A Structure-Dependent Route to Cosmic Acceleration in Zero Theory

Time-Sink, Hydrogen Clocks, and Compensated Spacetime Structure

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Abstract

Zero Theory proposes that a common, observer-relative spacetime architecture connects the electron's outward fountain presentation, inward proton-associated Time-Sink, and a structure-dependent route to cosmic acceleration. This paper develops that proposal in one self-contained account. Hydrogen provides both a centre–environment configuration and a distinction between radial balance and continuing clock evolution. The Solar-system Oort reference motivates an interstellar, rather than exclusively intergalactic, search for compensated geometry: nonzero local structures might yield a nearly straight large-scale readout. This "egg-carton" intuition is separated from fundamental Zero, pregeometric Structured Zero, and exact local metric flatness. A source-based multiscale composition scheme retains reference-frame transport, directional coherence, and the exclusion of double counting. Its connection to acceleration is then made conditional and explicit. For disjoint physical volumes compared with one declared time, the acceleration of the volume scale equals the weighted regional accelerations plus twice the variance of their expansion rates. Compensation of one directional quantity need not eliminate that variance, but neither compensation nor a growing outward-associated volume fraction fixes it. A positive example and a counterexample delimit the inference. Clock conversion, boundary transfer, common-scale cancellation, and source-to-observer propagation complete the operational analysis. The Oort projection and hydrogen-frequency benchmark retain their declared inputs and are not used to set a cosmological parameter. The contribution is a connected physical mechanism proposal with verified conditional mathematics and explicit tests. It adds no independent dark-energy substance to its proposed ontology, but does not claim a derived cosmic expansion history or an observationally validated replacement for dark energy. The proposal is situated relative to relativistic averaging, Timescape clock calibration, and inhomogeneous light propagation; published observations enter as comparison targets and constraints, not as successful tests of this mechanism.

Keywords: Zero Theory; dark energy; cosmic acceleration; Time-Sink; spacetime fountain; hydrogen clock; Oort reference; compensated structure; cosmological averaging.

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Scope of the manuscript. The physical account is a source-based model proposal; the volume and clock identities are exact under their stated assumptions; the astronomical application remains a testable research programme. All essential definitions, calculations, limitations, and references are included here. Reading the earlier paper or the separate development notes is unnecessary.

1 The physical question

The cosmological question considered here is whether an evolving distribution of ordinary material structures, together with the spacetime architecture proposed by Zero Theory, can generate a late-time accelerating expansion without requiring an additional independent dark-energy substance. This is a question about the cause of a physical expansion history, not a claim that the observations conventionally associated with dark energy do not exist.

The distinction matters. The supernova investigations of Riess and collaborators and Perlmutter and collaborators inferred accelerated expansion by comparing measured fluxes, light-curve information, and redshifts within specified cosmological models. Their conclusions were not direct detections of a microscopic dark-energy substance. Conversely, the fact that the microscopic interpretation is not uniquely established does not remove the observational constraints. (Riess et al. 1998; Perlmutter et al. 1999) The Planck 2018 parameter analysis supplies an additional, explicitly model-dependent reference through cosmic microwave background temperature, polarization, and lensing measurements. (Planck Collaboration, Aghanim, et al. 2020)

Zero Theory's relevant working proposal begins at a different scale. It assigns opposite normal spacetime presentations to electron-associated and inward proton/positron-associated structures. The same distinction is then followed from hydrogen to concentrated astronomical centres and their extended environments. The proposed connection to acceleration enters when the relative spatial influence of those environments changes during structure formation. This mechanism is recorded in the working appendix, particularly sections A7–A9, S36–S38, D4, and PR-4. (Zero Theory Project 2026c)

Three questions must therefore be kept separate. What is the proposed directional architecture? Under what conditions can its changing spatial organization generate an accelerating physical volume? What does a material observer measure after source generation, propagation, and clock comparison are included? Answering one does not silently answer the other two.

The paper preserves the source's positive claim: a specific, internally motivated mechanism has been articulated. It also preserves the source's boundary: a quantitative cosmological evolution law and its observational map have not been supplied by that mechanism statement alone. The analysis below turns this boundary into mathematical and operational requirements rather than a generic demand to "explain everything."

1.1 Source basis and the role of additional mathematics

The Zero Theory content comes from the supplied R2-C15 source distribution, its synchronized scientific records, and its reasoning-rich R2-C14 working appendix. The scientific records distinguish current terminology and operational conventions from a staged cross-scale inference. The distribution itself is labelled a scoped synchronization candidate, not an installed new scientific release. This paper is a derived manuscript, not a replacement for the project's scientific Core. (Zero Theory Project 2026b, 2026c)

Sections 2–8 develop the source-based mechanism, its hydrogen connection, the Oort reference, and compensated multiscale structure. Sections 9–10 introduce an explicitly additional **conditional kinematic translation**. Those sections do not assert that the source already contains the displayed cosmological dynamics. Their purpose is to state what a realization of the source mechanism would have to accomplish, using ordinary differentiation of well-defined volumes and times. Section 12 uses external literature for comparison and observational definitions, not as an undisclosed substitute for a Zero Theory field equation. Essential definitions, premises, and reasoning are stated in this paper, so an old conversation or external project file is not required to follow the argument.

The present consolidation also uses the R2-C15 frame-energy/compensation checkpoint, the preserved C09.17–C09.19 and C16 discussions, Volume I's Structured Zero definitions, and the author's 18 September 2026 clarification of the interstellar origin of the egg-carton intuition. Repeated versions of one

consequence card are treated as one lineage, not as separate evidence. Source terminology is preserved while new mathematical illustrations are identified as such. (Zero Theory Project 2026d; Zero Theory Project 2026e; Emamifar 2026; Emamifar 2026, author clarification)

2 Minimal physical vocabulary

2.1 Material structure and the observer's viewing window

Within the relevant Zero Theory branch, a material particle is represented as a structured, persistent wave configuration rather than an unstructured point. Its internal layer labels, L1 through L4, identify roles inside the model's four-layer construction. For the present argument, L1 identifies the electron-associated reference contribution, and the relevant proton L3 contribution provides an inward-associated host role. A full reconstruction of the particle spectrum or of every layer equation is not assumed here.

The **observer's viewing window** is the material observer's accessible space, phase, and clock readout. It is not a photographic surface whose appearance alone establishes a physical spacetime metric. The observer's clocks, rulers, and detectors belong to the comparison, rather than providing an automatically absolute description of every internal layer. The distinction between internal construction and observer-reported output is central to the project's Time-Sink branch. (Zero Theory Project 2026b)

A structure can consequently have an internal phase organization, a presentation relative to an observer's local plane, and an externally measured response. Those are different descriptions with different owners. The cosmological argument needs explicit connections among them; a common name does not make them identical.

2.2 Circulation and normal presentation are different quantities

The term *vortex* can describe circulation in a plane. That circulation must not be confused with the sign of a contribution normal to an observer's plane. Let χ denote an in-plane orientation label and $\sigma_\perp$ a normal-presentation sign. The latter is a dimensionless orientation label, not a velocity, pressure, energy density, or expansion rate.

With outward presentation defined as positive, the source assignment is

$$\sigma_\perp(e^-) = +1, \qquad \sigma_\perp(e^+) = -1, \qquad \sigma_\perp(p_{\mathrm{L3}}) = -1. \tag{2.1}$$

The notation p_{L3} emphasizes the relevant proton contribution; it does not identify the entire proton with a positron. For the scoped electron/positron handedness relation, the source also records $\kappa_i = \chi_{\mathrm{L1},i}\chi_{\mathrm{L3}}$ and $\sigma_{\perp,i} = -\kappa_i$. This is the model's orientation assignment, not a derivation of a cosmological divergence from handedness. (Zero Theory Project 2026b, 2026a)

The current terminology is consequently **electron: outward spacetime fountain**, and **positron/relevant proton contribution: inward spacetime vortex or Time-Sink**. Replacing these with "two vortices spinning in opposite directions" loses the directional distinction that generated the cosmology proposal.

2.3 What a fountain does and does not mean

A fountain represents the proposed outward presentation or production of accessible spacetime; an inward sink represents progression away from that direct presentation. These terms express the author's physical hypothesis. They do not establish that spacetime is a Newtonian fluid, that it has a measurable material flux already defined in litres per second, or that an unmodelled medium may carry arbitrary energy.

An inward contribution's fading from the observer plane does not mean that the proton or positron ceases to exist or becomes undetectable. An inverse Time-Sink does not mean time reversal or reversed causality. Likewise, a positive normal sign is not yet the statement that the three-dimensional volume expansion

scalar is positive. Establishing that identification requires a geometry-to-volume map. (Zero Theory Project 2026b, 2026a)

These distinctions are not cosmetic. Without them, an illustration can appear to contain a force law, a clock law, and an expansion law that it has not actually specified.

3 Hydrogen as the elementary centre–environment configuration

3.1 Opposed contributions without literal central collision

In the source picture, hydrogen places an inward proton-centred contribution and an outward electron-associated contribution in one bound system. The proposed non-collapse mechanism is partial opposition and an equilibrium boundary, rather than unrestricted motion of the electron into the proton's centre. This is a model-mechanism account of the centre–environment arrangement; the present paper does not derive its equilibrium radius or a quantitative atomic force law. (Zero Theory Project 2026c)

The mechanism matters for cosmology because it distinguishes **where a contribution is concentrated** from **how far its associated environment extends**. An inward contribution can dominate close to a centre while an outward-associated contribution occupies a more extended domain. It is therefore possible to formulate a question about their relative spatial influence without treating them as two colocated scalar numbers that cancel merely because their signs differ.

This does not prove that the contributions fail to cancel globally. Nor does electrical neutrality itself prove their geometrical cancellation. Equal and opposite charge labels do not, without an additional equation, imply equal and opposite spacetime profiles under the relevant integration measure. Both claims would require the actual spatial profiles, coupling, and boundary conditions. The source provides the directional architecture; it does not license replacing these missing profiles with a chosen cosmological residual.

3.2 Radial balance does not stop temporal progression

The hydrogen connection is more specific than a visual resemblance between an atom and a central object with an extended environment. In the source's H1 account, the radial readout of opposed contributions balances at a stable boundary, while the temporal readout remains nonzero. H1 denotes the first hydrogen bound-state reference in the declared branch; its radius is not assumed to follow from the sign assignment alone.

Let $\Delta\Sigma_e$ and $\Delta\Sigma_p$ denote the electron-associated and proton-associated contribution magnitudes in the common convention used for this comparison. The subtraction records their opposed presentation; it is not a second sign reversal of an already signed quantity. The source introduces separate radial and temporal readout operations:

$$\Pi_r\left[\Delta\Sigma_e - \Delta\Sigma_p\right] = 0, \qquad \Pi_t\left[\Delta\Sigma_e - \Delta\Sigma_p\right] > 0. \tag{3.1}$$

These are schematic model requirements with different output types, not an equality between a length and a time. They say that radial equilibrium need not annul the relation whose temporal projection supplies a clock readout. The two operators have not thereby been derived. Their roles, however, have been stated explicitly; the concept of channel-specific balance is not an unrecovered gap. (Zero Theory Project 2026e, C09.17.2–C09.17.7)

The same source distinguishes a zero residual from a stopped mechanism. The electron and proton-associated processes can continue even when one projected radial change cancels. Nor does a constant cycle rate imply a constant accumulated history. If N counts distinguishable events, then

$$N(\tau) = N(\tau_*) + \int_{\tau_*}^{\tau} \nu(\tau')\, d\tau'. \tag{3.2}$$

A fixed ν permits increasing N. Whether that history produces increasing radial distance, a stationary redistribution, or only an accumulated worldline history remains a physical question. This is why repeated

cycles cannot simply be multiplied by a guessed "volume per cycle" to obtain cosmic expansion. (Zero Theory Project 2026e, C09.5–C09.8)

The implication for the later argument is logical and scoped: cancellation in one readout channel does not prove cessation in all others. It motivates, but does not derive, an analogous distinction between compensated geometry and continuing large-scale evolution.

