whether a physically acceptable realization exists.

The *Electro* trajectory is independently piecewise:

$$R_E(t) = \begin{cases} R_E^{(1)}(t), & \dot{R}_E^{(1)} > 0, \\ R_E^{(\mathrm{O})}(t), & \dot{R}_E : + \to -, \\ R_E^{(2)}(t), & \dot{R}_E^{(2)} < 0, \\ R_E^{(\mathrm{C})}(t), & \dot{R}_E : - \to +, \\ R_E^{(3)}(t), & \dot{R}_E^{(3)} > 0. \end{cases} \tag{776}$$

128.2 Background matching

At each transition, the metric should be continuous:

$$[g_{\mu\nu}]_{t_j^-}^{t_j^+} = 0, \tag{777}$$

unless the model explicitly includes a singular surface layer.

A smooth background also requires

$$a(t_j^-) = a(t_j^+), \tag{778}$$

and preferably

$$H(t_j^-) = H(t_j^+). \tag{779}$$

If H is discontinuous, the associated stress–energy distribution must be specified.

128.3 Third-leg Hubble function

The observable third leg must produce

$$H_3^2(z) = H_0^2 \left[\Omega_r(1+z)^4 + \Omega_m(1+z)^3 + \Omega_k(1+z)^2 + \Omega_{\mathrm{C}} F_{\mathrm{C}}(z) + \Omega_E F_E(z)\right], \tag{780}$$

where

$$F_{\mathrm{C}}(z) = \exp\left[3\int_0^z \frac{1+w_{\mathrm{C}}(z')}{1+z'}\mathrm{d}z'\right]. \tag{781}$$

The function $F_E(z)$ represents any surviving third-leg *Electro* contribution.

A minimal late-time model may require

$$\Omega_E F_E(z) \ll 1 \tag{782}$$

over the well-measured low-redshift interval.

The exact result must be obtained from the third-leg dynamical equations.

129 Distance–Redshift Tests

129.1 Comoving distance

For the observable third leg, the line-of-sight comoving distance is

$$D_C(z) = c \int_0^z \frac{\mathrm{d}z'}{H_3(z')}. \tag{783}$$

The transverse comoving distance is

$$D_M(z) = \begin{cases} \frac{c}{H_0\sqrt{\Omega_k}} \sinh\left[\sqrt{\Omega_k}\frac{H_0 D_C}{c}\right], & \Omega_k > 0, \\ D_C, & \Omega_k = 0, \\ \frac{c}{H_0\sqrt{|\Omega_k|}} \sin\left[\sqrt{|\Omega_k|}\frac{H_0 D_C}{c}\right], & \Omega_k < 0. \end{cases} \tag{784}$$

The luminosity distance is

$$d_L(z) = (1+z)D_M(z). \tag{785}$$

The angular-diameter distance is

$$d_A(z) = \frac{D_M(z)}{1+z}. \tag{786}$$

129.2 Supernova requirement

The predicted distance modulus is

$$\mu(z) = 5\log_{10}\left[\frac{d_L(z)}{10\ \mathrm{pc}}\right]. \tag{787}$$

The model must fit Type Ia supernova data without introducing an independent correction at every redshift (Riess et al., 1998; Perlmutter et al., 1999).

A residual relative to standard cosmology may be defined as

$$\Delta\mu(z) = \mu_{\mathrm{TB}}(z) - \mu_{\Lambda\mathrm{CDM}}(z). \tag{788}$$

A distinctive prediction requires a derived shape for $\Delta\mu(z)$.

129.3 Baryon acoustic oscillation requirement

The model must reproduce baryon acoustic oscillation distance measures, including the observed acoustic feature and modern survey constraints (Eisenstein et al., 2005; Alam et al., 2021), and combinations such as

$$D_V(z) = \left[(1+z)^2 d_A^2(z) \frac{cz}{H(z)}\right]^{1/3}. \tag{789}$$

It must also reproduce the appropriate sound-horizon calibration.

A modified early third-leg history changes both the ruler and the distance measurement.

The two effects must be treated consistently.

129.4 No direct distance–time identification

The approximately 46.08-billion-light-year model distance and the approximately 13.824-billion-year third-leg time are not directly interchangeable.

The relationship between them follows from integration of the expansion history.

The paper therefore preserves

$$46.08 \text{ Gly} \neq 46.08 \text{ Gyr} \tag{790}$$

as physical quantities, even when numerical ratios are studied.

130 Cosmic Age and Full-History Duration

130.1 Third-leg age

The third-leg age inferred from the observable expansion is

$$T_3 = \int_0^\infty \frac{\mathrm{d}z}{(1+z)H_3(z)}. \tag{791}$$

Paper IV adopts the working empirical anchor

$$T_3 \approx 13.824 \text{ Gyr}. \tag{792}$$

This value is not automatically the full age of the complete three-leg history.

130.2 Full elapsed time

The total elapsed effective duration is

$$T_{\mathrm{full}} = T_1 + \Delta T_{\mathrm{O}} + T_2 + \Delta T_{\mathrm{C}} + T_3. \tag{793}$$

The framework does not yet fix

$$T_{\mathrm{full}}. \tag{794}$$

It also does not require

$$T_1 = T_2 = T_3. \tag{795}$$

Approximate equality may be explored later, but it is not imposed as a foundational result.

130.3 Model calculability

Once the trajectories and transition intervals are specified, the full elapsed duration becomes calculable.

Thus,

$$T_{\mathrm{full}} = \mathcal{T}\left[a_j(t), R_E^{(j)}(t), \tau_{\mathrm{O}}, \tau_{\mathrm{C}}\right]. \tag{796}$$

Until those functions are defined, any total age remains provisional.

131 Horizon and Causal-History Candidate-Resolution Tests

131.1 Standard third-leg horizon

The third-leg comoving particle horizon is

$$\chi_{\mathrm{hor}}^{(3)}(t) = \int_{t_{\mathrm{C}}}^{t} \frac{c\,\mathrm{d}t'}{a_3(t')}. \tag{797}$$

If only the third leg is included, regions separated by more than this distance may appear causally disconnected.

131.2 Full-history conformal interval

The Triple Bounce model proposes that the relevant causal interval may include all three legs:

$$\Delta\eta_{\text{full}} = \int_{t_0}^{t_{\text{O}}} \frac{c\,\mathrm{d}t}{a_1(t)} + \int_{\text{O}} \frac{c\,\mathrm{d}t}{a_{\text{O}}(t)} + \int_{t_{\text{O}}}^{t_{\text{C}}} \frac{c\,\mathrm{d}t}{a_2(t)} + \int_{\text{C}} \frac{c\,\mathrm{d}t}{a_{\text{C}}(t)} + \int_{t_{\text{C}}}^{t} \frac{c\,\mathrm{d}t}{a_3(t)}. \tag{798}$$

The transition integrals are included only when their durations are finite.

131.3 Horizon viability criterion

For the Triple Bounce candidate horizon resolution to remain viable, it must satisfy

$$\Delta\eta_{\text{full}} \geq \Delta\eta_{\text{required}}, \tag{799}$$

where $\Delta\eta_{\text{required}}$ is the conformal separation needed to establish the observed large-scale correlation.

A shared topological origin is not sufficient by itself.

The integral must be large enough.

131.4 Causal inheritance versus signal transport

The framework examines two related candidate mechanisms:

1. direct causal contact through the longer conformal history; and
2. structural inheritance from a common earlier state.

These mechanisms must be separated mathematically.

A structural pattern inherited from the first leg may correlate regions without requiring new third-leg signal exchange.

However, the generation of that common pattern must still satisfy the causal rules of the earlier theory.

131.5 Failure condition

If the full conformal interval remains too small and no causal pre-singularity mechanism is defined, the Triple Bounce horizon candidate resolution fails.

Paper II performs the dedicated horizon analysis.

132 Curvature and Flatness Candidate-Resolution Tests

132.1 Curvature parameter

The standard curvature density parameter is

$$\Omega_k(t) = -\frac{kc^2}{a^2H^2}. \tag{800}$$

Near-flatness requires

$$|\Omega_k| \ll 1. \tag{801}$$

The Triple Bounce framework asks whether the balanced pre-singularity mode and prior-leg evolution could contribute to producing or preserving low observable curvature. The horizontal oscillation is not itself a flatness derivation.

