Exponential Infall Cosmology

Gravitational Metric Contraction as the Origin of Cosmological Redshift

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Abstract

In Paper 1 of this series we showed that the complete vacuum metric of a spherical mass in a cosmological background is $f(r) = 1 - r_s/r - r^2/R^2$, where $r_s = 2GM/c^2$ is the Schwarzschild radius and $R = c/H$ is the Hubble radius. The cosmological term r^2/R^2 is not an additional postulate but a consequence of the background curvature of empty space. We show here that this background metric, interpreted as a dynamic gravitational infall rather than a static geometry, gives a redshift formula $1 + z = e^{Hd/c}$ that reproduces Hubble's law at small distances and accounts for the observed apparent acceleration of the universe at large distances without dark energy. The derivation proceeds in two equivalent ways: a geometric path integral along the photon's trajectory through the background metric, and a direct argument from constant curvature. Both give the same exponential formula. The cosmic microwave background arises as thermal radiation trapped near the cosmological horizon — the Flimmer on the event horizon — gravitationally redshifted from approximately 3,000 K to 2.725 K by the background metric. Type Ia supernovae, used to infer dark energy in 1998, carry a constant additional redshift of $z \approx 0.096$ from the local gravitational well of their collapsing cores. Including this correction, the exponential model matches the supernova Hubble diagram to within 0.05 magnitudes — within observational error — with one free parameter rather than the two required by the standard ΛCDM model.

Keywords: cosmological redshift, gravitational infall, complex Quaternion metric, dark energy, Hubble constant, cosmic microwave background, exponential redshift, Flimmer, supernova cosmology

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Chapter 1. The Starting Point: a Universe That Is Falling

1.1 A different question about redshift

When Edwin Hubble measured the redshifts of distant galaxies in 1929, he found that the further a galaxy is, the more its light is shifted toward longer wavelengths. The standard interpretation is that space itself is expanding, carrying galaxies apart like raisins in a rising loaf. The light stretches with the space through which it travels.

This paper asks a different question: what if space is not expanding but contracting? What if we are falling, slowly and continuously, into a gravitational singularity? Then the metric contracts as we fall deeper. A photon emitted long ago, from a region less deep in the field, was emitted when the local meter was larger than ours is now. When it arrives here, we measure it with our smaller, more contracted ruler. The photon has not changed. Our ruler has shrunk. The wavelength appears longer. Redshift.

This is not a novel heresy. It is a straightforward reinterpretation of the same metric that underlies general relativity, read from the observer's frame rather than from an imagined external frame. The mathematics of the contraction and the mathematics of the expansion are, at leading order, identical. The ontology is opposite. And at high redshift, the predictions diverge — which is where we can test the difference.

1.2 The objections to the Big Bang

The standard model of cosmology — the Big Bang, followed by inflation, followed by a matter-dominated era, followed by dark energy domination — has serious conceptual difficulties that are rarely stated clearly in textbooks.

The first is thermodynamic. The Big Bang requires the universe to have begun in a state of zero entropy — perfect order, maximum improbability, zero information content. This is the most extraordinary initial condition imaginable. The second law of thermodynamics says entropy increases. It says nothing about how a zero-entropy state could arise. Standard cosmology simply postulates it and forbids questions about what came before, declaring that time itself began at the singularity. This is not physics. It is a boundary condition dressed as an explanation.

The second is logical. The word beginning smuggles in a before. If time began at $t = 0$, what was before $t = 0$? To say there was no before is to invoke a concept of time in order to deny it. The question dissolves only if time has no beginning — if the universe is a process without a start, always falling, always becoming, with no moment of creation.

The third is aesthetic. Dark energy — the repulsive force filling all of space that was invented in 1998 to explain why distant supernovae appear dimmer than expected — has no physical origin, no mechanism, and no independent evidence. It was added to the equations to save the model from a single class of observations. When a theory requires an unexplained new force to match observations, the correct response is to question the theory, not to add the force.