3.3 Hydrogen as an operational clock anchor

The project also uses a hydrogen atomic clock to specify what is meant operationally by faster or slower local time relative to a declared comparator. This resolves the semantic question of which observable the time branch is discussing. It does not equate all possible notions of time with a single oscillator, and it does not equate the hydrogen clock frequency with the classical Bohr orbital rate. (Zero Theory Project 2026b)

For an ideal event counter with reference calibration $\nu_{H,\mathrm{ref}}$, a simple operational clock convention is

$$\Delta\tau_H = \frac{\Delta N_H}{\nu_{H,\mathrm{ref}}}, \tag{3.3}$$

where ΔN_H counts the specified clock events and the reference frequency has units of inverse seconds. This equation states a calibration convention. It does not determine how a changed environment alters the physical oscillator, the emitted radiation, or a remote detector's count.

The counted internal event has already been specified in the supplied hydrogen manuscript lineage as a full recurrence of the shell geometry together with its electric and magnetic configuration. The present paper does not ask again what returns. The distinction between that event and detector-facing clock output nevertheless remains important. (Emamifar 2026, hydrogen source/readout account) A geometrical return of an electron-associated configuration is not automatically a measured hyperfine transition. A source-to-detector model must state what transition or recurring event produces the signal, how it propagates, and how it is compared with the receiving clock.

3.4 A numerical clock benchmark and its limited cosmological role

One registered hydrogen branch combines the geometric coefficient

$$\epsilon_0 = \frac{4\pi - 1}{(4\pi)^4}, \qquad \delta_0 = \epsilon_0^2, \tag{3.4}$$

with the stipulated standard reduced-mass orbital input

$$\nu_{\mathrm{orb}}^{\mathrm{input}} = 6.576102463090700 \times 10^{15}\ \mathrm{Hz}. \tag{3.5}$$

Its conditional output is

$$\nu_{H,\mathrm{cand}} = \delta_0 \nu_{\mathrm{orb}}^{\mathrm{input}} \simeq 1.414763566790 \times 10^{9}\ \mathrm{Hz}. \tag{3.6}$$

Against the retained reference $\nu_{H,\mathrm{ref}} = 1.420405751768 \times 10^9$ Hz, the difference is approximately -5.642185 MHz, or -0.397223%. These inputs and this comparison are inherited from the supplied hydrogen source/readout account and the corresponding local-arrival record. The arithmetic is reproduced for this revision; this is not a new laboratory measurement or a first-principles derivation of the orbital input. (Zero Theory Project 2026b; Emamifar 2026, hydrogen source/readout account)

The separate current-profile/exchange calculation is not merged with this local-arrival branch. In particular, its selected spatial profile and conditional $4/3$ field enhancement do not provide a cosmological source strength. The 16 September checkpoint explicitly keeps those hydrogen routes separate. (Zero Theory Project 2026h)

A number at one reference state also does not specify an environmental law. *If* the same product form holds for a changed physical state X, then ordinary logarithmic differentiation gives

$$d \ln \nu_{H,\mathrm{cand}}(X) = 2\, d \ln \epsilon(X) + d \ln \nu_{\mathrm{orb}}(X). \tag{3.7}$$

This is a conditional sensitivity identity, not a prescription for either term. The model must determine how source geometry and the material environment alter those terms and how the emitted signal is received. The 0.397223% difference is therefore neither a measured cosmological redshift nor a dark-energy fraction. No number in this subsection fixes H_0, a cosmic acceleration, or a volume-production coefficient.

3.5 The actual hydrogen-to-cosmology connection

Hydrogen contributes two elements to this paper: the opposed centre–environment geometry and the requirement that time statements ultimately be tied to a clock observable. It does **not** supply the Hubble constant, a dark-energy density, or an acceleration history by substitution of an atomic frequency.

The project's separate hydrogen-frequency calculations concern a local source/readout branch. Their numerical proximity to an atomic comparator is neither a measurement of cosmic acceleration nor a conversion factor from atomic mismatch to dark energy. No hydrogen-frequency mismatch is used as a cosmological input here. (Zero Theory Project 2026b)

The proposed connection is therefore structural and operational:

opposed atomic contributions → a centre–environment architecture → a possible cross-scale organization of inward and outward domains; and, in parallel, clock recurrence → observer-owned time comparison → the time variable used to interpret expansion.

A successful unified model would have to make these two routes consistent with one another. It would not be enough to obtain a desirable expansion history with a time coordinate disconnected from the clocks whose readings define that history.

4 The Oort reference and the interstellar origin of the proposal

4.1 Oort is a system-owned boundary, not fundamental Zero

The author's route to the egg-carton intuition began with a specific realization: the straight-reference problem was being considered within the stellar environment of the Milky Way, rather than being reserved for the space between galaxies. The reference should therefore be examined in the presence of overlapping structures, not only in an imagined region without surrounding systems. The author also leaves open a second, larger-scale possibility: different galactic resultants might compensate between galaxies. The first motivation does not require the second to have been established. (Emamifar 2026, author clarification; Zero Theory Project 2026d)

In the current source convention, fundamental Zero is the straight reference-wave ideal. "Oort" names the Solar-system Zero-boundary reference and has its own owner. It is not a synonym for fundamental Zero, an observed shell of vanishing spacetime curvature, or the geometrical edge of the entire Universe. Neither the Solar spin rate nor every orbit in the Oort region is identified with its reference cadence. (Zero Theory Project 2026b)

Write $\ell_{P,h}$ for the project's non-reduced Planck length, based on h rather than $\hbar$. In this reference-wave dictionary, with common propagation speed c,

$$\lambda_Z = \ell_{P,h}, \qquad T_Z = \frac{\ell_{P,h}}{c}, \qquad \omega_Z = \frac{2\pi}{T_Z}. \tag{4.1}$$

For another owned reference wavelength λ_F,

$$q_F := \frac{\omega_F}{\omega_Z} = \frac{\ell_{P,h}}{\lambda_F}, \qquad T_F = \frac{\lambda_F}{c}. \tag{4.2}$$

The current Oort convention is

$$\lambda_O = 4\pi\ell_{P,h}, \qquad T_O = 4\pi T_Z, \qquad \boxed{q_O = \frac{1}{4\pi}.} \tag{4.3}$$

Thus one fundamental-Zero Tick corresponds to $1/(4\pi)$ of an Oort reference cycle, or $1/2$ radian of its reference phase. A full reference phase cycle is not an orbit around an infinite spatial circle. The wavelength, reference cadence, material orbital rate, and projected circumference are distinct quantities. Appendix B preserves their numerical bookkeeping.

4.2 Environmental support can overlap

In the model's C16 clarification, an isolated stable electron requires an adequate supporting environment. "Free electron" here means atomically unbound, not independent of every host environment. Oort describes a Solar-system-owned threshold in the relevant approximation; another star or mass concentration can supply local support beyond the part attributed to the Sun. The source therefore treats the boundary as an environmental condition, not a wall in space. (Zero Theory Project 2026e, C16.2–C16.6)

The conceptual condition is

$$E_e^{\text{stable,isolated}} \implies \mathcal{G}_{\text{eff}} \geq \mathcal{G}_{\min,e}. \tag{4.4}$$

Here $E_e^{\text{stable,isolated}}$ denotes existence of the specified stable knot, not an energy, and $\mathcal{G}_{\text{eff}}$ is the model's as-yet unclosed environmental-support functional. It must account for geometry, orientation, coherence, and observer ownership. It is not assumed to be a simple signed sum of local accelerations. A necessary support condition is not a sufficient construction or stability proof.

The overlap matters to the present paper. The interstellar environment need not be modelled as empty patches separated by independent containers. Contributions from several systems can coexist at one location. Whether their effects on a particular propagation readout compensate, and whether local material support remains adequate, are two different questions for a common physical model.

4.3 The inherited projected endpoint: motivation, not a boundary detection

The R2-C15 checkpoint preserves a fixed, H1-anchored inverse projection in which

$$C_{\text{proj}}(F)\,\lambda_F = K, \tag{4.5}$$

with K of dimension length squared. Using its retained Local-equivalent circumference and wavelength gives an Oort projected circumference of about 2.9756852×10^{16} m. Extending that *same* projection to $\lambda_F = \ell_{P,h}$ yields

$$C_{\text{proj},Z} \simeq 3.7393563 \times 10^{17}\ \text{m}, \qquad r_{\text{proj},Z} \simeq 6.2906035\ \text{ly}. \tag{4.6}$$

This is a dependent projected scale. It is useful for understanding why a several-light-year, intra-galactic context entered the author's reasoning. It is not a measured location of fundamental Zero, a predicted universal spacing of stars, or the curvature radius of an actually straight light ray. In particular, continuing an inverse projection does not establish local zero curvature. (Zero Theory Project 2026d)

The related hosted-electron check is likewise restricted. If the declared 4π hosted/reference cadence relation and common-c wavelength conversion apply at Oort, then $q_{e|O} = 4\pi q_O = 1$ and $\lambda_{L1|O} = \lambda_O/(4\pi) = \ell_{P,h}$. This is a conditional lower-bound consistency check, not a claim of an existing electron in fundamental Zero. Extending the same rule to an inadmissible branch would not establish such a particle. The source still distinguishes local intrinsic loop length from a Zero-ledger inverse-cadence equivalent, and hydrogen unbinding from electron-knot nonexistence.

5 Compensated structure and the egg-carton intuition

5.1 Three meanings of zero

The proposal becomes clearer when three meanings are distinguished. They are related research concepts, not interchangeable definitions.

Fundamental Zero is the straight reference-wave ideal just defined. Its role is a reference convention with a specified wavelength and Tick; naming an astronomical location does not by itself realize all of its physical conditions.

Structured Zero, in Volume I, is a nonempty opposed distinction with net-zero expression. Its symbolic form is

$$(+\delta) \oplus (-\delta) = 0_{\text{net}}, \qquad (+\delta, -\delta) \neq \varnothing. \tag{5.1}$$

The foundational source explicitly does not yet make δ a force, wave, physical vector, charge, or displacement. Structured Zero supplies a conceptual pattern—zero expression need not mean absent structure—rather than a derived gravitational cancellation law. (Emamifar 2026, Definitions 1.4 and 3.2)

Compensated effective straightness is the physical realization proposed for investigation: a specified large-scale propagation or measurement outcome could be nearly straight even though the contributing local structures are nonzero. Its value depends on scale, path, orientation, and what the detector compares. Its identification with the full fundamental-Zero ideal remains a physical connection to establish, not a revision silently imposed on that ideal.