132.2 Curvature propagation

A complete model must propagate curvature from the pre-singularity boundary through both reversals.

Schematically,

$$\Omega_{k,\mathrm{pre}} \xrightarrow{\mathcal{T}_0} \Omega_k^{(1)} \xrightarrow{\mathcal{T}_\mathrm{O}} \Omega_k^{(2)} \xrightarrow{\mathcal{T}_\mathrm{C}} \Omega_k^{(3)}. \tag{802}$$

The framework cannot merely set

$$\Omega_k^{(3)} = 0 \tag{803}$$

as an unexplained initial condition.

It must derive conditions under which the third-leg value remains small.

132.3 Balanced-state interpretation

The initial asymmetry parameter introduced earlier,

$$\epsilon_\mathrm{asym} = \frac{\|\delta\Psi\|}{\|A\Phi_0\|}, \tag{804}$$

may source residual curvature.

A schematic relation is

$$\Omega_k^{(3)} = \mathcal{K}\left[\epsilon_{\text{asym}}, a_1, a_2, a_3, \mathcal{T}_{\text{O}}, \mathcal{T}_{\text{C}}\right]. \tag{805}$$

Near-flatness requires the function $\mathcal{K}$ to remain small without extreme fine tuning.

132.4 Curvature-mechanism rejection condition

If the declared boundary and transfer mechanism generically amplifies curvature or anisotropy throughout its frozen admissible domain, that near-flatness mechanism is rejected. This does not automatically reject the triple directional history.

A viable model requires a stable basin of initial states satisfying

$$\left|\Omega_k^{(3)}\right| < \Omega_{k,\max} \tag{806}$$

over a non-negligible region of parameter space.

Paper II develops this test.

133 Cosmic Microwave Background Tests

133.1 Angular spectra

The cosmic microwave background temperature and polarization fields are expanded as

$$X(\hat{\boldsymbol{n}}) = \sum_{\ell m} a_{\ell m}^X Y_{\ell m}(\hat{\boldsymbol{n}}), \tag{807}$$

where

$$X \in \{T, E, B\}. \tag{808}$$

The angular power spectra are

$$C_\ell^{XY} = \frac{1}{2\ell+1} \sum_m \left\langle a_{\ell m}^X a_{\ell m}^{Y*} \right\rangle. \tag{809}$$

The Triple Bounce model must reproduce the measured spectra to acceptable accuracy (Planck Collaboration et al., 2020).

133.2 Acoustic scale

The angular acoustic scale is approximately

$$\theta_* = \frac{r_s(z_*)}{D_M(z_*)}, \tag{810}$$

where $r_s(z_*)$ is the comoving sound horizon at last scattering and $D_M(z_*)$ is the transverse comoving distance.

A modified third-leg expansion changes both quantities.

The model cannot alter one without recalculating the other.

133.3 Inherited primordial spectrum

The curvature spectrum may be decomposed as

$$\mathcal{P}_\mathcal{R}(k) = A_s \left(\frac{k}{k_*}\right)^{n_s-1} \left[1 + \mathcal{F}_{\text{inherit}}(k)\right]. \tag{811}$$

The inherited function $\mathcal{F}_{\text{inherit}}(k)$ must be derived from the prior-leg dynamics.

It cannot be chosen separately for each observed anomaly.

133.4 Transfer to the CMB

The angular spectra are determined schematically by

$$C_\ell^{XY} = 4\pi \int \frac{\mathrm{d}k}{k} \mathcal{P}_\mathcal{R}(k) \Delta_\ell^X(k) \Delta_\ell^Y(k), \tag{812}$$

where $\Delta_\ell^X(k)$ are radiation-transfer functions.

The inherited perturbation spectrum must therefore pass through standard third-leg plasma physics.

133.5 Required CMB successes

A viable model must reproduce:

- the acoustic peak positions;
- relative peak heights;
- the damping tail;
- temperature–polarization cross-correlations;

- large-angle temperature power;
- lensing smoothing;
- reionization signatures; and
- acceptable limits on tensor modes and non-Gaussianity.

133.6 CMB-recovery rejection condition

The tested inherited-initial-condition and third-leg transfer realization is rejected if every admissible frozen implementation inevitably destroys the observed acoustic structure. This is a CMB-recovery verdict, not an automatic rejection of the triple directional history, the pre-singularity oscillation, or the independent horizon and flatness claims.

134 Primordial Perturbation Tests

134.1 Scalar perturbations

The third-leg scalar perturbations must begin from a central-transition mapping:

$$\left\{\mathcal{W}_{12}, \mathcal{M}_{ij}^{(12)}, \delta f_i, g_{\mu\nu}^{(2)}\right\} \xrightarrow{\mathcal{T}_{\mathrm{C}}} \{\mathcal{R}, \delta_i, \theta_i, \Phi, \Psi\}_{t_{\mathrm{C}}^{+}} . \tag{813}$$

The model must determine:

- the amplitude A_s;
- the spectral index n_s;
- possible running;
- isocurvature content;
- phase coherence;
- non-Gaussianity; and
- statistical anisotropy.

134.2 Tensor perturbations

Tensor modes satisfy an equation of the schematic form

$$h_k'' + 2\mathcal{H}h_k' + c_T^2 k^2 h_k = \Pi_k^{\mathrm{TT}}, \tag{814}$$

where:

- primes denote derivatives with respect to conformal time;
- $\mathcal{H} = a'/a$;
- c_T is the tensor propagation speed; and
- Π_k^{TT} is the transverse–traceless source.

A viable low-energy theory must recover acceptable gravitational-wave propagation.

The Triple Bounce transitions may generate tensor modes.

Their amplitude cannot exceed observational bounds.

134.3 Isocurvature modes

Multiple effective sectors may generate relative-entropy perturbations.

For sectors i and j, an isocurvature mode may be written as

$$S_{ij} = 3\left(\zeta_i - \zeta_j\right), \tag{815}$$

where ζ_i is the curvature perturbation on uniform-density hypersurfaces for sector i.

The model must either suppress such modes or show that they remain within observational limits.

134.4 Perturbation stability

A generic scalar perturbation with kinetic coefficient K and sound speed squared c_s^2 is stable only if

$$K > 0, \tag{816}$$

and

$$c_s^2 \geq 0. \tag{817}$$

If either reversal produces extended regions with

$$K < 0 \quad \text{or} \quad c_s^2 < 0, \tag{818}$$

the resulting instability may invalidate the model.

135 Large-Scale Structure and Growth Tests

135.1 Linear growth

The matter density contrast is

$$\delta_m = \frac{\rho_m - \bar{\rho}_m}{\bar{\rho}_m}. \tag{819}$$

A standard linear growth equation, obtained within linear cosmological perturbation theory (Ma and Bertschinger, 1995; Dodelson, 2003), is

$$\ddot{\delta}_m + 2H\dot{\delta}_m - 4\pi G_{\text{eff}}\rho_m\delta_m = S_{\text{inherit}}. \tag{820}$$

The Triple Bounce framework must derive:

- $G_{\text{eff}}(k,t)$;
- the inherited source S_{inherit};
- the initial amplitude;
- the scale dependence; and
- the late-time growth rate.

135.2 Growth factor

Define the linear growth factor $D(a)$ by

$$\delta_m(a, \boldsymbol{k}) = D(a, \boldsymbol{k})\delta_m(a_{\text{init}}, \boldsymbol{k}). \tag{821}$$

The logarithmic growth rate is

$$f(a,k) = \frac{\partial \ln D(a,k)}{\partial \ln a}. \tag{822}$$

This structure-growth factor must not be confused with the packet growth factor introduced in Paper IV.

The two quantities represent different concepts.