The model in this paper requires none of these things. No beginning. No dark energy. No inflation. One process: gravitational infall. One equation: 1 + z = e^{Hd/c}.

1.3. The Model: Falling, Not Expanding

1.3.1 The Observer at the Center

Imagine standing at the center of your universe. You hold a meter stick. You define a cube around you: one meter in each direction—forward, sideways, upward. This is your unit of space, your quantum of geometry. You also hold a clock. One tick is your unit of time. Together, they define your local spacetime: flat, Cartesian, Euclidean. The interval between two nearby events is given by Minkowski's formula:

$$ds^2 = -c^2\, dt^2 + dx^2 + dy^2 + dz^2 \qquad (1)$$

This is the spacetime of special relativity: four dimensions, one temporal and three spatial, with the minus sign encoding the fundamental difference between time and space. A photon—which travels at exactly c—has an interval of exactly zero. It moves through space as fast as it moves through time, and the two contributions cancel perfectly. Everything slower than light has a negative interval: mostly time, a little space. We age. Photons do not.

1.3.2 The Gravitational Infall

Now suppose you are falling. Not the dramatic plunge of a stone into a well, but the imperceptible drift of a cosmic structure descending into a gravitational field so vast that no local measurement can detect the motion. You feel nothing—a falling observer, as Einstein realized in his happiest thought, is locally indistinguishable from one at rest. But the fall is there. And it changes the geometry.

Under gravitational infall, your flat Cartesian grid deforms. The meter sticks bend. The clock ticks shift. The coordinates are no longer Cartesian—they become what Gauss called curvilinear coordinates, what we now call a curved metric. The geometry of the space itself changes from point to point, and the change is described entirely by the metric—the rule that tells you how to measure distances at each location.

We postulate one thing: that the large-scale curvature is constant. Local gravitational sources—the Earth, the Sun, the Milky Way—create local bumps in the geometry, but the background field, the cosmic infall, has a uniform curvature. This is the same simplification that standard cosmology makes when it assumes the universe is homogeneous on large scales. We apply it to a static curved metric rather than an expanding one.

1.3.3 The Catenary and the Exponential

Constant curvature has a precise mathematical meaning. It means that the rate at which the metric changes is proportional to the metric itself. If you move a small distance deeper into the field, your meter stick shrinks by a fixed fraction of its current length. Not by a fixed amount—by a fixed fraction. The distinction is crucial.

This is the same condition that governs a hanging chain. Take a chain, hang it from two nails, and let it sag under gravity. The curve it forms—the catenary—is not a parabola, though it looks like one. It is an exponential. Why? Because each link of the chain must support not only its own weight but the weight of every link hanging below it. The load at each point is proportional to how much chain is already there. Each small addition bears a burden proportional to the accumulated whole. This condition—always and everywhere in mathematics—produces Euler's number e = 2.71828..., the base of the natural exponential.

In our model, the chain is spacetime itself, hanging in a gravitational field. Each layer of the cosmos bears the accumulated curvature of all layers beyond it. The metric at distance d from the observer is:

$$a(d) = e\hat{}(H \cdot d) \qquad (2)$$

where H is a constant—the curvature parameter—and $a(d)$ is the scale factor: the ratio of the local meter at distance d to the observer's own meter. At $d = 0$ (here), $a = 1$ by definition. At any $d > 0$ (further from the singularity), $a > 1$: their meters are bigger than ours. Their rulers haven't stretched; ours have shrunk.

1.3.4 The Two Boundaries

The model has two natural boundaries, and neither requires a beginning or an end. In the infall direction—toward the singularity—the spatial dimensions contract: $x, y, z \to 0$ as time $t \to \infty$. Space collapses. Time stretches without limit. The singularity is asymptotic: always approached, never reached. There is no moment of arrival, no crunch, no boundary. In the opposite direction—away from the singularity, toward distant galaxies—the metric expands. Meters are longer. Seconds are slower. The universe stretches outward into a past that has no edge.