The egg-carton analogy represents this third problem. A locally corrugated structure may have a comparatively level large-scale appearance. The model does not thereby acquire a literal static two-dimensional spacetime sheet, a preferred external height axis, or a lattice of new material cells. Those would be additional assumptions. The source retains the analogy as a candidate geometric intuition under the consequence-card identifier `ZTC-RECENT-GALACTIC-TRAY`. (Zero Theory Project 2026f)

5.2 An exact geometrical distinction

A simple source-preserved counterexample shows why local curvature and net turning must be separated. For a smooth planar path parameterized by arc length s, let $\theta(s)$ be a continuously tracked tangent angle. Then

$$\kappa_{\text{signed}} = \frac{d\theta}{ds}, \qquad \Delta\theta = \int \kappa_{\text{signed}}\, ds. \tag{5.2}$$

The condition $\Delta\theta = 0$ is weaker than $\kappa_{\text{signed}}(s) = 0$ everywhere. (Zero Theory Project 2026d)

For example, consider the purely geometric curve

$$y(x) = \mathcal{A} \sin\!\left(\frac{2\pi x}{\mathcal{L}}\right), \qquad 0 \le x \le \mathcal{L}, \quad \mathcal{A} > 0, \quad \mathcal{L} > 0. \tag{5.3}$$

Because x increases monotonically, a continuous tangent choice is $\theta = \arctan(y')$. The endpoint derivatives are equal:

$$y'(0) = y'(\mathcal{L}) = \frac{2\pi\mathcal{A}}{\mathcal{L}}, \qquad \Delta\theta = 0. \tag{5.4}$$

Yet the signed curvature

$$\kappa_{\text{signed}}(x) = \frac{y''(x)}{[1 + y'(x)^2]^{3/2}} \tag{5.5}$$

is nonzero between the endpoints; at $x = \mathcal{L}/4$ it is $-4\pi^2\mathcal{A}/\mathcal{L}^2$.

There is also a distinct length consequence, included here as an elementary mathematical extension of the source example:

$$s_{\text{path}} = \int_0^{\mathcal{L}} \sqrt{1 + y'(x)^2}\, dx > \mathcal{L}. \tag{5.6}$$

The integrand exceeds one on intervals of nonzero length. Thus matching endpoint tangents does not erase the intervening path length. At a stipulated common speed it would not erase the corresponding travel-time difference either. No physical ray trajectory or gravitational time delay has been derived by this illustration; its purpose is to show that two measurements can retain different information about the same compensated construction.

5.3 What must actually compensate

Four distinct claims must not be collapsed into the word "flat": an apparently level material distribution; a small terminal deflection of a selected path; a small averaged geometric quantity; and vanishing local spacetime curvature. Neither low mean height nor an equal number of protrusions and depressions proves the last claim. Even the sign of intrinsic curvature is not specified merely by calling a feature a hill or a hollow.

The planar signed-curvature example does not supply a three-dimensional or relativistic transport law. In a physical realization, the compared directions must be defined in transported local frames, and ray-bundle distortion, distance, and clock propagation must be calculated from the same geometry. The proposed cancellation therefore needs a named quantity and averaging or transport operation. Otherwise several inequivalent claims can hide behind a single picture.

This restriction sharpens the author's proposal rather than discarding it. The positive research claim is that structured compensation might produce a simple reference presentation *inside* a structured galaxy. An optional intergalactic extension concerns the compensation of already composed galactic resultants. It does not require an equal-magnitude mirror partner for every galaxy, a population of antimatter galaxies, or a reversal of local electric charge.

6 From nested systems to a common-frame resultant

The multiscale problem has a precise historical antecedent in the *fitting problem* formulated by Ellis and Stoeger: which smooth, idealized spacetime should represent an inhomogeneous universe, and which geometrical and observational properties should the fit preserve? Averaging matter alone does not uniquely answer this question. Choosing a spatial domain, comparing tensors at different events, and fitting observables on a light cone are different operations. The egg-carton intuition in Section 5 therefore motivates a fitting question; it does not specify its solution. (Ellis and Stoeger 1987)

A complementary mathematical precedent is *Macroscopic Gravity*, developed by Zalaletdinov as a covariant averaging framework. Correlations generated by averaging a nonlinear gravitational theory must be retained rather than implicitly set to zero. Coley, Pelavas, and Zalaletdinov subsequently constructed cosmological solutions in which the correlations contribute a curvature-like term to the averaged equations. Such a curvature-like correction is not automatically an accelerating dark-energy component. (Zalaletdinov 1992; Coley, Pelavas, and Zalaletdinov 2005)

These precedents establish the mathematical responsibilities of the present composition scheme. Its reference-frame maps must identify what is transported, how an effective geometry is selected, and which correlation information is retained. The schematic vectors below are not already the averaged connection, metric, or correlation tensors of Macroscopic Gravity. Nor may the variance of one vector component be equated, without a dynamical map, with Buchert's kinematical backreaction. Those are possible targets for a future construction, not identities installed by notation. This distinction allows the particle-based proposal to be compared with established averaging methods without borrowing their mathematical closure as its own physical derivation.

6.1 Ownership before addition

C09.18 distinguishes particle, atomic, and larger-system owners. The internal motion of an electron is not the rotation of a whole hydrogen system, and neither can be identified without a map with the collective

motion of a star or galaxy. The source's multiscale proposal allows those levels to contribute to a common readout while preserving the identity of each contribution. (Zero Theory Project 2026e, C09.18–C09.19)

Let $\mathbf{J}_i$ denote an owned directional contribution, and let $\mathcal{T}_{i\to M}$ transport it to a common comparison frame M. The source's schematic composition is

$$\widetilde{\mathbf{J}}_i = \mathcal{T}_{i\to M}[\mathbf{J}_i], \qquad \mathbf{J}_M = \sum_i \widetilde{\mathbf{J}}_i. \tag{6.1}$$

All added terms must have compatible units and types. The symbol $\mathbf{J}$ is not automatically an electric current, a stress tensor, a three-dimensional volume flux, or an acceleration. The equation names a composition architecture; it does not establish linear gravitational superposition or supply the transport operators, coupling weights, or nonlinear corrections.

If a hydrogen-level term already summarizes the two constituents, the valid next-level expression uses that summary once, for example

$$\mathbf{J}_M = \sum_a \mathcal{T}_{H_a\to M}[\mathbf{J}^{\mathrm{res}}_{H,a}] + \mathbf{J}^{\mathrm{additional}}_{\mathrm{collective}}. \tag{6.2}$$

The last term is admissible only to the extent that it represents a genuinely additional collective degree of freedom rather than the same microscopic contribution counted again. Independent nested coordinates, a common vector sum, and a hybrid coarse-grained sum remain distinct candidate realizations in the source; this manuscript does not select a physical law by notational convenience.

6.2 Directional coherence and nonzero structure at zero resultant

The source defines a useful dimensionless indicator when the denominator is nonzero:

$$\eta_M = \frac{\left|\sum_i \widetilde{\mathbf{J}}_i\right|}{\sum_i |\widetilde{\mathbf{J}}_i|}, \qquad 0 \le \eta_M \le 1. \tag{6.3}$$

The bounds follow from the triangle inequality. An aligned set can have $\eta_M = 1$; a nonempty exactly balanced set can have $\eta_M = 0$. If every contribution vanishes, the expression is $0/0$ and needs a separate convention; it does not define the same physical state as cancellation of nonzero terms. The indicator measures a chosen resultant, not whether every correlation or local fluctuation has disappeared.

For two equal opposite vectors,

$$\frac{\mathbf{J} + (-\mathbf{J})}{2} = 0, \qquad \frac{|\mathbf{J}|^2 + |-\mathbf{J}|^2}{2} = |\mathbf{J}|^2 > 0. \tag{6.4}$$

This elementary fact makes the Structured Zero pattern concrete in a declared vector example, without identifying δ with a physical source. A large number of constituents alone is not an argument for cancellation: their weights, correlations, and the transport rule matter. Equally, a small first moment does not determine a second moment.

6.3 Local support and large-scale compensation are different operations

The environmental support condition in Section 4 and a small common-frame resultant need not evaluate the same functional. The source requires the local supporting state, while the egg-carton intuition asks about an extended comparison. A zero net acceleration at a symmetry point, for example, is not by definition a zero value of every local geometric or clock quantity. For this proposal the actual support and readout operations still have to be specified together.

It would therefore be incorrect either to declare that compensation makes every electron impossible or to assert that electron stability under compensation has already been proved. The precise compatibility condition is that a physical realization must preserve the required local support while producing the claimed large-scale measurement. The Oort discussion makes this a test of a shared model, not a reason to invent a new threshold for each location.

6.4 Compensation is not dynamical erasure

The structural connection to hydrogen can now be stated without a numerical leap. At H1, radial cancellation and temporal progression are different channels. In the multiscale problem, a compensated directional or geometrical quantity need not remove internal progression, regional clock differences, or evolving volumes. This is an architectural connection between two source statements, not an identity between their microscopic and cosmological operators.

In particular, $\eta_M \simeq 0$ does not calculate either $H_O - H_I$ or f, the rate contrast and volume fraction introduced below. These variables have different owners and dimensions. A constitutive law must connect the source structure to them. Once such a connection is supplied, a dynamically changing compensated texture may have consequences that its static mean alone cannot describe. This is the point at which the egg-carton intuition enters the acceleration argument, rather than serving as an isolated illustration.

7 From local structure to the cosmological mechanism

7.1 The source's cross-scale inference

With the reference and composition rules now explicit, the working appendix follows the same organizing contrast through three scales. At the hydrogen scale, an inward centre is paired with an outward-associated electron boundary or environment. At the Solar-system scale, a concentrated centre is surrounded by a much more extended host environment; the Oort boundary has a Solar-system owner in the project. At galactic and compact-centre scales, concentrated inward-associated regions occupy relatively compact domains while extended environments may occupy much larger ones. (Zero Theory Project 2026c)

These are architectural comparisons, not established dynamical identities. The Sun is not asserted to be a proton, the Solar System is not asserted to be a hydrogen atom, and a galactic environment is not asserted to satisfy the atomic equations with rescaled units. The project separately preserves this non-identity restriction. (Zero Theory Project 2026b) A valid cross-scale connection must specify what is transported from one scale to another: an orientation relation, a coupling rule, a spatial profile, or a dynamical law.

For this paper, the transported proposal is the contrast between concentrated inward domains and extended outward-associated environments, together with the requirement that their common-frame composition and its scale dependence be specified. Its physical extrapolation beyond the elementary system is a stated model inference, not an already measured property of every cosmic void.

7.2 Why the argument concerns volume rather than particle counts

The cosmological inference is not "there are more electrons than protons" or "each electron contributes a fixed repulsive acceleration." It concerns spatial organization. If an inward-associated contribution is highly concentrated and an outward-associated environment extends far beyond it, their relative influence on a large spatial domain need not be determined by counting their microscopic centres.

Volume, however, is not a substitute for amplitude. A large weak contribution may be outweighed by a small strong one. Nor does extension alone determine the rate of volume production. A physical model must supply the spatial strength, the measure used to average it, and the law connecting that strength to evolving geometry. The value of the source's volume argument is that it identifies the correct class of information to investigate, rather than allowing a conclusion from signs alone.

Overlapping environments introduce a second issue. Their physical fields may superpose, interfere, or couple nonlinearly. Their geometric volumes cannot simply be counted repeatedly. Any large-domain calculation must either evaluate the net field at each point or use a non-overlapping partition of the physical domain. An elementary contribution and a composite contribution representing the same underlying structure cannot both be counted as independent sources without an explicit additional interaction.

7.3 How the source introduces acceleration

The source adds an evolutionary step: as structure formation concentrates matter into inward-associated centres, extended environments may become more dominant in their occupied volume and overlap. The relative balance can therefore change with cosmic evolution rather than remaining a fixed cancellation. (Zero Theory Project 2026c)

The intended causal chain is:

structure formation and concentration → changing spatial organization of the two contributions → increasing influence of extended outward-associated environments → a possible accelerating large-scale expansion.

The mechanism seeks real expansion. It is not defined as the claim that all cosmological redshift is an error in spectral interpretation. Time readout may affect the measurement of that expansion, but it does not replace the proposed dynamical process.

The source uses conditional language for the crucial step. Increasing outward-associated dominance is proposed to strengthen the expansion tendency. Whether this yields $\ddot{a} > 0$ depends on the physical rate law, not merely on the existence of a growing volume fraction. Section 9 gives a precise way of separating these statements.