135.3 Matter power spectrum

The matter power spectrum is defined through

$$\langle \delta_m(\boldsymbol{k})\delta_m^*(\boldsymbol{k}')\rangle = (2\pi)^3\delta_D(\boldsymbol{k}-\boldsymbol{k}')P_m(k). \tag{823}$$

The Triple Bounce prediction may be written as

$$P_m^{\mathrm{TB}}(k,z) = P_m^{\mathrm{base}}(k,z)\left[1+\Delta_{\mathrm{inherit}}(k,z)\right]. \tag{824}$$

The function $\Delta_{\mathrm{inherit}}$ must be derived from the earlier-leg dynamics.

135.4 Weak lensing and clustering

The model must simultaneously reproduce:

- galaxy clustering;
- redshift-space distortions;
- weak gravitational lensing;
- cluster abundance;
- void statistics;
- filament statistics; and
- cross-correlations among tracers.

An inherited-web correction that improves one observable while unavoidably damaging the others is unacceptable.

136 Inherited-Web Tests

136.1 Primary structural prediction

The central structural prediction is

$$r_{13}(k) \to 1 \tag{825}$$

on sufficiently large scales, where $r_{13}(k)$ measures correlation between first-leg structure and third-leg structure.

Because first-leg structure is not directly observed, the practical test requires a proxy derived from the model.

The model must reconstruct an expected third-leg statistic that retains the prior-leg memory.

136.2 Potential observable proxies

Candidate proxies include:

- excess long-range filament alignment;
- specific junction-degree distributions;
- nonrandom void adjacency;
- scale-dependent phase correlations;
- matter–magnetic-field alignment;
- multipass vorticity statistics; and
- cross-correlations with primordial perturbation features.

136.3 Null hypothesis

The null hypothesis is that all observed structure is adequately generated from standard third-leg initial conditions and gravitational evolution.

Symbolically,

$$H_0 : \quad S_{\text{inherit}} = 0. \tag{826}$$

The Triple Bounce alternative is

$$H_1: \quad S_{\text{inherit}} \neq 0 \tag{827}$$

or an equivalent inherited modification of the initial conditions.

136.4 Degeneracy control

A valid test must compare the inherited model with flexible standard initial-condition models.

The framework cannot claim evidence merely because a standard scale-free spectrum fits imperfectly.

The alternative model must outperform appropriately extended one-leg models without excessive additional freedom.

137 Magnetic and Dynamo-Junction Tests

137.1 Primordial magnetic correlations

If *Electro*–magnetic coupling occurs at the central transition, the third leg may contain primordial magnetic structure.

A magnetic power spectrum may be defined by

$$\left\langle B_i(\boldsymbol{k}) B_j^*(\boldsymbol{k}') \right\rangle = (2\pi)^3 \delta_D(\boldsymbol{k} - \boldsymbol{k}') P_{ij}^B(k). \tag{828}$$

For an isotropic divergence-free field,

$$P_{ij}^B(k) = \left(\delta_{ij} - \hat{k}_i \hat{k}_j\right) P_B(k) + i\epsilon_{ijl} \hat{k}_l P_H(k), \tag{829}$$

where $P_H(k)$ represents a possible helical component.

The Triple Bounce model must derive the amplitude and shape of these spectra.

137.2 Web alignment

The alignment statistic is

$$\mathcal{A}_{B\mathcal{W}}(L) = \left\langle \left| \hat{\boldsymbol{B}} \cdot \hat{\boldsymbol{n}}_{\mathcal{W}} \right| \right\rangle_L . \tag{830}$$

A three-pass inheritance model may predict scale-dependent alignment.

The sign and magnitude must be specified before comparison with data.

137.3 Dynamo-junction hierarchy

The framework predicts that junctions with stronger inherited ancestry may have different magnetic and rotational properties.

A test statistic may be

$$P\left(B, \omega, J \mid N_{\mathcal{J}}, S_{\mathcal{J}}, \mathcal{A}_{\mathcal{J}}\right). \tag{831}$$

The model should predict how this distribution changes with junction ancestry.

137.4 Astrophysical contamination

Ordinary astrophysical processes can generate magnetic fields and vorticity.

A valid primordial-junction test must account for:

- stellar feedback;
- active galactic nuclei;
- mergers;
- accretion shocks;
- plasma turbulence;
- ordinary dynamos; and
- observational selection.

A magnetic alignment alone would not prove the Triple Bounce model.

138 Reversal and Transition Tests

138.1 Existence of two regular reversals

The model must produce two physically distinct sign changes:

$$\dot{R}_E: \quad + \to - \quad \text{and} \quad - \to +. \tag{832}$$

The outer reversal must occur while

$$H(t_{\mathrm{O}}) > 0, \tag{833}$$

and the central reversal must occur while

$$H(t_{\mathrm{C}}) > 0. \tag{834}$$

138.2 Finite stress–energy

The transitions must avoid divergent density, pressure, or interaction currents:

$$|\rho_i|\,, \qquad |p_i|\,, \qquad |Q_i^{\mu}| < \infty. \tag{835}$$

138.3 Transition stability

Small perturbations of the reversal solution should remain controlled.

Let

$$R_E(t) = \bar{R}_E(t) + \delta R_E(t). \tag{836}$$

A stable transition requires

$$|\delta R_E(t)| < \infty \tag{837}$$

and preferably decay or bounded oscillation away from the transition.

138.4 No arbitrary sign switching

The sign change cannot be inserted by hand without a dynamical cause.

A valid model must derive the standardized transition profile from:

- an effective potential;
- an interaction law;
- a phase transition;
- a conservation-constrained momentum transfer; or
- another defined physical mechanism.

If the reversal equation remains purely prescribed, the model is kinematic rather than fully dynamical.

139 Packet Correspondence Across Papers I–IV

139.1 Paper I status

The packet construction in Paper I is intentionally brief. It presents only the anchored 10/3 radius-scale relation, the nominal 320-million-year packet count, and the resulting positive dimensionless factor

$$g_{\text{packet}} = \exp\left[\frac{\ln(10/3)}{43.2}\right] \approx 1.0283. \tag{838}$$

The result is a provisional quantitative correspondence. It is not a completed expansion law, independent prediction, measurement, or validation of the Triple Bounce architecture.

139.2 Paper II buildup

Paper II must formalize the packet variables, units, assumptions, and continuous-growth representation while keeping the packet construction separate from inflationary e-fold accounting. In particular, analytical packet samples must not be mistaken for physically discontinuous jumps in expansion.

139.3 Paper III buildup

Paper III must test whether the Gravity Triune dynamics—especially the continued outward chasing function—can supply a physical interpretation for the positive growth factor and any relationship to negative-pressure dark-energy behavior. A numerical resemblance alone cannot determine the sign convention, equation of state, or interaction law.

139.4 Paper IV reconstruction

Paper IV carries the strongest packet analysis. It reconstructs the exact inputs and arithmetic, preserves dimensional distinctions, audits the proposed 2.304-billion-year candidate for independent derivation, performs sensitivity and robustness tests, and compares the declared third-leg endpoint structure with relevant cosmological benchmarks. Its final provenance audit excludes the 2.304-billion-year candidate from the active hierarchy.

The reconstruction must state clearly whether the factor remains a heuristic correspondence, becomes a derived consequence of a dynamical model, or fails under more precise inputs.

139.5 No proof by proximity

Numerical proximity alone does not establish physical identity. The packet factor gains scientific value only if the companion papers derive why the packet hierarchy should participate in third-leg expansion and produce a falsifiable consequence.

140 Parameter Discipline

140.1 Parameter categories

Every parameter must be placed in one of four categories.

I. **Observed or reconstructed anchors**

$$\boldsymbol{\theta}_{\text{anchor}} = \{T_3, D_{\text{model}}, H_0, \Omega_i, \ldots\}. \tag{839}$$

II. **Defined model parameters**

$$\boldsymbol{\theta}_{\text{def}} = \{\tau_{\text{O}}, \tau_{\text{C}}, \alpha_3, \lambda_2, \tau_{\mathcal{W}}, \ldots\}. \tag{840}$$

III. **Derived quantities**

$$\boldsymbol{\theta}_{\text{derived}} = \{H(z), C_\ell, P_m(k), g_{\text{packet}}, \ldots\}. \tag{841}$$

IV. **Predicted observables**

$$\boldsymbol{\mathcal{O}}_{\text{pred}} = \{\Delta\mu(z), \mathcal{A}_{B\mathcal{W}}, B_{\text{inherit}}, P(N_{\mathcal{J}}), \ldots\}. \tag{842}$$

A quantity cannot be used both as an input and as an independent prediction in the same analysis.