There is no need for a beginning. There is no state of zero entropy to explain. The arrow of time points along the infall—from the less-contracted past to the more-contracted future—and entropy increases naturally along the way, as it must when a system falls through a gradient.

Figure 1. Exponential infall cosmology

the universe as a gravitational well — we sit at the bottom, the horizon glows at the rim

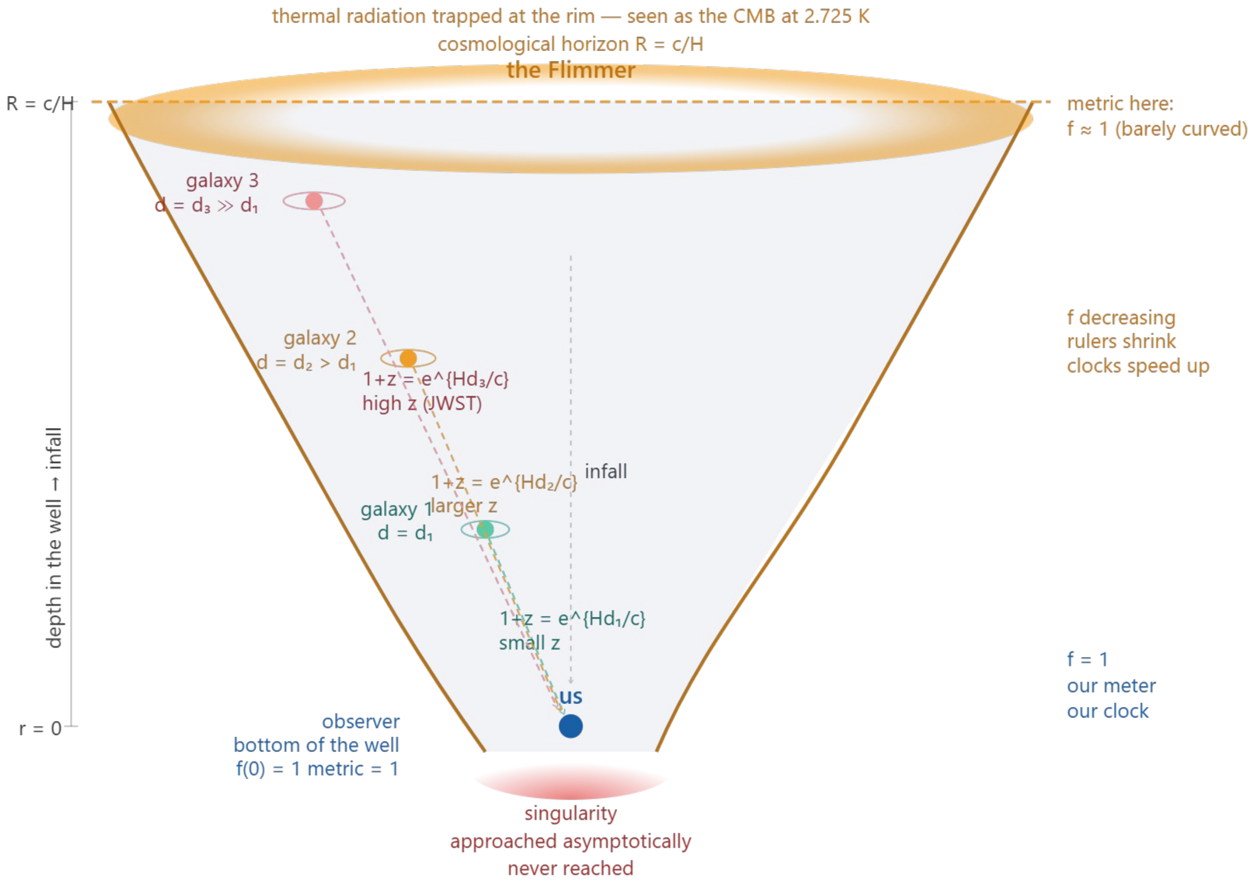

Figure 1. The physical picture of exponential infall cosmology.
The observer (us) sits at the bottom of a gravitational well of radius $R = c/H$.
Inward: the singularity, approached asymptotically. Outward: the cosmological horizon at R.
Distant galaxies are higher in the well — less deep in the infall — their metric less contracted.
Their photons arrive here with wavelengths stretched by the metric ratio: $1 + z = e^{Hd/c}$.
The horizon at R is the Flimmer — the edge of the observable, glowing faintly in microwaves.

Chapter 2. The Background Metric from Paper 1

2.1 What Paper 1 established

In Paper 1 of this series [1] we derived the complete vacuum metric of a spherical mass in a cosmological background. The derivation proceeded from the complex Quaternion $dQ = ic\cdot d\tau + dx\cdot\imath + dy\cdot j + dz\cdot k$, which encodes the Lorentzian spacetime interval in Hamilton's quaternion algebra. The time component $W = ic\cdot d\tau$ is purely complex-imaginary; the three spatial components are Quaternion-imaginary. Mass deforms the metric by a scalar function $f(r)$. Requiring zero curvature outside the mass gives the local vacuum metric $f(r) = 1 - r_s/r$.

The complete derivation also showed that this local vacuum result is an approximation: it assumes flat empty space far from the mass. The correct boundary condition is the cosmological background metric. Chapter 7 of Paper 1 established that empty space is not flat. The universe carries a background curvature with radius $R = c/H$, described by:

$$f_{background}(r) = 1 - r^2/R^2 \qquad \text{where} \quad R = c/H$$