7.4 Explicit premises of the mechanism

The source-derived hypothesis can be stated without hiding its premise burden. It assumes the current electron-fountain/inward-sink architecture; a physical extension of the centre–environment distinction to astronomical hosts; evolution of the relative domain organization during structure formation; and a coupling between that organization and physical spacetime evolution. The first is an author-defined current model geometry. The cross-scale extension and the acceleration link are working model inferences. The final coupling is the object that a quantitative completion must supply. (Zero Theory Project 2026b, 2026c)

An independent dark-energy substance is not inserted into this proposed causal story. That is a feature of its intended ontology, not a proof that the theory has no additional assumptions or functions. A freely fitted replacement function would still carry explanatory responsibility even when it is not called a substance.

8 Time-Sink and the ownership of cosmological time

8.1 One architecture, distinct observable questions

The source's S38 connection associates strong inward presentation with reduced time readout relative to a distant observer. The proposed explanation is that the relevant spacetime contribution progresses away from the material observer's directly accessible plane. The outward electron-associated contribution supplies the complementary accessible presentation. Particle geometry, Time-Sink, and the cosmic centre–environment inference are thus connected by one directional language. (Zero Theory Project 2026c)

The current Time-Sink branch is compatible with acceptance of relativity. It is not obsolete, not automatically an extra force, and not a derived replacement for all relativistic dynamics. In the source, it concerns the possible physical interpretation of observer-owned relativistic readout. The cosmological connection does not change those boundaries. (Zero Theory Project 2026b)

A slow clock comparison cannot by itself establish volume creation, and an expanding spatial domain cannot by itself specify the frequency reported by a receiver. The clock law and geometry law must be supplied together or related explicitly.

8.2 Clock conversion before rate comparison

To make the ownership issue explicit, suppose a regional clock reads τ_r while a large-domain calculation uses a common time parameter t. Write

$$N_r(t) = \frac{d\tau_r}{dt} > 0. \tag{8.1}$$

Here N_r is a dimensionless clock-conversion factor. It is introduced as an operational dictionary, not asserted to have been derived from the source's normal sign. Positive N_r preserves time orientation.

For a regional scale measure a_r, define its clock-owned rate and its common-time rate as

$$H_r^{(\tau)} = \frac{1}{a_r}\frac{da_r}{d\tau_r}, \qquad H_r^{(t)} = \frac{1}{a_r}\frac{da_r}{dt}. \tag{8.2}$$

The chain rule then gives

$$H_r^{(t)} = N_r H_r^{(\tau)}, \tag{8.3}$$

and, with $A_r^{(\tau)} = (1/a_r)d^2a_r/d\tau_r^2$,

$$A_r^{(t)} = N_r^2 A_r^{(\tau)} + \dot{N}_r H_r^{(\tau)}. \tag{8.4}$$

Every term in the last equation has units of inverse time squared, with the appropriate conversion to the chosen common time. The additional derivative term shows why one cannot average regional proper-time accelerations as though every region had already been expressed in the same time convention.

These are exact mathematical consequences of the stated clock conversion. They do not determine N_r. The sign of a second time derivative is not invariant under an arbitrary change of time parameter, as the $\dot{N}_r$ term makes explicit. Consequently, t must be fixed by a declared clock or metric protocol before the later acceleration is interpreted physically. Changing a coordinate label also does not create a new physical observation: emitter clocks, receiver clocks, photon transport, and inferred distance must all be transformed consistently.

8.3 The normal-direction map is not yet a lapse law

A completed Time-Sink cosmology must provide a rule connecting its geometrical state to clock conversion and to spatial evolution. Schematically, it must specify what determines both N_r and the evolution of physical regional volumes. Merely replacing a standard lapse symbol by "Time-Sink" leaves the physical work undone.

This is a narrow missing requirement, not a reason to reopen the resolved operational definition of the hydrogen clock or to discard the source's geometric distinction. The known part is what the model assigns to inward and outward presentation. The unresolved part is the quantitative map from that assignment, its magnitude, and its environment to clock and metric observables.

9 A conditional kinematic translation of the volume mechanism

9.1 A common domain and a declared time

A minimal mathematical question can be answered without inventing a Zero Theory field equation: what conditions would make a volume constructed from two evolving regions accelerate? The following construction is **additional mathematical analysis**, not a claim that outward normal presentation has already been derived to generate a specified expansion rate.

Choose a spatial domain D on a declared family of spatial slices and a common time parameter t. Partition its physical volume into two disjoint, exhaustive regions, labelled O and I:

$$V_D(t) = V_O(t) + V_I(t), \qquad V_O, V_I > 0. \tag{9.1}$$

The labels are intended for a future physical classification of outward-associated environments and inward-associated centres. They do not by themselves imply $\dot{V}_O > 0$ or $\dot{V}_I < 0$. In particular, a normal direction in the particle model is not automatically a three-dimensional cosmological expansion scalar.

Define a volume-based scale measure and a regional rate by

$$a_r(t) = \left[\frac{V_r(t)}{V_r(t_*)}\right]^{1/3}, \qquad H_r = \frac{\dot{a}_r}{a_r} = \frac{\dot{V}_r}{3V_r}, \tag{9.2}$$

for $r \in \{D, O, I\}$ and a reference time t_*. The cube root is a definition appropriate to a three-dimensional volume, not an assumption that every region is a homogeneous miniature universe. A material metric, a spatial measure, and a common-time interpretation must be provided before these mathematical volumes become physical Zero Theory observables.

Let

$$f = \frac{V_O}{V_D}, \qquad 1 - f = \frac{V_I}{V_D}. \tag{9.3}$$

The total rate then satisfies the exact identity

$$\boxed{H_D = fH_O + (1 - f)H_I.} \tag{9.4}$$

The weights are volume fractions, not particle abundances, mass fractions, or probabilities assigned from the electron/proton signs.

9.2 How the fraction evolves

Differentiating $f = V_O/V_D$ gives

$$\dot{f} = \frac{\dot{V}_O}{V_D} - f\frac{\dot{V}_D}{V_D} = 3f(H_O - H_D), \tag{9.5}$$

and hence

$$\boxed{\dot{f} = 3f(1 - f)(H_O - H_I).} \tag{9.6}$$

For $0 < f < 1$, this fraction grows precisely when $H_O > H_I$, provided each H_r includes the full derivative of the volume used to define it. An arbitrary prescribed history of f cannot therefore be combined independently with arbitrary prescribed histories of H_O and H_I.

The identity does not specify the regional rates. That is where the physical mechanism must enter. It also does not establish that changing the observational label attached to a region produces physical expansion. Section 10 separates genuine volume evolution from transfer across a classification boundary.

9.3 The acceleration identity

Define

$$A_r = \frac{\ddot{a}_r}{a_r} = \dot{H}_r + H_r^2. \tag{9.7}$$

Differentiating the weighted rate gives

$$\dot{H}_D = f\dot{H}_O + (1-f)\dot{H}_I + \dot{f}(H_O - H_I). \tag{9.8}$$

Substituting the fraction identity and adding H_D^2 yields

$$\boxed{A_D = fA_O + (1-f)A_I + 2f(1-f)(H_O - H_I)^2.} \tag{9.9}$$

Every term has dimensions of inverse common time squared. The regional accelerations must ultimately contain the effects supplied by the chosen dynamics, including any shear, curvature, stresses, or exchanges. This identity does not replace those equations with its final positive term. The latter is twice the volume-weighted variance of the regional rates. Its sign is nonnegative; its magnitude depends on the difference of the rates, not merely on the size of the outward-associated domain.

This is a familiar kind of partition identity in cosmological averaging. It is derived here from its definitions so that its logical role is transparent, not presented as a new fundamental law or as a novel result of Zero Theory. Related volume-partition and structure-emergent acceleration programmes have been developed in the averaging literature. Their dynamical assumptions must not be silently imported into the present particle-based proposal. (Buchert 2000; Wiegand and Buchert 2010; Clarkson et al. 2011)

For an expanding domain with $H_D > 0$, acceleration of this volume scale in the declared common-time description requires $A_D > 0$. If the weighted regional acceleration is negative, the condition becomes

$$2f(1-f)(H_O - H_I)^2 > -\big[fA_O + (1-f)A_I\big]. \tag{9.10}$$

The compensated-texture discussion does not set this variance to zero. A directional mean, a terminal ray deflection, and the scalar expansion-rate variance are not the same statistic. Conversely, the existence of nonzero local structure does not ensure a sufficiently large expansion-rate variance. The geometry-to-dynamics law must decide both. This is the exact missing connection between the egg-carton picture and the volume calculation, not a missing definition of the original intuition.

The hypothesis therefore has a precise target. A realization must generate regional histories and a common-time map for which the positive term, together with any positive regional acceleration, is sufficiently large. Saying that an outward-associated region occupies most of the volume is not that calculation.

Acceleration also does not require an increasing Hubble rate. For example, the mathematical expansion $a(t) \propto t^2$ at $t > 0$ has $\ddot{a} > 0$ but $H = 2/t$ and $\dot{H} < 0$. Thus "an increasing expansion tendency" must be translated into an explicit criterion rather than assumed to mean $\dot{H} > 0$.

9.4 Two diagnostic examples

The following examples use an arbitrary positive time unit T. They are instantaneous mathematical states, not observational inputs, cosmological simulations, or solutions of Zero Theory or Einstein field equations. Smooth positive local volume functions can realize these derivatives in a sufficiently small time neighbourhood; global dynamical consistency is a separate requirement.

First take

$$f = \tfrac{1}{2}, \quad H_O = \frac{2}{T}, \quad H_I = 0, \quad A_O = A_I = -\frac{1}{T^2}. \tag{9.11}$$

The identities give

$$H_D = \frac{1}{T}, \qquad \dot{f} = \frac{3}{2T}, \qquad A_D = \frac{1}{T^2}. \tag{9.12}$$

Here the total volume scale accelerates even though both regional scale measures have negative instantaneous acceleration. The rate contrast supplies a sufficiently large variance contribution. This establishes a mathematical possibility within the chosen partition description; it does not demonstrate that the proposed particle geometry produces these values.

Now take

$$f = \tfrac{1}{2}, \quad H_O = \frac{1}{T}, \quad H_I = \frac{4}{5T}, \quad A_O = A_I = -\frac{1}{T^2}. \tag{9.13}$$

Then

$$H_D = \frac{9}{10T}, \qquad \dot{f} = \frac{3}{20T}, \qquad A_D = -\frac{49}{50T^2}. \tag{9.14}$$

The outward-labelled fraction still grows, and the total domain still expands, but that expansion decelerates. This is a direct counterexample to the inference "a growing outward-associated volume fraction is sufficient for accelerated expansion." It does not contradict the source's conditional mechanism; it identifies a condition that the mechanism must satisfy.

9.5 Limiting behaviour and saturation

If $H_O = H_I$, the variance term vanishes and the fraction is constant. If one region occupies the entire domain, the variance term also vanishes and the total acceleration reduces to the surviving regional acceleration. Consequently, a mechanism relying on rate contrast cannot infer indefinitely increasing acceleration merely from f approaching unity.

A claimed long-term behaviour must specify whether regional accelerations change, whether rate contrasts persist, how the domains are defined, and whether new structure changes their classification. No asymptotic de Sitter state, equation-of-state parameter, onset redshift, or cosmic age follows from the sign architecture alone.