140.2 Free-parameter count

The effective number of free parameters is

$$N_{\text{free}} = \dim(\boldsymbol{\theta}_{\text{def}}) - N_{\text{constraints}}. \tag{843}$$

A model with excessive freedom may fit many observations without providing explanatory value.

140.3 Shared parameters across datasets

The same parameter values must be used across:

- background expansion;
- the cosmic microwave background;
- structure growth;
- lensing;
- magnetic observables;
- junction statistics; and
- packet-scale tests.

Dataset-specific parameters should be limited to established nuisance quantities.

140.4 Blind prediction

Where possible, parameters should be calibrated on one subset of data and tested on another.

Let

$$\mathcal{D} = \mathcal{D}_{\rm cal} \cup \mathcal{D}_{\rm val}, \tag{844}$$

with

$$\mathcal{D}_{\rm cal} \cap \mathcal{D}_{\rm val} = \varnothing. \tag{845}$$

The model is calibrated on $\mathcal{D}_{\rm cal}$ and judged on $\mathcal{D}_{\rm val}$.

141 Statistical Model Comparison

141.1 Likelihood

For data vector $\boldsymbol{d}$, model prediction $\boldsymbol{m}(\boldsymbol{\theta})$, and covariance matrix C,

$$\chi^2(\boldsymbol{\theta}) = [\boldsymbol{d} - \boldsymbol{m}(\boldsymbol{\theta})]^{\mathsf{T}} \, \mathsf{C}^{-1} \, [\boldsymbol{d} - \boldsymbol{m}(\boldsymbol{\theta})] \,. \tag{846}$$

For a Gaussian likelihood,

$$-2 \ln \mathcal{L} = \chi^2 + \text{constant}. \tag{847}$$

The Triple Bounce model must be evaluated using the same data treatment as its comparison model.

141.2 Information criteria

Akaike and Bayesian information criteria may be written as (Akaike, 1974; Schwarz, 1978)

$$\mathrm{AIC} = 2k - 2 \ln \mathcal{L}_{\max}, \tag{848}$$

and

$$\mathrm{BIC} = k \ln N - 2 \ln \mathcal{L}_{\max}, \tag{849}$$

where k is the number of fitted parameters and N is the number of data points.

These criteria penalize additional freedom.

141.3 Bayesian evidence

The Bayesian evidence and its use in cosmological model selection are reviewed by Trotta (2008); the evidence is

$$Z = \int \mathcal{L}\left(\mathcal{D} \mid \boldsymbol{\theta}\right) \pi(\boldsymbol{\theta}) \mathrm{d}\boldsymbol{\theta}, \tag{850}$$

where $\pi(\boldsymbol{\theta})$ is the prior distribution.

The evidence ratio, or Bayes factor (Kass and Raftery, 1995), is

$$K = \frac{Z_{\mathrm{TB}}}{Z_{\Lambda\mathrm{CDM}}}. \tag{851}$$

A better maximum fit is not sufficient if it requires a large, fine-tuned parameter volume.

141.4 Posterior predictive checking

The posterior predictive distribution is

$$P\left(\widetilde{\mathcal{D}} \mid \mathcal{D}\right) = \int P\left(\widetilde{\mathcal{D}} \mid \boldsymbol{\theta}\right) P\left(\boldsymbol{\theta} \mid \mathcal{D}\right) \mathrm{d}\boldsymbol{\theta}. \tag{852}$$

The model should generate simulated datasets resembling the observed data across multiple summary statistics.

142 Primary Claim-Specific Rejection Conditions

The following conditions are deliberately compartmentalized. Each verdict applies to the named claim family and to the demonstrated level within that family. The entire Triple Bounce architecture is rejected only if a conflict follows from its defining postulates across every admissible realization, not merely from one mechanism, transfer law, or observable role.

142.1 No self-consistent inward Electro solution

If no solution exists satisfying

$$\dot{a} > 0, \qquad \dot{R}_E < 0 \tag{853}$$

during the second leg under physically acceptable stress–energy, the tested triple-directional realization is rejected.

142.2 No physical reversal mechanism

If the two sign changes can be produced only by arbitrary manual switching, the model remains incomplete and nonpredictive.

142.3 Conservation failure

If

$$\nabla_\mu T^{\mu\nu}_{\text{tot}} \neq 0 \tag{854}$$

without a consistent extension of the theory, the tested realization is theoretically inadmissible.

142.4 Unstable transitions

Unavoidable ghosts, gradient instabilities, divergent perturbations, or singular stress–energy reject the tested transition realization. They reject the core directional architecture only if the pathology follows from every admissible realization of the two transitions.

142.5 Insufficient causal history

If

$$\Delta\eta_{\text{full}} < \Delta\eta_{\text{required}}, \tag{855}$$

and no alternative causal mechanism exists, the proposed horizon reinterpretation fails.

142.6 Curvature amplification

If the hidden legs generically produce

$$\left|\Omega_k^{(3)}\right| \gg \Omega_{k,\text{obs}}, \tag{856}$$

the tested near-flatness mechanism is rejected.

142.7 Cosmic microwave background failure

If a frozen central-handoff and third-leg transfer realization cannot reproduce the cosmic microwave background temperature and polarization spectra, its CMB-recovery claim is rejected regardless of success in other claim families. Those other successes or failures retain their own status.

142.8 Structure-growth failure

If the inherited web inevitably produces an unacceptable matter power spectrum, excessive anisotropy, or incorrect lensing behavior, the tested inherited-web realization is rejected.

142.9 No scaffold-retention mechanism

If physically acceptable dynamics force

$$\mathcal{R}_{13} \to 0, \tag{857}$$

the inherited-web hypothesis fails.

142.10 No electromagnetic recovery

If the precursor sectors cannot recover Lorentz-covariant standard electromagnetism, the proposed *Electro*–magnetic interpretation fails.

142.11 Privileged observer requirement

If the observed isotropy requires the observer to occupy a specially selected central location, the tested centrality-dependent realization is strongly disfavored.

142.12 Uncontrolled parameter expansion

If each dataset requires independent adjustable functions, the model loses falsifiability.

142.13 No distinctive prediction

If the complete model is observationally identical to standard cosmology and introduces no explanatory compression, the Triple Bounce interpretation remains metaphysical rather than empirically testable.

143 Staged Research Program

The Triple Bounce research program should proceed in stages.

143.1 Stage I: foundational architecture

Paper I defines:

- the pre-singularity boundary;
- the three directional legs;
- the separation of $a(t)$ and $R_E(t)$;
- the inherited-web hypothesis;
- the Gravity Triune;
- the provisional Electricity and Magnetism Triunes;
- the transition architecture;
- the principal unknowns; and
- the falsification conditions.

143.2 Stage II: inflation, horizon, and flatness

Paper II must derive:

- the full conformal-time history;
- the causal-contact condition;
- the relationship between observed third-leg history and standard inflationary reconstruction;
- curvature propagation across all legs;
- the candidate balanced-state contribution to near-flatness;
- the perturbation requirements ordinarily supplied by inflation;
- distinctive tests of the incomplete-history hypothesis; and
- the distinction between smooth continuous expansion and analytical packet sampling.

143.3 Stage III: Gravity Triune dynamics

Paper III must develop:

- a mathematical Gravity Triune model;
- binding, scaffolding, and chasing variables;
- dark-sector interaction terms;
- effective equations of state;
- background expansion;
- the candidate physical interpretation of the positive packet-derived growth factor;
- structure growth;
- gravitational slip;
- stability; and
- observational constraints.