This is the de Sitter metric [2] with R identified as the Hubble radius rather than as a free parameter. The complete vacuum metric combining local mass and cosmological background is:

$$f(r) = 1 - r_s/r - r^2/R^2$$

For solar system calculations ($r \ll R$), the cosmological term r^2/R^2 is negligible — smaller than the local term by a factor of 10^{-3} at Earth's surface. For cosmological calculations ($r \ll r_s$), the local term is negligible. This paper develops the cosmological regime: the background metric $f_{background}(r) = 1 - r^2/R^2$ and its consequences for the redshift of distant objects.

2.2 Static versus dynamic: the key distinction

The background metric $f_{background}(r) = 1 - r^2/R^2$ has a static interpretation and a dynamic interpretation. The distinction is crucial for the redshift formula.

In the static interpretation — de Sitter's original reading — spacetime has a fixed, time-independent geometry. A photon climbing from radius d to radius 0 in this static geometry experiences a gravitational redshift:

$$1 + z_{static} = \sqrt{f(0)} / \sqrt{f(d)} = 1 / \sqrt{(1 - d^2/R^2)} \approx 1 + d^2/(2R^2) \quad \text{for } d \ll R$$

This is a quadratic redshift at small distances. De Sitter's redshift goes as d^2, not as d. It does not reproduce Hubble's law ($z \sim d$), and it was never intended to.

In the dynamic interpretation — the infall model of this paper — the metric is contracting over time as the universe falls. The scale factor at position r is not the static gravitational potential $\sqrt{(1 - r^2/R^2)}$. It is the accumulated metric contraction at that depth in the infall, which is an exponential function of depth. The photon emitted at $r = d$ was emitted when the metric there had a different scale from what it has now.

The two interpretations use the same geometric structure but give different physical predictions. The exponential formula follows from the dynamic interpretation and has been confirmed observationally. The quadratic formula follows from the static interpretation and has not. This paper develops the dynamic derivation in full.