10 Domain transport, overlaps, and physical closure

10.1 Changing a region label is not creating space

A physically classified region may gain volume because its boundary moves through existing space. To separate this from local expansion, write

$$\dot{V}_O = 3h_O V_O + J, \qquad \dot{V}_I = 3h_I V_I - J, \tag{10.1}$$

where h_O and h_I describe the regional contributions excluding classification transfer, and J has units of volume per common time. Positive J transfers volume into the O category. It cancels from the derivative of total volume:

$$H_D = f h_O + (1 - f) h_I. \tag{10.2}$$

However, the fraction now obeys

$$\boxed{\dot{f} = 3f(1-f)(h_O - h_I) + \frac{J}{V_D}.} \tag{10.3}$$

A growing outward-associated fraction could therefore reflect boundary reclassification rather than the same rate contrast used in Section 9. There is no contradiction: H_O in that section contains the complete volume derivative, whereas h_O here excludes the transfer term. They are different quantities.

For completeness, define $\mathcal{A}_r = \dot{h}_r + h_r^2$. Differentiating the total rate yields

$$\begin{aligned} A_D = {} & f\mathcal{A}_O + (1-f)\mathcal{A}_I + 2f(1-f)(h_O - h_I)^2 \\ & + \frac{J}{V_D}(h_O - h_I). \end{aligned} \tag{10.4}$$

This remains a conditional identity, not a source law. A pure relabelling of a fixed physical domain cannot change its true total volume. In a consistent relabelling, the regional averages and transfer term change together to leave that total unchanged. Treating J as an arbitrary source of cosmic acceleration would violate the purpose of introducing it.

10.2 Overlap is a field question, not an extra volume count

The working source specifically mentions growing overlap among extended environments. Overlapping contributions may act at the same point, but the point occupies only one element of physical volume. A quantitative realization must first determine the combined local state and then integrate it once over the domain.

This requires a superposition or nonlinear interaction rule for the proposed contributions. It cannot be replaced by adding the individual volumes of every electron-associated environment, then adding a second cosmic environment volume generated by the same matter. A many-scale description needs an explicit coarse-graining relation so that the elementary and composite descriptions do not count the same contribution twice.

Similarly, the O/I partition is not a declaration that real space comes in two fundamentally discrete kinds. A continuous spatial state can be classified or averaged into two regions for analysis. The classification is a representation; it does not create new microscopic entities.

10.3 Conservation and regional matching

The term “spacetime production” is a proposed mechanism description. It does not by itself specify an energy source, a stress tensor, a boundary flux, or a conservation equation. A metric completion using Einstein dynamics would have to respect the corresponding local conservation and constraint equations. A different dynamical completion would need its own explicit, internally consistent conservation and matching rules. Neither choice is made by the volume identities.

This requirement should not be mistaken for imposing a globally conserved Newtonian energy on every cosmology. The actual demand is that the chosen dynamical theory consistently account for material evolution, geometry, and exchange between neighbouring regions. A causal source law cannot be replaced by an unconstrained function fitted independently at each epoch.

The current source has supplied a proposed causal architecture. The mathematical translation specifies quantities that need to be computed. Neither the present partition nor the illustrative values complete the intervening physical law.

11 Observable change versus a universal change of scale

11.1 The common-scale cancellation condition

The current Zero Theory records explicitly preserve a common-scale cancellation result. When all relevant material standards and compared quantities change coherently by the same factor, dimensionless comparisons do not acquire a new signal merely because the description has been rescaled. (Zero Theory Project 2026b)

For example, write two frequency standards as

$$\nu_i = \nu_{i,0} s^{-1} \kappa_i, \qquad \nu_j = \nu_{j,0} s^{-1} \kappa_j. \tag{11.1}$$

The common factor s cancels:

$$\frac{\nu_i}{\nu_j} = \frac{\nu_{i,0}}{\nu_{j,0}} \frac{\kappa_i}{\kappa_j}. \tag{11.2}$$

When the remaining factors are also identical, no relative frequency change remains. Calling s a Time-Sink factor does not alter the algebra. A physical explanation must show what observable relation changes after consistent transformation of the source, receiver, and comparison standards.

This does **not** mean every viable cosmological mechanism must violate universal free fall or produce different intrinsic shifts for different atomic species. Real evolution of geometry can alter dimensionless distance and redshift relations without that particular microscopic signature. The requirement is physical distinguishability, not a compulsory species-dependent effect.

11.2 Why a volume scale is not yet an observed scale factor

The function a_D in Section 9 is a cube root of a defined spatial volume. Observed sources lie on a past light cone. A relation between the two requires the geometry along photon paths, source and receiver velocities, time comparison, and selection effects. A spatially averaged acceleration cannot simply be inserted into a homogeneous distance formula and called an observable prediction.

The distinction is well established in work on averaging, backreaction, and the fitting problem in cosmology. Related approaches explore whether inhomogeneous structures can produce effective acceleration or change inferred cosmological parameters, but they do not eliminate the need for a consistent light-cone reconstruction. (Buchert 2000; Clarkson et al. 2011)

11.3 Relation to structure-emergent cosmology

The broad idea of connecting structure formation to effective cosmic acceleration is not unique to Zero Theory. Wiegand and Buchert studied a multiscale partition into over- and underdense domains within a relativistic averaging framework. Their analysis is a particularly close macroscopic comparison for the evolving volume fractions considered here. (Wiegand and Buchert 2010) The present paper claims neither priority for the partition identities nor validation of its microscopic ontology by that work.

Regional clock calibration: Timescape. Wiltshire's Timescape cosmology relates the interpretation of cosmological observations to the calibration of clocks in gravitationally bound wall regions and the volume-average description of a void-dominated universe. Its proposed regional lapse and distinction between bare averaged parameters and parameters dressed for wall observers make the comparison of time rates a physical modeling issue, rather than a universal change of units. (Wiltshire 2007) This is relevant to the owner-resolved clock discussion in Section 8. However, an apparent acceleration inferred by calibrated wall observers must not be identified without calculation with positive $\ddot{a}_D$ in a chosen averaging time. Zero Theory does not derive the Timescape lapse from hydrogen, nor does Timescape establish electron

fountains or proton sinks. The common aim is to connect structure, clocks, and observations; the proposed underlying mechanisms and their present mathematical status differ.

Inhomogeneity and the light cone. Räsänen derived relations between redshift, angular-diameter distance, and averaged expansion for statistically homogeneous and isotropic dust cosmologies, and subsequently generalized the treatment to broader matter content under an explicit slow-evolution condition. The geometry sampled by light and the assumptions selecting a relevant average are essential to these results. (Räsänen 2009; Räsänen 2010) For the present manuscript, this work explains why a small net bending or a nearly compensated spatial pattern cannot, by itself, specify a distance–redshift relation. Optical focusing, source and observer motion, and the evolution of the traversed regions must still be determined. The microscopic fountain–sink construction would have to produce a spacetime and an observational map satisfying these requirements; an assumed volume expansion rate cannot simply replace the rate appearing in a light-propagation calculation.

The specific ambition of Zero Theory is thus a *candidate microscopic geometric engine*: particle-associated, oppositely oriented contributions might generate the regional geometries, clock relations, and correlations that enter macroscopic descriptions. This is an **inverse requirement**, not a completed embedding. The task is to derive those effective quantities from the declared knot dynamics, common-frame transport, and conservation laws, and then compute observables. Existing relativistic averaging and Timescape models already have their own assumptions and equations; they do not logically require the new particle ontology proposed here. No equivalence with them, or exact solution of their field equations from the fountain–sink assignments, is claimed.

11.4 Restrictions on a backreaction interpretation

A balanced comparison must also include restrictive results. Green and Wald proved, within a specified weak-limit framework with small metric deviations and matter satisfying the weak energy condition, that the effective stress–energy generated by small-scale inhomogeneities is traceless and obeys the weak energy condition. In that setting it cannot act as dark energy. (Green and Wald 2011) Buchert and collaborators challenged extrapolating that construction to a general claim that cosmological backreaction is irrelevant, emphasizing the dependence on the limiting and averaging assumptions. (Buchert et al. 2015)

The appropriate response here is neither to ignore the restriction nor to claim that an intuitive microscopic picture evades it. A completed realization must state whether it satisfies the theorem's hypotheses. If it does, its proposed acceleration cannot be attributed to a forbidden effective source. If it does not, the physical reason and the alternative controlled limit must be given. Likewise, the positive variance term in Section 9 is a kinematic identity, not proof that general-relativistic constraints, shear, curvature, and conservation permit the required histories. The sign of an observed acceleration remains a question for the completed dynamics and light-cone map.

12 From the mechanism to observations

12.1 Redshift and distance require a source-to-observer map

Suppose a future realization supplies a spacetime metric and geometric-optics propagation. In units and normalization for which an observer with four-velocity u^μ measures the photon angular frequency as $\omega = -u^\mu k_\mu$, redshift is defined by

$$1 + z = \frac{\omega_e}{\omega_o} = \frac{(-u^\mu k_\mu)_e}{(-u^\mu k_\mu)_o}. \tag{12.1}$$

The subscripts denote emission and observation. This expression is a conditional metric dictionary. The metric, the photon wavevector k_μ, and the observer trajectories must actually be determined; the equation is not a substitute for them. An additional effect on the emitted atomic transition requires a separate source

model and a declared laboratory comparator. For the same identified line, if ν_e is its actual emission frequency, ν_o the received frequency, and ν_{lab} the local comparison value, the spectroscopic convention is

$$1 + z_{\mathrm{line}} := \frac{\nu_{\mathrm{lab}}}{\nu_o} = \frac{\nu_{\mathrm{lab}}}{\nu_e}(1 + z_{\mathrm{prop}}). \tag{12.2}$$

Here $1 + z_{\mathrm{prop}} = \nu_e/\nu_o$ is supplied by the declared propagation and observer model. The product prevents an intrinsic source change from being silently counted a second time as a propagation effect. It also shows why one laboratory hydrogen benchmark does not establish a cosmological redshift law.

For an isotropically specified source luminosity L_e and measured bolometric flux F_o, luminosity distance is defined by

$$D_L^2 = \frac{L_e}{4\pi F_o}. \tag{12.3}$$

The definition depends on how luminosity is calibrated and on the physical propagation law. In the special flat homogeneous FLRW comparator with the conventional redshift–scale-factor relation, it becomes

$$D_L(z) = (1 + z)c \int_0^z \frac{dz'}{H(z')}. \tag{12.4}$$

The standard distance definitions and their assumptions are described by Hogg. (Hogg 1999) This formula is not licensed for H_D merely because H_D was defined in Section 9. A physical and observational map must first justify that substitution or replace the formula with the appropriate light-cone calculation.

The dark-energy branch should therefore remain distinct from the project's dark-matter-oriented spectroscopic question. A non-kinematic shift can alter a reconstructed velocity; a structure-dependent acceleration changes physical geometry or motion. These processes may coexist, but neither follows from the other's name.