143.4 Stage IV: expansion history and packet reconstruction

Paper IV must develop:

- the piecewise *Electro* trajectory;
- the standardized reversal equations;
- the observable third-leg expansion model;
- the exact status of the 13.824-billion-year anchor;
- the exact status of the 46.08-billion-light-year model distance;
- the 10/3 structural ratio;
- the 320-million-year packet;
- the provenance and exclusion status of the proposed 2.304-billion-year candidate interval;
- the positive factor near 1.0283;
- full dimensional, arithmetic, and sensitivity reconstruction;
- comparison of the declared third-leg endpoint timing with relevant standard cosmological benchmarks;
- the candidate relationship to negative-pressure dark-energy behavior; and
- the distinction between correspondence, derivation, and prediction.

143.5 Stage V: integrated numerical model

After Papers II–IV, the program requires a unified numerical model containing:

$$\{a(t), R_E(t), \rho_i(t), \delta_i(k,t), \mathcal{W}(k,t), F_{\mu\nu}, Q_i^{\mu}\}\,. \tag{858}$$

The integrated model must evolve from the first resolved boundary through the present third-leg epoch.

143.6 Stage VI: observational comparison

The final stage requires comparison with:

- supernova data;

- baryon acoustic oscillation measurements;
- cosmic microwave background temperature and polarization;
- large-scale clustering;
- weak lensing;
- redshift-space distortions;
- void and filament catalogs;
- magnetic-field observations; and
- gravitational-wave constraints.

144 Transparency and Reproducibility Requirements

A speculative cosmological framework requires unusually clear documentation.

The following materials should accompany the companion quantitative papers:

1. all governing equations;
2. all boundary and matching conditions;
3. the full parameter list;
4. the distinction between fixed, fitted, and derived quantities;
5. numerical integration code;
6. initial-condition files;
7. likelihood definitions;
8. data preprocessing procedures;
9. prior distributions;
10. convergence diagnostics;
11. sensitivity tests;
12. packet-input sensitivity calculations;
13. failed parameter regions; and
14. comparison-model settings.

The model should report negative results as well as successful fits.

A parameter choice that fails should not disappear from the research record when it provides information about the framework's viable domain.

Hypothesis 18 (Stand-or-fall implementation)**.** *The Triple Bounce framework should be implemented so that independent researchers can reproduce its calculations, vary its assumptions, and identify precisely where it succeeds or fails.*

145 Formal Summary of Predictions and Claim-Specific Tests

The predictive program may be summarized as

$$\boxed{\begin{aligned} \text{three-leg dynamics} &\longrightarrow \text{third-leg initial conditions} \\ &\longrightarrow \text{observable expansion and structure} \\ &\longrightarrow \text{statistical comparison} \\ &\longrightarrow \text{acceptance, revision, or rejection} \end{aligned}} \tag{859}$$

The minimum background requirements are

$$H(t) > 0, \qquad \dot{R}_E : + \to - \to +, \qquad \nabla_\mu T^{\mu\nu}_{\text{tot}} = 0. \tag{860}$$

The horizon requirement is

$$\Delta\eta_{\text{full}} \geq \Delta\eta_{\text{required}}. \tag{861}$$

The curvature requirement is

$$\left|\Omega_k^{(3)}\right| \ll 1 \tag{862}$$

without unexplained fine tuning.

The inherited-web requirement is

$$r_{13}(k \to 0) \approx 1 \tag{863}$$

together with at least one observable proxy for that retention.

The electromagnetic requirement is

$$\mathcal{L}_{\text{precursor}} \longrightarrow \mathcal{L}_{\text{Maxwell}} \tag{864}$$

in the tested third-leg regime.

The packet correspondence is

$$g_{\text{packet}} = \exp\left[\frac{\ln(10/3)}{43.2}\right] \approx 1.0283, \tag{865}$$

using the nominal 320-million-year packet only within the observable third leg.

The statistical requirement is

$$\text{improved explanatory power} > \text{penalty for additional freedom}. \tag{866}$$

The final falsification principle is

$$\boxed{\text{The framework must be allowed to fail.}} \tag{867}$$

Its scientific value depends upon making that failure condition explicit.

146 Discussion

Paper I has developed the Triple Bounce Cosmological Framework as a structured three-leg interpretation of cosmic history.

The framework proposes that the observable universe is primarily the third outward leg of a longer sequence:

$$\boxed{\text{outward} \longrightarrow \text{inward} \longrightarrow \text{outward}} \tag{868}$$

for the active *Electro* sector.

The larger cosmic volume is not required to follow the same directional sequence.

Instead, the foundational distinction is

$$\text{global metric expansion} \neq \text{sector-specific } \textit{Electro} \text{ motion}. \tag{869}$$

This distinction permits

$$H(t) > 0, \qquad \dot{R}_E(t) < 0 \tag{870}$$

during the second leg.

The framework further proposes that:

1. the first outward leg co-forms *Electro* pathways and distributed dark-matter scaffolding;
2. the inherited pathway–scaffold structure persists across the inward return;
3. the second inward leg adds counter-directed structural and energetic history;
4. the unresolved central reversal occurs within a transformed nonequilibrium state;
5. the third outward leg may establish ordinary electromagnetic behavior through candidate Electro–magnetism coupling;
6. stable ordinary matter is proposed to become organized preferentially along the inherited web;
7. major intersections may operate as three-pass dynamo junctions; and
8. classical gravity, dark matter, and dark energy operate as the binding, scaffolding, and chasing members of a Gravity Triune.

These statements define the model's architecture.

They do not yet constitute a complete fundamental theory.

The principal value of the first paper is therefore not that it solves every cosmological problem, but that it converts a broad conceptual proposal into:

- defined variables;
- separated physical roles;
- explicit assumptions;
- candidate equations;
- transition conditions;
- observational requirements;
- falsification conditions; and
- a staged mathematical research program.

147 Comparison with Standard Cosmology

147.1 Shared observational foundation

The Triple Bounce framework does not reject the primary observational foundation of modern cosmology.

It retains as required inputs:

- the measured redshift–distance relation;
- Type Ia supernova luminosity distances;
- baryon acoustic oscillation measurements;
- the cosmic microwave background temperature and polarization spectra;
- light-element abundances;
- large-scale structure;
- gravitational lensing;
- local tests of general relativity;
- standard laboratory electromagnetism; and
- established particle and nuclear physics.

The disagreement is therefore not primarily with the measurements.

It concerns the interpretation of the earliest reconstructable third-leg state.

147.2 Standard one-leg reconstruction

In standard cosmology, the observable expansion is extrapolated backward through a single connected history.

The standard reconstruction uses

$$H(z) \tag{871}$$

to infer:

- lookback time;
- comoving distance;

- the age of the universe;
- the particle horizon;
- the sound horizon;
- curvature evolution;
- the thermal history; and
- primordial conditions.

Inflation is ordinarily placed near the beginning of this reconstructed history to account for causal correlation, near-flatness, and the origin of primordial perturbations.

147.3 Triple Bounce reinterpretation

The Triple Bounce framework proposes that the third-leg reconstruction is observationally meaningful but historically incomplete.

Symbolically,

$$\text{standard reconstruction}: \quad \mathcal{H}_{\text{obs}} = \mathcal{H}_{\text{total}}, \tag{872}$$

whereas

$$\text{Triple Bounce}: \quad \mathcal{H}_{\text{obs}} \subset \mathcal{H}_{\text{total}}. \tag{873}$$

The third leg retains the successful hot-state and late-time physics.

The first two legs alter the proposed origin of:

- causal correlation;
- near-flat geometry;
- the primordial structural field;
- the initial third-leg perturbations;
- the matter-organization environment; and
- the apparent beginning of observable cosmic time.

147.4 Standard cosmology is not declared observationally false

The Triple Bounce framework does not claim that standard cosmological calculations are numerically invalid simply because they use a one-leg history.

A fitted model may accurately reconstruct the observable third leg while remaining incomplete as a description of a larger hidden history.

The proposed relationship is therefore

$$\text{accurate within the observed domain} \quad \not\Rightarrow \quad \text{complete cosmic history}. \tag{874}$$

The burden remains on the Triple Bounce framework to demonstrate that its broader history produces measurable consequences.

148 Comparison with Other Bounce and Cyclic Frameworks

148.1 Conventional cosmological bounce

In many bounce cosmologies, the scale factor contracts before reaching a minimum and re-expanding.