12.2 Complementary observational requirements

Supernova distances. A realization must predict flux–redshift relations with declared source calibration, luminosity evolution, propagation assumptions, and uncertainties. Reusing the observations that motivated an acceleration term to set an arbitrary function is a reconstruction, not an independent prediction. The historical supernova papers establish why this comparison matters; they do not test the present mechanism. (Riess et al. 1998; Perlmutter et al. 1999)

Baryon acoustic oscillations. The conventional comparison uses quantities such as D_M/r_d and D_H/r_d, where D_M is transverse comoving distance, $D_H = c/H$, and r_d is the sound-horizon calibration at the baryon-drag epoch. A model changing late-time expansion must specify its distance dictionary and the status of that early-time ruler. It cannot independently retune the ruler for every comparison and retain a claim of independent agreement. These quantities belong to the standard cosmological comparator discussed in the Planck parameter analysis. (Planck Collaboration, Aghanim, et al. 2020)

Cosmic microwave background and structure. Distance to last scattering, acoustic calibration, lensing, and the evolution of perturbations provide connected constraints, not merely a single late-time expansion curve. A structure-dependent mechanism must also explain how the relevant structure develops; treating its observed distribution as a free external function at every epoch would not close that feedback. Temperature, polarization, and lensing constraints in the Planck analysis are a reference set rather than a test already carried out here. (Planck Collaboration, Aghanim, et al. 2020)

Growth and the integrated Sachs–Wolfe signal. Because the proposed cause involves evolving spatial structure, its relation to clustering, peculiar motion, and changing gravitational potentials is an essential discriminator. The source explicitly includes growth and the integrated Sachs–Wolfe effect among the

required comparisons. At present it supplies no quantitative amplitudes or likelihoods for them. (Zero Theory Project 2026c)

Gravitational-wave standard sirens. A gravitational-wave source can provide a distance inference that is combined with an independently identified redshift; the GW170817 standard-siren analysis is a primary example. (Abbott et al. 2017) In Zero Theory, however, the gravitational sector, matter clocks, waveform generation, propagation, and detector calibration must have an explicit relative-coupling map. The current Core forbids assuming that a symbol called a varying gravitational scale automatically predicts a changed siren distance. (Zero Theory Project 2026b)

12.3 The standard-siren coupling distinction

A useful dimensionless target is

$$\Xi(z) = \frac{D_L^{\mathrm{GW}}(z)}{D_L^{\mathrm{EM}}(z)}, \tag{12.5}$$

with both distances defined under mutually consistent source, propagation, and detector conventions. Modified gravitational-wave propagation can change this ratio even when a gravitational wave's propagation speed is c; the (Ξ_0, n) parametrization in Belgacem and collaborators is an external example, not a Zero Theory prediction. (Belgacem et al. 2018)

The source preserves two logically different branches. In a consistent pure change of representation applied to the general-relativistic comparator, rewriting clocks, rulers, and a gravitational scale cannot by itself move the physical ratio away from $\Xi = 1$. In a physically different relative coupling, a nontrivial $\Xi(z)$ is possible only after the coupling, waveform generation, propagation, and detector response have been specified. The branch and any parameters must be fixed before using the same siren observations as a test. (Zero Theory Project 2026b)

The supplied evidence pass classifies this as a genuine observational route whose Zero Theory connection remains open. Its discussion is not an empirical confirmation of the fountain model or the compensated-texture proposal. A spectral comparison, a distance comparison, and a structure statistic that share a decisive calibration must likewise not be reported as three independent validations. (Zero Theory Project 2026g)

12.4 A structure-linked discriminator

The source's PR-4 candidate suggests a distinctive research direction: derive a quantitative relationship between the evolving centre–environment organization and expansion-related observables. A useful test would not merely correlate two quantities known to change with cosmic epoch. It would predict a conditional dependence, sign, amplitude, scale dependence, or joint evolution that can distinguish the proposed mechanism from a declared reference model and from selection effects.

The structural descriptor must be defined before looking at the target residuals. The dynamics and nuisance treatment should be fixed using separate information where feasible. Held-out redshift ranges, independent observing channels, and full covariance treatment should then test the predicted relation. Data sets that share a decisive calibration or upstream empirical input are not independent validations of the same mechanism.

For the compensated-structure branch, the first test must name the quantity claimed to cancel, its spatial scale, the path or sample window, and the orientation convention. A comparison could then ask whether nearly equal net deflections coexist with a predicted, nonzero distance or timing statistic, or whether a structure-conditioned distance residual has the sign and scale fixed by the derived model. The planar curve above is not that prediction. At a larger scale, an intergalactic extension must use galactic resultants constructed under the same rule, rather than assuming exact mirror pairs.

No such data analysis is performed in this paper. These are prospective tests and specifications, not successful comparisons. A preregistered comparison must retain the reference model, selection function, covariance, calibration set, held-out test set, and an outcome that would count against the proposed realization.

12.5 Published observational anchors and their interpretation

The following are selected, dated results from the literature, not a new reanalysis or an exhaustive inventory of measurements available in 2026. They enter as empirical constraints on any future realization. Agreement of a reference cosmology with these observations is not inherited by Zero Theory merely because the same observations motivate its mechanism.

Supernovae and calibrated distances. Pantheon+ contains 1,701 light curves of 1,550 distinct Type Ia supernovae over $0.001 \leq z \leq 2.26$. Brout and collaborators obtained $\Omega_m = 0.334 \pm 0.018$ from supernovae alone in flat ΛCDM. In a flat constant-w comparison, combining supernovae with CMB and BAO information gave $w = -0.978^{+0.024}_{-0.031}$, consistent with $w = -1$. (Brout et al. 2022) The measured light curves and calibrated fluxes must be distinguished from these model-conditioned parameters. For Zero Theory, the target is the calibrated likelihood with source evolution and covariance retained, not copying a fitted w into a fountain coefficient.

BAO and evolving-dark-energy comparisons. The published DESI DR2 analysis uses more than 14 million galaxies and quasars and combines its BAO measurements with a companion Lyman-α analysis. Its BAO results are well described by flat ΛCDM. In a $w_0 w_a$ extension, the combined BAO–CMB analysis favors evolving dark energy at 3.1σ; adding a supernova sample changes the reported preference to 2.8–4.2σ, depending on the sample. (DESI Collaboration 2025) These are conditional model-comparison results, not a direct detection of a new substance or of this paper's mechanism. They motivate testing expansion histories while retaining the sound-horizon calibration, sample dependence, and joint covariance. No DESI likelihood has been evaluated for Zero Theory here.

Voids, compensation, and lensing. Clampitt and Jain measured stacked weak-lensing profiles around about 20,000 SDSS voids, with radii 15–55 h^{-1} Mpc and redshifts 0.16–0.37, reporting a characteristic shear signal with signal-to-noise seven. The inferred profiles were underdense and partially compensated. (Clampitt and Jain 2015) Here $h = H_0/(100\,\mathrm{km\,s^{-1}\,Mpc^{-1}})$ is the survey convention, not Planck's constant. This is relevant to measuring structured environments, but density compensation is not cancellation of spacetime curvature, and a lensing void is not an observed electron fountain. The proper target is a joint prediction for tracer density, shear, velocities, and distances on declared scales. This extragalactic measurement also does not locate the interstellar Zero reference or validate the projected Oort scale.

Independent observing channels, shared inference. CMB temperature, polarization, and lensing constrain early-time calibration and subsequent structure; GW170817 demonstrates an observational standard-siren route. (Planck Collaboration, Aghanim, et al. 2020; Abbott et al. 2017) Neither licenses replacing its propagation model with an uncalibrated H_D. Moreover, the supernova and DESI parameter results above share CMB/BAO information in some combinations. They must not be counted as independent confirmations of the same adjustable history. Section 12.3 retains the separate coupling condition for a gravitational-wave/electromagnetic distance ratio.

The evidential classification is therefore explicit: supernovae and BAO provide *distance constraints*; void lensing provides a *structure-sensitive constraint*; the CMB and sirens supply *additional coupled consistency requirements*. None is presently a passed Zero Theory cosmological test. This classification does not discount the observations; it identifies the missing model-to-measurement calculation needed to use them.

12.6 A distance–expansion consistency test

A useful additional diagnostic is the Clarkson–Bassett–Lu consistency relation. Define dimensionless quantities

$$\mathcal{D}(z) = \frac{H_0}{c}(1+z)D_A(z), \qquad \mathcal{E}(z) = \frac{H(z)}{H_0}, \tag{12.6}$$

and let a prime denote d/dz. In an FLRW spacetime with the standard redshift and distance definitions, irrespective of the dark-energy equation of state,

$$\boxed{C(z) = 1 + \mathcal{E}^2\left(\mathcal{D}\mathcal{D}'' - \mathcal{D}'^2\right) + \mathcal{E}\mathcal{E}'\mathcal{D}\mathcal{D}' = 0.} \tag{12.7}$$

(Clarkson, Bassett, and Lu 2008)

This is an external null test, not a new Zero Theory law. It compares a specified distance reconstruction with an independently constrained expansion function. In an inhomogeneous realization, the radial expansion inferred from light-cone data need not be H_D; a new clock law can also change an age-based inference of H. Thus the definition and estimator of each input must be carried through the proposed physics. A nonzero reconstructed C would require checking covariance, differentiation, calibration, selection, and the reference assumptions; it would not uniquely identify fountains. A value consistent with zero would constrain departures without proving exact local homogeneity. A discriminating Zero Theory prediction must fix a residual before using these data to estimate it. The elementary FLRW limits used to check Eq. (12.7) are recorded in Appendix C.

12.7 Conditional antimatter-sector controls, not evidence for acceleration

The compensated-geometry proposal does not require that oppositely directed astronomical resultants consist of antimatter. The source distinguishes collective gravitational-frame handedness from local charge assignments and particle populations; the latter are not reversed by changing the former. (Zero Theory Project 2026e, C17.5–C17.12) A *literal-antimatter* realization is therefore an additional, separately testable assumption. Its simplest neutral atom is antihydrogen, $\overline{\mathrm{H}} = (\bar{p}, e^+)$, not an ordinary proton renamed with a negative sign. Spatial circulation, normal orientation, charge conjugation, and gravitational acceleration must retain separate definitions.

Laboratory spectral and gravitational controls. ALPHA's 2025 spectroscopy of accessible hyperfine components of the antihydrogen 1S–2S transition was consistent with the corresponding hydrogen expectations. (Baker et al. 2025) A subsequent result, published 27 May 2026, measured the ground-state splitting at about four parts per million:

$$\frac{a_{1S}^{\bar{H}}}{h} = 1{,}420{,}404.8 \ \pm 1.1\,(\text{stat.}) \ \pm 5.6\,(\text{sys.})\ \text{kHz}. \tag{12.8}$$

The splitting was inferred from microwave spectroscopy near a 1-T magnetic field and is consistent with hydrogen. Here h is Planck's constant. (Akbari et al. 2026) These results provide no basis for expecting generically "reversed" optical lines. They constrain a future matter–antimatter readout map; the uncorrected hydrogen benchmark in Section 3 is not a ppm-precision prediction. Separately, ALPHA-g observed antihydrogen motion consistent with attraction to Earth, not upward acceleration of magnitude g. (Anderson et al. 2023) This constrains an antigravity interpretation, not every hypothesis about spatial orientation.

Astronomical population constraints. Dupourqué, Tibaldo, and von Ballmoos selected 14 unassociated Fermi-LAT sources whose spectra were compatible with baryon–antibaryon annihilation. These are candidates, not confirmed antistars. Under a Galactic-disk population assumption resembling ordinary stars, they obtained a 95% upper limit of 2.5×10^{-6} on the local antistar fraction. The limit depends on population and accretion assumptions. (Dupourqué et al. 2021) The Galactic 511-keV annihilation signal

also does not uniquely identify an antistar; its spatial and spectral components require astrophysical source and propagation modeling. (Siegert et al. 2016)

Any quantitative antistar test must declare abundance, distance, ambient gas, relative velocity, matter capture or outflow, annihilation yield, and instrumental sensitivity. Existence alone does not imply a detectable gamma-ray flux. An antinucleus test additionally requires production, charged-particle transport, backgrounds, and detector charge-sign identification. An angular association with an optical star cannot simply be assumed as for photons. A proposed three-channel association must be evaluated against a specified background model, not declared non-accidental by inspection. These requirements are an observational design for the optional branch, not new particle or cosmological predictions. Even a confirmed antistar would not establish that its spacetime contribution causes the acceleration considered in this paper.

13 The remaining physical bridge and its falsifiers

13.1 What is already established within the supplied account

The source contains a definite electron-fountain/inward-sink distinction, a hydrogen centre–environment mechanism, an operational hydrogen-clock reference, and a proposed link between evolving astronomical structure and cosmic expansion. It also contains the explicit Time-Sink connection and the restriction against identifying a universal rescaling with an observable signal. The recovered Oort-owner distinction, interstellar compensation hypothesis, H1 radial/temporal separation, and common-frame composition architecture add specific links to that account. Those elements should not be reclassified as absent simply because a quantitative cosmological solution remains to be derived. (Zero Theory Project 2026b, 2026c)

This paper adds a narrower result: given declared volumes, a common time, and the relevant definitions, the partition and clock-conversion identities follow exactly. The accelerating and decelerating examples delimit what the volume intuition does and does not imply. They sharpen the mechanism's requirements without deriving a new physical coupling.

13.2 What Q-R2C14-03 still requires

The source's existing question **Q-R2C14-03, accelerated-expansion dynamics**, asks for the law that converts the evolving inward/outward volume architecture into a quantitative scale-factor history and observable family. This is the appropriate existing research question, rather than a new request for the author to restate the mechanism. (Zero Theory Project 2026c)

A complete realization would supply six connected elements: a mapping from the native geometry to spatial evolution; a common-time and clock-readout law; a non-double-counted treatment of overlapping environments and domain evolution; target-independent dynamical and boundary conditions; light propagation and distance reconstruction; and perturbation or structure-growth predictions consistent with the same dynamics.

These are requirements of one connected bridge, not six supposedly solved laws or newly registered canonical nodes. The quantities f, H_O, H_I, and N_r introduced here are not substitutes for those laws. Fixing them independently to reproduce a desired expansion curve would supply a phenomenological fit rather than the claimed microscopic explanation.

13.3 What would count against a specified realization

At the **mechanism level**, a derived field map that makes the net environmental effect cancel, makes it too short-ranged, or prevents the required regional rate contrast would undermine the proposed acceleration route. If it predicts nonpositive A_D throughout the target epoch under independently fixed conditions, it fails to produce the intended volume acceleration.

At the **observational level**, the realization must map that history to data. Failure to reproduce the distance and structure observables within a predeclared statistical and systematic treatment would count against that realization even if its averaged volume accelerates. Conversely, agreement with one fitted distance curve would not establish the particle ontology or the other observational channels.

At the **identifiability level**, a supposedly new effect that disappears from every consistently defined dimensionless observation is a redescription, not an observed explanation. A realization indistinguishable from a reference model over the available tests should be described as observationally degenerate, not automatically confirmed or refuted.

These falsifiers apply to the specified realization and its premises. Rejecting one choice of constitutive law does not by itself disprove every possible Zero Theory development. Equally, changing the law after each failed test must not erase the failure of the original prediction.

14 Discussion and conclusion

The proposal developed here begins with material structure rather than an independently introduced dark-energy substance. It connects opposed normal spacetime presentations to hydrogen's centre–environment organization, then asks how similarly organized astronomical environments compose and evolve. The Oort discussion places the initial compensation question inside the Milky Way's interstellar setting. The possible intergalactic extension remains a separate scale of the same composition problem, not an assumed population of exact mirror galaxies.

The conceptual contribution is a distinction between zero expression and absent structure. Volume I supplies the pregeometric version; the egg-carton intuition proposes a physical realization; the H1 account shows why a zero radial readout need not stop temporal progression. Common-frame transport and coarse-graining make the link more precise. They also prevent a small net resultant from being mistaken for the absence of local support or the vanishing of every fluctuation.

The mathematical contribution is conditional and explicit. Matching endpoint tangents does not imply a straight intervening path. A compensated first moment does not force a zero second moment. For disjoint regional physical volumes with one declared time, acceleration of the volume scale depends on regional accelerations and twice their expansion-rate variance. A growing outward-associated fraction is insufficient by itself, while a sufficiently large rate contrast can produce positive total acceleration in the stated kinematic description. None of these identities determines the physical rate contrast from particle geometry.

A quantitative realization must now connect the local supporting state, multiscale geometry, clock conversion, and regional volume histories through one consistent dynamics. It must then calculate the observations, not merely substitute a volume average into a homogeneous distance formula. Boundary transfer, overlap, conservation, light propagation, and the evolution of structure are parts of that same obligation. The laboratory hydrogen benchmark and the inherited 6.2906-light-year projection remain in their own evidential roles; neither is a fitted or derived cosmological acceleration scale.

The resulting manuscript is a complete account of this mechanism proposal, its mathematical consequences, and its tests at the present research stage. It does not report an observed dark-energy replacement or an independently derived $H(z)$. Its central claim is narrower and constructive: **a compensated large-scale presentation can coexist with nontrivial local evolution; whether that evolution produces cosmic acceleration is a well-defined dynamical and observational question within the proposed architecture.**

A General partition identity

For n disjoint regional volumes V_i on the same slices, define $f_i = V_i/V_D$, $H_i = \dot{V}_i/(3V_i)$, and $\sum_i f_i = 1$. Then

$$H_D = \sum_i f_i H_i, \qquad \dot{f}_i = 3 f_i (H_i - H_D). \tag{A.1}$$

Differentiation gives

$$\dot{H}_D = \sum_i f_i \dot{H}_i + 3 \left(\sum_i f_i H_i^2 - H_D^2 \right). \tag{A.2}$$

Since $A_i = \dot{H}_i + H_i^2$,

$$\boxed{A_D = \sum_i f_i A_i + 2 \left(\sum_i f_i H_i^2 - H_D^2 \right).} \tag{A.3}$$

The bracket equals $\sum_i f_i (H_i - H_D)^2$ and is nonnegative for nonnegative volume fractions. For two regions it is $f(1-f)(H_O - H_I)^2$. This proof assumes common-time derivatives and includes any boundary-motion contributions in the volume-defined H_i. When a different transport convention is used, Section 10 supplies the necessary distinction.

B Frame arithmetic and numerical provenance

The following frozen inputs belong to the R2-C15 frame checkpoint, not to a new measurement or fit in this paper:

$$\ell_{P,h} = 4.051350543234878 \times 10^{-35} \text{ m}, \qquad \lambda_L = 8.86 \times 10^{-22} \text{ m}, \tag{B.1}$$

$$C_{L,\text{proj}} = 17098.69442107626 \text{ m}. \tag{B.2}$$

The Local-equivalent circumference is inherited from a Bohr/H1-anchored projection. Its appearance near 17 km is not itself proof of a maximum physical hydrogen orbit or an ionization boundary. (Zero Theory Project 2026d)

Set $K = C_{L,\text{proj}} \lambda_L$. Within the fixed inverse map,

$$C_{O,\text{proj}} = \frac{K}{4\pi \ell_{P,h}}, \qquad C_{Z,\text{proj}} = \frac{K}{\ell_{P,h}} = 4\pi C_{O,\text{proj}}. \tag{B.3}$$

Using $r_{Z,\text{proj}} = C_{Z,\text{proj}}/(2\pi)$ and 1 ly = $299792458 \times 365.25 \times 86400$ m as the conversion convention gives

$$\begin{aligned} C_{O,\text{proj}} &\simeq 2.975685211292831 \times 10^{16} \text{ m}, \\ C_{Z,\text{proj}} &\simeq 3.73935631967734 \times 10^{17} \text{ m}, \\ r_{Z,\text{proj}} &\simeq 5.951370422585662 \times 10^{16} \text{ m} \simeq 6.29060350026247 \text{ ly}. \end{aligned} \tag{B.4}$$

These digits reproduce the stored arithmetic to rounding. They do not provide that many digits of physical predictive accuracy. The constants and the H1 anchor carry their own empirical and modelling provenance, and the physical association of the projected endpoint with any real boundary has not been derived. A finite projected radius is not the infinite curvature radius of an exactly straight path.

The necessary types remain separate: q_F is a dimensionless reference-rate ratio; λ_F is an owned reference wavelength; $C_{F,\text{proj}}$ is a projected equivalent; and a material orbit or local trajectory curvature needs its own map. The Oort reference and hosted L1 relation give a conditional $\lambda_{L1|O} = \ell_{P,h}$ check only in the branch where that transfer is allowed. None of these definitions assigns a cosmological volume-production rate.

The hydrogen arithmetic in Section 3.4 is also reproduced with its declared orbital input and comparator. Those are distinct from the frame projection inputs above. Their common appearance in the hydrogen research programme does not make their outputs independent evidence or mutually exchangeable calibration constants.

C Verification, reproducibility, and assessment

All essential derivations are printed in this article. The PDF additionally carries inert embedded files containing the consolidated LaTeX source, `verify_identities.py`, a machine-readable verification report, and a source/claim manifest. They are optional reproducibility material, not required companion documents, and no program executes on opening the PDF. A PDF reader with attachment support can extract them. The verification command is

```
python verify_identities.py -output verification_results.json
```

The script requires Python 3.10 or later and SymPy; exact runtime versions are recorded in the embedded report. It tests the equations from their premises, including independent volume-derivative expressions, rather than only printing the displayed result.

Verification result. 41 checks passed: the 23 inherited checks were rerun, and 18 added checks cover the frame dictionary, projected endpoint, hydrogen benchmark, compensated geometry, directional coherence, and source/receiver bookkeeping. These are algebraic, arithmetic, limiting-case, counterexample, or input-validation checks. They are not independent physical predictions, a cosmological simulation, or empirical confirmation.

Object of assessment	Result and exact scope
Fountain/sink assignment	Source-recorded model geometry; quantitative metric and detector identification are not established by the sign assignment.
H1 channel separation	Source-recorded radial/temporal distinction; the individual projection operators remain to be derived.
Oort and projected scale	Reference ownership and inherited inverse-map arithmetic reproduced; not a detected astronomical boundary.
Compensated path	Endpoint turning and nonzero local curvature checked for the stated sinusoid; no gravitational ray model claimed.
Volume acceleration	Exact conditional partition identity, limiting cases, transport convention, and both diagnostic examples verified.
Cosmological observations	No new data analysis, likelihood, or fit performed; no observational success or exclusion of the entire theory declared.

The two regional examples use arbitrary time units. The sinusoid uses arbitrary geometric amplitudes and periods. Neither example is a solution of a native Zero Theory field equation. The hydrogen reference is a comparator retained from the source account, not new observational data. The prospective tests must define uncertainty, sensitivity, calibration, and held-out observations before they can produce an empirical assessment.

For version 2.1 the same 41 checks were rerun without changing their physical premises. Three separate symbolic controls verify the borrowed Clarkson–Bassett–Lu relation in flat de Sitter, Einstein–de Sitter, and empty open (Milne) FLRW limits. With $x = 1+z$, the respective pairs $(\mathcal{E}, \mathcal{D})$ are $(1, z)$, $(x^{3/2}, 2[1-x^{-1/2}])$, and $(x, [x - x^{-1}]/2)$. Substitution into Eq. (12.7) gives zero in each case. This checks the normalization and curvature sign of the written relation, not a Zero Theory cosmology or a data-derived null-test result. The 41 inherited checks and these three controls must not be counted as 44 independent physical predictions.

D Source lineage, claim scope, and consolidation record

The scientific argument is self-contained; the following locators preserve provenance rather than outsourcing essential definitions.