A conventional bounce is often characterized by

$$H(t_b) = 0, \qquad \dot{H}(t_b) > 0. \tag{875}$$

The Triple Bounce framework differs because the two principal reversals belong to the active *Electro* trajectory.

The global background may satisfy

$$H(t_{\mathrm{O}}) > 0, \qquad H(t_{\mathrm{C}}) > 0. \tag{876}$$

The model is therefore a sectoral directional-bounce theory rather than, at the foundational level, a global scale-factor bounce theory.

148.2 Matter-bounce scenarios

Matter-bounce scenarios generally employ a contracting phase capable of generating an approximately scale-invariant perturbation spectrum before a transition to expansion.

The Triple Bounce second leg does not initially require contraction of the entire metric background.

It instead proposes inward motion of *Electro* through an expanding scaffold.

Consequently, any perturbation mechanism must be derived from:

- sector-specific motion;
- pathway memory;
- central convergence;
- transition dynamics; and
- third-leg inheritance.

148.3 Ekpyrotic and cyclic scenarios

Ekpyrotic and cyclic frameworks often use a slow-contracting phase with a stiff effective equation of state to suppress anisotropy and prepare a subsequent expansion.

The Triple Bounce model instead begins from balanced pre-singularity ordering and retains global outward expansion as a possible condition throughout all three legs.

It must therefore solve anisotropy and curvature through a different mechanism.

148.4 Quantum-gravity bounce scenarios

Some bounce models replace a classical singularity through quantum geometry, modified Friedmann equations, or high-density corrections. More generally, departures from general relativity must be assessed against the broader modified-gravity framework (Clifton et al., 2012).

The Triple Bounce framework does not yet specify a quantum-gravity mechanism for either reversal.

It remains compatible with the possibility that a later completion uses quantum-gravitational corrections, but such corrections are not part of the present derivation.

148.5 Conformal and aeonic cyclic scenarios

Some cyclic proposals connect the remote future of one cosmic aeon to the beginning of another through conformal restructuring.

The Triple Bounce framework does not yet define the termination of the current third leg or the generation of a later pre-singularity state.

It therefore addresses a bounded three-leg sequence before attempting a complete eternal recurrence model.

148.6 Distinctive architectural feature

The defining difference can be summarized as

$$\boxed{\text{two reversals of an active sector} \quad \text{inside a potentially continuously expanding background}} \tag{877}$$

combined with

$$\boxed{\text{persistent structural memory across all three legs.}} \tag{878}$$

Whether this distinction is physically viable depends on the effective field theory and observational calculations developed in the companion papers.

149 Principal Strengths of the Framework

The Triple Bounce framework possesses several conceptual strengths.

These strengths do not establish that the model is correct.

They identify reasons the framework is worth formal investigation.

149.1 Separation of sectoral and metric motion

The distinction between

$$a(t) \quad \text{and} \quad R_E(t) \tag{879}$$

creates a clear mathematical route for representing inward motion without universal contraction.

This removes the need to force every cosmic component into one shared trajectory.

149.2 Unified three-leg architecture

The framework assigns a specific function to each directional leg:

$$\text{first leg} : \text{path formation}, \tag{880}$$

$$\text{second leg} : \text{return and counter-history}, \tag{881}$$

$$\text{third leg} : \text{electromagnetic and material occupation.} \tag{882}$$

The three legs are therefore not repetitions of one process.

149.3 Structural memory

The inherited-web hypothesis offers a single mechanism connecting:

- primordial geometry;
- large-scale structure;
- filament and void organization;
- junction hierarchy;
- magnetic alignment; and
- third-leg initial conditions.

If mathematically successful, this may provide explanatory compression across otherwise separate observations.

149.4 Explicit distinction between data and interpretation

The framework distinguishes:

$$\text{measurement} \neq \text{model-dependent reconstruction.} \tag{883}$$

This distinction is particularly important for cosmic age, comoving distance, horizon scales, and primordial conditions.

149.5 Functional dark-sector organization

The Gravity Triune provides a clear functional division:

$$\text{binding} + \text{scaffolding} + \text{chasing.} \tag{884}$$

This grammar may help organize the relationships among classical gravity, dark matter, and dark energy without prematurely claiming their microscopic identity.

149.6 Falsification built into the framework

Paper I identifies explicit failure conditions involving:

- conservation;
- transition stability;
- curvature;
- causality;
- the cosmic microwave background;
- structure growth;
- electromagnetic recovery;
- observer centrality;
- parameter freedom; and
- distinctive predictions.

The framework is therefore intended to be rejectable.

149.7 Compatibility with staged development

The architecture can be investigated in stages.

The background trajectory can be studied before the full particle model is known.

The causal history can be tested before the complete Gravity Triune is derived.

The packet-growth correspondence can be evaluated separately from the ultimate microphysical origin of the proposed packet hierarchy.

This modularity allows parts of the framework to fail without making every other part mathematically inaccessible.

150 Major Unresolved Problems

The framework also contains major unresolved problems.

These are not minor details.

They determine whether the proposal can become a viable cosmology.

150.1 Microphysical identity of Electro

The model does not yet identify *Electro* as a known field, particle, collective excitation, or quantum-gravitational degree of freedom.

A complete theory must derive:

- its action;
- its stress–energy tensor;
- its propagation law;
- its interaction currents;
- its characteristic speed;
- its stability conditions; and
- its relation to ordinary electromagnetism.

150.2 Physical causes of the reversals

The outer and central reversals are represented kinematically but not yet derived dynamically.

A completed model must explain why

$$\dot{R}_E : + \to - \tag{885}$$

at the outer transition and why

$$\dot{R}_E : - \to + \tag{886}$$

at the central transition.

The two reversals may have different causes.

150.3 Lorentz-covariant electromagnetic emergence

The proposed pre-coupling distinction between *Electro* and a provisional Magnetism Triune sector is not part of standard electrodynamics.

The model must show how the low-energy covariant electromagnetic tensor

$$F_{\mu\nu} \tag{887}$$

emerges without violating established Lorentz symmetry and gauge invariance.

150.4 Scaffold memory mechanism

The inherited-web hypothesis requires a real physical carrier of structural memory.

The model must determine whether that memory resides in:

- dark-matter density;
- dark-matter phase;
- field orientation;
- topological structure;
- metric geometry;
- nonlocal correlations;
- an order parameter; or
- another degree of freedom.

Without a retention mechanism, the central structural claim fails.

150.5 Third-leg perturbation spectrum

The model does not yet derive the amplitude, scale dependence, phase structure, or statistical properties of the third-leg primordial perturbations.

It must reproduce:

$$\{A_s, n_s, C_\ell, P_m(k), f_{\rm NL}, r, S_{ij}\} \tag{888}$$

within observational limits.

150.6 Matter–antimatter asymmetry

The central transition provides nonequilibrium conditions but does not yet provide the required particle-physics mechanism for baryogenesis or leptogenesis.

Electromagnetic coupling alone is insufficient.

150.7 Full-history time and distance

The complete durations

$$T_1, \qquad T_2, \qquad \Delta T_{\mathrm{O}}, \qquad \Delta T_{\mathrm{C}} \tag{889}$$

remain unresolved.

The model distance

$$46.08 \text{ Gly} \tag{890}$$

cannot be converted directly into total elapsed time.

150.8 Physical origin of the packet hierarchy

The 320-million-year packet and proposed larger hierarchy are imported into the exploratory third-leg calculation.

Paper I does not derive their cosmological origin.

The numerical packet correspondence cannot become a physical law until a mechanism connects the hierarchy to expansion.

150.9 Future endpoint

The framework does not determine whether the third leg:

- continues indefinitely;
- approaches a new asymptotic state;
- undergoes another reversal;
- transitions to a new pre-singularity state; or
- begins another larger cycle.

The present paper ends before that question.

151 Theoretical Implications

If the Triple Bounce architecture is viable, it would carry several important implications.

151.1 The observable beginning would be a transition

The hot early state reconstructed from third-leg observations would not represent the absolute beginning of all cosmic history.

It would represent the outcome of the central reversal.