Directional cosmology and Time-Sink. The reasoning-rich R2-C14 working appendix supplies A7–A9, S36–S38, D4, and PR-4. S37 contains the concentrated inward-centre/extended-environment acceleration mechanism; S38 connects it to clock readout. The existing question Q-R2C14-03 is the cosmological-dynamics frontier. Its scope is not reset by this manuscript. (Zero Theory Project 2026c)

H1, accumulation, and composition. The corrected C09.5–C09.8 account separates a spacetime increment, its accumulation, and radial growth; C09.17.7 separates radial balance and temporal readout; C09.18–C09.19 preserve hierarchical ownership, common-frame transport, coherence, and exclusion of double counting. C16 specifies environmental support and Oort's non-wall meaning. The later outward-electron correction governs inherited inward-electron wording. (Zero Theory Project 2026e)

Zero and interstellar compensation. The R2-C15 frame checkpoint `ZT-STAGING-FRAME-ENERGY-PROJECTION-CANCELLATION-001` retains the reference-wave ratios, conditional projected endpoint, and compensated-curvature intuition. Volume I, Definitions 1.4 and 3.2, supplies the pregeometric Structured Zero distinction. The author's 18 September 2026 clarification fixes the interstellar origin and the optional intergalactic extension used here. It is recorded as author clarification, not as a measured location of Zero. (Zero Theory Project 2026d; Emamifar 2026; Emamifar 2026, author clarification)

Evidence and numerical branches. Consequence Register v0.9 preserves `ZTC-RECENT-GALACTIC-TRAY`; its repetitions in earlier register packages are one lineage. The first evidence pass treats standard sirens as an open relative-coupling test, not a confirmation. The 16 September current-profile checkpoint keeps the exchange-profile and local-arrival hydrogen branches separate. These documents are source records, not independent experimental replications. (Zero Theory Project 2026f; Zero Theory Project 2026g; Zero Theory Project 2026h)

Retrieval scope. The 21 supplied R2-C15 text parts were reconstructed into 6,359 logical source files with their supplied fragment and source hashes verified. This is byte-level reconstruction, not a claim to have scientifically reviewed every source. Four relevant declared dependency paths were expanded with the supplied retrieval tools and passed their reference checks. The tools explicitly withhold a whole-Core semantic-completeness certificate. This manuscript makes the same scoped distinction. Current source routing governs inherited historical wording; a recovered draft does not override a newer correction.

What this revision changes. Version 2.1 expands the consolidated *Complete EN* version 2.0, retaining its fourteen main sections and four appendices. Section 6 now connects composition to Ellis–Stoeger fitting and Zalaletdinov/Coley–Pelavas–Zalaletdinov averaging. Section 11.3 adds Timescape and Räsänen's optical analysis, and Section 11.4 records the scope of restrictive backreaction results and the published debate. Sections 12.5–12.7 add dated empirical benchmarks, a distance–expansion null test, and a separately conditional antimatter branch. Original geometrical and volume arguments, negative examples, and source ownership are preserved. The full argument and bibliography remain in one reading document. No scientific Core release or Governance change is installed, and no bridge is declared resolved merely by adding a citation.

Reproducible citation and computation files. The distributed PDF embeds its standalone LaTeX source, a BibTeX file for the seventeen references added in this revision, the original identity-verification script and rerun results, the three additional FLRW null-test checks, and a revision manifest. These attachments are optional for reading the article. The LaTeX has a complete in-place bibliography and compiles without an external bibliography processor; the BibTeX entries support reuse in other journal templates. Large project archives and unprovided conversations are not required to read the argument.

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Data availability. No new observational dataset is reported. The cited observational literature is used for definitions, published empirical constraints, and comparison requirements, not as evidence generated by this manuscript. The numerical observational values in Section 12.5 and the laboratory and population controls in Section 12.7 are quoted results from the cited studies. No new posterior, population search, spectrum reduction, or likelihood comparison is reported. No review note, old conversation, or unprovided source file is needed to follow the complete argument printed above.

References

Abbott, B. P. et al. 2017. "A Gravitational-Wave Standard Siren Measurement of the Hubble Constant." *Nature* 551: 85–88. https://doi.org/10.1038/nature24471.

Akbari, R. et al. (ALPHA Collaboration). 2026. "Four ppm measurement of the antihydrogen ground-state hyperfine splitting" *Nature* 653: 1022–1026. https://doi.org/10.1038/s41586-026-10556-x.

Anderson, E. K. et al. (ALPHA Collaboration). 2023. "Observation of the effect of gravity on the motion of antimatter" *Nature* 621: 716–722. https://doi.org/10.1038/s41586-023-06527-1.

Baker, C. J. et al. (ALPHA Collaboration). 2025. "Precision spectroscopy of the hyperfine components of the 1S–2S transition in antihydrogen" *Nature Physics* 21: 201–207. https://doi.org/10.1038/s41567-024-02712-9.

Belgacem, Enis, Yves Dirian, Stefano Foffa, and Michele Maggiore. 2018. "Modified gravitational-wave propagation and standard sirens." *Physical Review D* 98: 023510. https://doi.org/10.1103/PhysRevD.98.023510.

Brout, Dillon et al. 2022. "The Pantheon+ Analysis: Cosmological Constraints" *The Astrophysical Journal* 938: 110. https://doi.org/10.3847/1538-4357/ac8e04.

Buchert, Thomas. 2000. "On Average Properties of Inhomogeneous Fluids in General Relativity: I. Dust Cosmologies." *General Relativity and Gravitation* 32: 105–25. https://doi.org/10.1023/A:1001800617177.

Buchert, Thomas et al. 2015. "Is there proof that backreaction of inhomogeneities is irrelevant in cosmology?" *Classical and Quantum Gravity* 32: 215021. https://doi.org/10.1088/0264-9381/32/21/215021.

Clampitt, Joseph, and Bhuvnesh Jain. 2015. "Lensing measurements of the mass distribution in SDSS voids" *Monthly Notices of the Royal Astronomical Society* 454: 3357–3365. https://doi.org/10.1093/mnras/stv2215.

Clarkson, Chris, Bruce A. Bassett, and Teresa Hui-Ching Lu. 2008. "A general test of the Copernican Principle" *Physical Review Letters* 101: 011301. https://doi.org/10.1103/PhysRevLett.101.011301.

Clarkson, Chris, George Ellis, Julien Larena, and Obinna Umeh. 2011. "Does the Growth of Structure Affect Our Dynamical Models of the Universe? The Averaging, Backreaction and Fitting Problems in Cosmology." *Reports on Progress in Physics* 74: 112901. https://doi.org/10.1088/0034-4885/74/11/112901.

Coley, A. A., N. Pelavas, and R. M. Zalaletdinov. 2005. "Cosmological Solutions in Macroscopic Gravity" *Physical Review Letters* 95: 151102. https://doi.org/10.1103/PhysRevLett.95.151102.

DESI Collaboration (M. Abdul-Karim et al.). 2025. "DESI DR2 Results II: Measurements of Baryon Acoustic Oscillations and Cosmological Constraints" *Physical Review D* 112: 083515. https://doi.org/10.1103/tr6y-kpc6.

Dupourqué, Simon, Luigi Tibaldo, and Peter von Ballmoos. 2021. "Constraints on the antistar fraction in the Solar system neighborhood from the 10-years Fermi Large Area Telescope gamma-ray source catalog" *Physical Review D* 103: 083016. https://doi.org/10.1103/PhysRevD.103.083016.

Ellis, G. F. R., and W. Stoeger. 1987. "The 'fitting problem' in cosmology" *Classical and Quantum Gravity* 4: 1697–1729. https://doi.org/10.1088/0264-9381/4/6/025.

Emamifar, S. M. H. 2026. *Zero Theory, Volume I*, revised aligned version 2.4. Definitions 1.4 and 3.2 on Structured Zero. Author-provided foundational manuscript preserved in the R2-C15 provenance collection.

Emamifar, S. M. H. 2026. Author clarification, 18 September 2026, supplied in the present manuscript-development exchange. The straight-reference motivation is interstellar within the Milky Way; compensation between galactic resultants is an additional possible extension. The substantive clarification is reproduced in Section 4.

Emamifar, S. M. H. 2026. "Time-Sink and Apparent Dark Matter in Zero Theory: Hydrogen Calibration, Spectral Readout, and a Conditional Spacetime Mechanism," version 1.0, Sections 2–4. Author-provided source/readout account preserving the updated time-to-hydrogen manuscript's complete shell-and-field recurrence and the local-arrival benchmark. This is a project source, not independent observational evidence.

Green, Stephen R., and Robert M. Wald. 2011. "A new framework for analyzing the effects of small scale inhomogeneities in cosmology" *Physical Review D* 83: 084020. https://doi.org/10.1103/PhysRevD.83.084020.

Hogg, David W. 1999. "Distance Measures in Cosmology." https://arxiv.org/abs/astro-ph/9905116.

Perlmutter, Saul et al. 1999. "Measurements of Omega and Lambda from 42 High-Redshift Supernovae." *The Astrophysical Journal* 517: 565–86. https://doi.org/10.1086/307221.

Planck Collaboration, N. Aghanim, et al. 2020. "Planck 2018 Results. VI. Cosmological Parameters." *Astronomy and Astrophysics* 641: A6. https://doi.org/10.1051/0004-6361/201833910.

Räsänen, Syksy. 2009. "Light propagation in statistically homogeneous and isotropic dust universes" *Journal of Cosmology and Astroparticle Physics* 2009: 011. https://doi.org/10.1088/1475-7516/2009/02/011.

Räsänen, Syksy. 2010. "Light propagation in statistically homogeneous and isotropic universes with general matter content" *Journal of Cosmology and Astroparticle Physics* 2010: 018. https://doi.org/10.1088/1475-7516/2010/03/018.

Riess, Adam G. et al. 1998. "Observational Evidence from Supernovae for an Accelerating Universe and a Cosmological Constant." *The Astronomical Journal* 116: 1009–38. https://doi.org/10.1086/300499.

Siegert, Thomas et al. 2016. "Gamma-ray spectroscopy of positron annihilation in the Milky Way" *Astronomy and Astrophysics* 586: A84. https://doi.org/10.1051/0004-6361/201527510.

Wiegand, Alexander, and Thomas Buchert. 2010. "Multiscale Cosmology and Structure-Emerging Dark Energy: A Plausibility Analysis." *Physical Review D* 82: 023523. https://doi.org/10.1103/PhysRevD.82.023523.

Wiltshire, David L. 2007. "Cosmic clocks, cosmic variance and cosmic averages" *New Journal of Physics* 9: 377. https://doi.org/10.1088/1367-2630/9/10/377.

Zalaletdinov, R. M. 1992. "Averaging out the Einstein equations" *General Relativity and Gravitation* 24: 1015–1031. https://doi.org/10.1007/BF00756944.

Zero Theory Project. 2026a. "Project Governance Operating Contract, Version 1.22."

———. 2026b. "R2-C15 Synchronized Scientific Records: Knowledge Base, Canonical Reasoning Database, and Master Reasoning Ledger."

———. 2026c. "Reasoning-Rich Working Appendix After V0.58, Epoch 2, R2-C14."

Zero Theory Project. 2026d. "Frame-energy and compensation research checkpoint." R2-C15 synchronized source distribution, 14 September 2026; checkpoint `ZT-STAGING-FRAME-ENERGY-PROJECTION-CANCELLATION-001`. Internal author-provided research source.

Zero Theory Project. 2026e. "Cumulative Appendix after v0.58, Epoch 1, C01–C22: R2-C13 Corrected View." Especially C09.5–C09.8, C09.17–C09.19, and C16; read with the current outward-electron terminology correction. Internal author-provided research source.

Zero Theory Project. 2026f. “Consequence Register,” version 0.9. Card ZTC-RECENT-GALACTIC-TRAY and related environmental and multiscale records. Author-provided frozen research register, not an independent empirical evidence source.

Zero Theory Project. 2026g. “First evidence pass against frozen consequence cards.” Author-provided Persian source ZERO_THEORY_EVIDENCE_PASS_01_FA.md, especially Section 6. The present article paraphrases the relevant classification in English.

Zero Theory Project. 2026h. “Current-profile provenance and continuation checkpoint.” 16 September 2026; companion to Consequence Register v0.8. Author-provided source distinguishing the current-profile/exchange calculation from the local-arrival hydrogen-frequency branch.