Thus,

$$\text{hot observable beginning} = \text{third-leg transition state,} \tag{891}$$

rather than

$$\text{hot observable beginning} = \text{absolute beginning of existence.} \tag{892}$$

151.2 Inflationary inference could reflect incomplete history

Some functions attributed to inflation might arise from a longer causal and structural history than the observable third leg alone.

This would not remove the observational achievements associated with inflation. It would instead reopen the question of whether their physical origin is unique or can be reproduced by the full three-leg history.

151.3 The cosmic web could possess pre-material ancestry

The large-scale cosmic web would not begin solely as a statistical matter perturbation during the visible third leg.

It would possess a pre-material energetic ancestry.

151.4 Dark sectors could carry historical functions

Dark matter and dark energy would not merely be present-day fitting components.

They would participate in the generation and preservation of cosmic history.

Dark matter would carry long-term structural memory.

Dark energy would preserve the outward chasing function across the *Electro* reversals.

151.5 Matter organization would occur within inherited geometry

Stable ordinary matter would become organized within a previously established spatial and directional architecture.

The relation would be

$$\text{pathway} \longrightarrow \text{scaffold} \longrightarrow \text{matter occupation.} \tag{893}$$

151.6 Magnetic structure could inherit multipass geometry

Primordial magnetic organization might reflect not only third-leg plasma physics but also inherited junction structure from the first two legs.

151.7 Cosmic age could become layered

The phrase *age of the universe* would require specification.

One would distinguish:

$$\{\text{third-leg observable age}, \text{full three-leg elapsed time}, \text{possible larger cyclic age}\}\,. \tag{894}$$

152 Consolidated Hypothesis Table

Table 5: Principal hypotheses introduced in Paper I.

Hypothesis	**Core statement**	**Primary required test**
Incomplete-history hypothesis	The observable expansion represents primarily the third leg of a longer cosmic history.	Derive third-leg observables from a full three-leg solution.
Triple directional history	The active *Electro* sector follows an outward–inward–outward trajectory.	Construct a stable dynamical solution with two derived reversals.
Sectoral reversal	*Electro* can reverse while the global scale factor remains increasing.	Show that $H > 0$ and $\dot{R}_E < 0$ coexist under acceptable stress–energy.

Balanced initial ordering	A dominant pre-singularity mode may contribute to low observable curvature and reduced anisotropy.	Propagate curvature through both reversals and recover near-flatness without extreme fine tuning.
Instability-triggered release	The first leg begins when the compressed pre-singularity state loses stability.	Derive the instability from an effective action or equivalent theory.
First-leg construction	The first outward passage establishes the dominant primordial pathways.	Generate a web field from first-leg dynamics.
Interwoven scaffold	The dark-matter scaffold and Electro pathway are co-formed.	Derive a physical coupling and persistent memory carrier.
First-leg structural memory	The first-leg imprint survives the second leg.	Demonstrate long-lived retention under expansion and return dynamics.
Internal return	The second leg is inward Electro motion through a globally expanding volume.	Solve the second-leg trajectory and continuity equations.
Second-leg pathway retention	The inward return remains strongly correlated with the first-leg path.	Calculate large-scale first-to-second-leg overlap.
Central nonequilibrium	The central transition provides conditions for strong nonequilibrium reorganization.	Derive distributions, interaction rates, and transition stability.
Third-leg transformation	The third leg begins from a transformed two-pass central state.	Construct the central matching map.
Inherited occupation	Third-leg matter preferentially occupies the preserved pathway.	Derive structure-growth consequences and compare with observations.
Dynamo precursor	Multipass junctions support later magnetic and rotational organization.	Predict junction-dependent magnetic or vorticity statistics.

Gravity Triune	Classical gravity, dark matter, and dark energy perform binding, scaffolding, and chasing functions.	Derive connected equations with constrained observable effects.
Stand-or-fall criterion	The framework is judged by consistency, derivation, and prediction.	Release reproducible equations, code, parameters, and failure regions.

The hypotheses in table 5 are not equally mature.

Some are kinematic.

Some are dynamical.

Some require new microphysics.

The table is intended to prevent those levels from being conflated.

153 Consolidated Model Architecture

The complete foundational architecture may be expressed through five layers.

153.1 Layer I: pre-singularity boundary

$$\mathcal{U}_{\text{pre}} \longrightarrow \text{instability}. \tag{895}$$

153.2 Layer II: directional history

$$\textit{Electro}: \quad \rightarrow \quad \leftarrow \quad \rightarrow . \tag{896}$$

153.3 Layer III: persistent structural history

$$\mathcal{W}_1 \longrightarrow \mathcal{W}_{12} \longrightarrow \mathcal{W}_3. \tag{897}$$

153.4 Layer IV: Triune functional history

$$\mathfrak{G} = \{\mathcal{B}, \mathcal{S}, \mathcal{C}\}. \tag{898}$$

153.5 Layer V: observable third-leg history

$$\text{radiation} \longrightarrow \text{stable matter} \longrightarrow \text{structure} \longrightarrow \text{late acceleration}. \tag{899}$$

The total architecture is

$$\boxed{\mathcal{U}_{\rm pre} \longrightarrow (\mathit{Electro} : \rightarrow\leftarrow\rightarrow) \longrightarrow (\mathcal{W}_1 \rightarrow \mathcal{W}_{12} \rightarrow \mathcal{W}_3) \longrightarrow \text{observable third-leg universe}} \tag{900}$$

within the continuing interaction of binding, scaffolding, and chasing.

154 Relationship Among Papers I–IV

154.1 Paper I: foundational framework

Paper I defines the complete conceptual and effective-dynamical architecture.

Its primary outputs are:

- the three-leg directional history;
- the distinction between $a(t)$ and $R_E(t)$;
- the pre-singularity boundary;
- the first-leg web;
- the second-leg return;
- the central transition;
- third-leg electromagnetic and matter organization;
- the inherited-web hypothesis;
- the Gravity Triune;
- candidate observables; and
- falsification requirements.

154.2 Paper II: inflation, horizon, and flatness

Paper II investigates whether the full three-leg history can reproduce the functions usually assigned to inflation.

Its principal calculations include:

$$\{\Delta\eta_{\rm full}, \Omega_k(t), \mathcal{P}_{\mathcal{R}}(k), \text{transition matching}\}\,. \tag{901}$$

Paper II must determine whether the incomplete-history interpretation is quantitatively viable.

154.3 Paper III: Gravity Triune

Paper III develops the mathematical relationship among:

$$\text{binding}, \qquad \text{scaffolding}, \qquad \text{chasing}. \tag{902}$$

Its principal tasks are:

- constructing the effective equations;
- specifying interactions;
- solving background evolution;
- testing perturbation stability;
- calculating structure growth; and
- constraining the model observationally.

154.4 Paper IV: third-leg expansion and packet reconstruction

Paper IV develops the detailed third-leg expansion and the most rigorous packet reconstruction.

Its principal anchors are

$$T_3 = 13.824 \text{ Gyr}, \tag{903}$$

$$D_{\rm model} = 46.08 \text{ Gly}, \tag{904}$$

$$\Delta t_{\rm packet} = 320 \text{ Myr}. \tag{905}$$

The structural relation and provisional packet factor are

$$\frac{D_{\text{model}}}{cT_3} = \frac{10}{3}, \tag{906}$$

$$g_{\text{packet}} = \exp\left[\frac{\ln(10/3)}{43.2}\right] \approx 1.0283. \tag{907}$$

Paper IV reconstructs rather than merely repeats these relations. It audits and excludes the proposed 2.304-billion-year candidate from the active hierarchy, tests nearby inputs and alternative formulations, and determines the strongest defensible status of the positive factor. Its final result is a constrained third-leg endpoint correspondence, not a global chronology map or a derived negative-pressure identity.

154.5 Combined program

The four papers form the sequence

$$\boxed{\begin{aligned} \text{architecture} &\longrightarrow \text{causal and geometric tests} \\ &\longrightarrow \text{Triune dynamics and packet interpretation} \\ &\longrightarrow \text{third-leg expansion and packet reconstruction} \end{aligned}} \tag{908}$$

155 Research Priorities Across Papers II–IV

The immediate priorities are ordered by scientific dependence.

155.1 Priority 1: define the full piecewise trajectory

Construct explicit functions for

$$R_E^{(1)}(t), \qquad R_E^{(2)}(t), \qquad R_E^{(3)}(t), \tag{909}$$

together with the two transition profiles.

155.2 Priority 2: define the background scale factor

Construct

$$a_1(t), \qquad a_2(t), \qquad a_3(t) \tag{910}$$

consistent with

$$H(t) > 0 \tag{911}$$

throughout the proposed history.

155.3 Priority 3: calculate conformal history

Evaluate

$$\Delta\eta_{\text{full}} = \sum_j \int_j \frac{c\,\mathrm{d}t}{a_j(t)}. \tag{912}$$

This is required before claiming a viable horizon candidate resolution.

155.4 Priority 4: propagate curvature

Determine whether the balanced initial state and transition maps produce

$$\left|\Omega_k^{(3)}\right| \ll 1. \tag{913}$$

155.5 Priority 5: define scaffold memory

Identify a field or order parameter carrying

$$\mathcal{W}, \qquad \boldsymbol{\mathcal{P}}, \qquad \mathcal{M}_{ij}. \tag{914}$$

155.6 Priority 6: construct the central matching map

Derive

$$\mathcal{T}_{\mathrm{C}} : \text{two-pass central state} \longrightarrow \text{third-leg initial perturbations}. \tag{915}$$

155.7 Priority 7: produce one distinctive observable

Select one observable that cannot be reproduced trivially by arbitrary third-leg initial conditions.

This may involve:

- phase correlation;
- junction topology;

- magnetic alignment;
- curvature evolution;
- a constrained feature in $H(z)$; or
- a packet-scale expansion signature.

156 Scientific Standards for Companion Papers and Subsequent Development

The companion papers and subsequent work should preserve several standards established in Paper I.

156.1 Do not convert unknowns into claims

The framework must not assign a physical mechanism merely because a numerical value appears suggestive.

Unknowns should remain identified as unknowns until derived.

156.2 Do not relabel observations as predictions

A value used to calibrate the model cannot later be claimed as an independent confirmation.

In particular,

$$T_3, \qquad D_{\text{model}}, \qquad \frac{10}{3} \tag{916}$$

must remain clearly classified.

156.3 Preserve units

Time, distance, curvature, energy density, and dimensionless growth factors must remain distinct.

Numerical similarity does not remove dimensional differences.

156.4 Use one parameter set across observations

The framework should not use separate unexplained adjustments for:

- the cosmic microwave background;

- supernova distances;
- structure growth;
- magnetic fields;
- junction statistics; and
- packet behavior.

156.5 Report failure regions

Parameter choices producing:

- instability;
- incorrect curvature;
- insufficient causal contact;
- excess anisotropy;
- incorrect acoustic structure;
- poor distance fits; or
- unacceptable structure growth

should be documented.

156.6 Permit revision of the framework

A failed component does not require protecting the original narrative.

The framework may need revision in:

- the number or meaning of sectors;
- the reversal mechanism;
- the memory carrier;
- the precursor interpretation;
- the packet construction;
- the assumed leg durations; or

- the relationship to inflation.

The stand-or-fall principle includes the possibility of partial reconstruction rather than only total acceptance or rejection.

157 Conclusion

This paper has presented the Triple Bounce Cosmological Framework as a three-leg interpretation of cosmic history.

The model begins from a dynamically oscillatory pre-singularity state whose growing instability precedes the singular opening and the first outward *Electro* leg.

During that first leg, *Electro* leads outward propagation while its pathways and a distributed dark-matter-associated scaffold are proposed to co-form.

A chasing sector associated with dark-energy-like behavior continues the outward evolution of the cosmic volume.

At the outer transition, *Electro* reverses direction while the larger background may remain expanding.

The second leg is therefore an internal inward return rather than a universal contraction.

The first-leg pathway remains structurally imprinted.

The inward return adds counter-directed energy, compression, interaction, and a second layer of directional history.

At the post-singularity topological origin, *Electro* enters a transformed central state within which the unresolved second reversal occurs.

During the resulting third outward leg, the framework proposes candidate coupling between *Electro* and the provisional Magnetism Triune sector. Ordinary electromagnetic behavior may become established, particle and radiation populations may reorganize, and any matter–antimatter asymmetry remains an open candidate consequence rather than a Paper I derivation.

Stable ordinary matter is then proposed to become organized within the inherited scaffold.

The visible cosmic web is interpreted as a third-leg occupation and nonlinear elaboration of pathways co-formed during the first leg and modified by the inward return.

The Gravity Triune organizes the principal large-scale functions as

$$\boxed{\text{binding} + \text{scaffolding} + \text{chasing}}. \tag{917}$$

Classical gravity performs the dominant binding role.

Dark matter performs the dominant scaffolding role.

Dark energy performs the dominant chasing role.

The framework remains incomplete.

It does not yet derive the identity of *Electro*, the two reversal mechanisms, the scaffold memory carrier, the pre-coupling magnetic-sector theory, the matter–antimatter asymmetry, the full perturbation spectrum, or the complete elapsed age.

These omissions are not concealed.

They define the mathematical work developed across the companion papers and the testing required beyond them.

The central claim of Paper I is therefore not that the Triple Bounce has already replaced standard cosmology.

It is that the proposal can be stated in a form that permits direct evaluation.

Its decisive questions are now explicit:

1. Can an active sector reverse twice while the background continues expanding?
2. Can the first-leg scaffold preserve structural memory through the inward return?
3. Can the central transition generate acceptable third-leg initial conditions?
4. Can the full history provide sufficient causal contact?
5. Can it naturally preserve near-flat geometry?
6. Can it reproduce the cosmic microwave background, nucleosynthesis, structure growth, and distance measurements?
7. Can the Gravity Triune be converted into stable field equations?
8. Can the packet correspondence become dynamical rather than merely numerical?
9. Can the model produce one distinctive prediction that standard cosmology does not reproduce naturally?

The Triple Bounce should therefore stand or fall on:

$$\boxed{\text{internal consistency} + \text{mathematical derivation} + \text{observational prediction}}. \tag{918}$$

It does not require belief.

It requires calculation.

A Master Symbol Reference

The following table consolidates the principal notation used throughout Paper I:

Symbol	**Intended meaning**
$a(t)$	Global cosmological scale factor.
$H(t)$	Hubble rate, $\dot{a}/a$.
$R_E(t)$	Effective physical radial coordinate of the active *Electro* sector.
$\chi_E(t)$	Effective comoving *Electro* coordinate.
$R_{\text{out}}(t)$	Effective outer cosmic scale.
$R_{\text{C}}(t)$	Effective chasing-sector progression where used.
t_{O}	Outer reversal time.
t_{C}	Central reversal time.
τ_{O}	Outer transition width.
τ_{C}	Central transition width.
$\mathcal{W}_1$	First-leg pathway field.
$\mathcal{W}_2$	Second-leg return-path or counter-imprint field.
$\mathcal{W}_{12}$	Combined first- and second-leg structural history.
$\mathcal{W}_3$	Third-leg occupied web.
$\boldsymbol{\mathcal{P}}_n$	Directional memory field for pass n.
$\mathcal{M}_{ij}^{(n)}$	Tensorial directional memory for pass n.
$\mathcal{B}$	Binding functional state.
$\mathcal{S}$	Scaffolding functional state.
$\mathcal{C}$	Chasing functional state.
$\mathfrak{G}$	Gravity Triune.
$\mathfrak{E}$	Provisional Electricity Triune.
$\mathfrak{M}$	Provisional Magnetism Triune.
$\mathcal{B}_{\text{pre}}$	Provisional effective variable for the pre-coupling Magnetism Triune sector.
$\mathcal{Q}_i$	Background sector energy-transfer rate.
Q_i^μ	Sector interaction four-current.
$\mathcal{R}_{13}$	First-to-third-leg structural retention coefficient.
α_3	Third-leg large-scale inheritance coefficient.
λ_2	Second-pass retention weight.
T_3	Observable third-leg duration anchor.
D_{model}	Third-leg model distance scale.
g_{packet}	Dimensionless third-leg packet growth factor.

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