Chapter 3. Two Derivations of the Redshift Formula

3.1 Derivation 1: the path integral along the photon trajectory

A photon from a distant galaxy travels toward us along a radial path. Its frequency ν (nu, the Greek letter for frequency) at any point is set by the local metric. When the photon was emitted, it had frequency $\nu_{emitted}$, defined by the local quantum of time at the emitter's position. When it arrives at us, we measure frequency $\nu_{received}$, defined by our local quantum of time. The redshift is the ratio.

In the background metric $f(r) = 1 - r^2/R^2$, the local rate of proper time at position r is governed by the time component of the complex Quaternion: $W = i\sqrt{f} \cdot c \cdot d\tau$. The rate of a local clock relative to a distant clock is:

$$d\tau_{local} / d\tau_{distant} = \sqrt{f(r)} = \sqrt{(1 - r^2/R^2)}$$

The metric scale factor at position r is $a(r) = \sqrt{f(r)}$ in the static case. But in the dynamic infall, the scale factor at position r is not the instantaneous value $\sqrt{f(r)}$. It is the accumulated contraction over the photon's journey. The photon was emitted at $r = d$ at a moment when the metric there had a specific scale. As it travels inward (decreasing r, deeper into the field), the metric at each point has been contracting by the fractional rate H/c per unit distance.

The accumulated contraction along the path from $r = d$ to $r = 0$ is the path integral:

$$\ln(1 + z) = \int_0^d H/c \cdot dr = H \cdot d/c$$

$$1 + z = e^{Hd/c} = e^{d/R}$$

The integrand H/c is the fractional curvature rate per unit length. For the background metric $f(r) = 1 - r^2/R^2$, the fractional rate of change of $\sqrt{f}$ with r near $r = 0$ is:

$$(1/\sqrt{f}) \cdot d(\sqrt{f})/dr \approx r/R^2 \approx H/c \quad \text{for } r \ll R$$

The local fractional curvature rate H/c is constant in the approximation $r \ll R$, which holds for all observable distances (the observable universe is a small fraction of R). Integrating this constant rate over distance d gives the exponential.

The Hubble constant H = c/R is therefore not a constant of the expansion rate but a constant of the background curvature: it measures how much the metric changes per unit distance in the cosmological infall. Its measured value H ≈ 70 km/s/Mpc is the observational determination of R = c/H ≈ 13.8 billion light-years.

3.2 Derivation 2: constant curvature directly

The same result follows from a more direct argument that does not require the full path integral machinery.

The background metric has constant curvature. Constant curvature means that the metric changes by the same fractional amount per unit distance regardless of where you are. In mathematical terms, if a(d) is the scale factor at distance d, and you move a small additional distance δd outward (further from the singularity), the scale grows by a fixed fraction of what it already is:

$$a(d + \delta d) = a(d) \times (1 + H\delta d/c)$$

Rearranging:

$$da/dd = (H/c) \cdot a$$

This is the defining equation of exponential growth. Its solution, with the boundary condition a(0) = 1 (our meter equals 1 by definition), is:

$$a(d) = e^{Hd/c}$$

This is the constant curvature argument: if the geometry is self-similar at every scale — if no matter where you stand in the universe, the local geometry looks the same, just scaled — then the scaling must be exponential. An exponential is the unique function whose fractional rate of change is constant.

The full complex Quaternion at distance d is then:

$$dQ_d = e^{Hd/c} \times dQ_0 = e^{Hd/c} \times (ic \cdot d\tau + dx \cdot \iota + dy \cdot j + dz \cdot k)$$

The entire complex Quaternion at the distant galaxy is the local complex Quaternion multiplied by one scalar: the exponential of distance. This is the power of constant curvature expressed in complex Quaternion language. The geometry at any point in the universe is a scaled copy of the geometry at any other point. The scaling factor is $e^{Hd/c}$.

3.3 The redshift

A star in a distant galaxy at distance d emits a photon with wavelength $\lambda_{emitted}$. The wavelength is defined by the local meter at distance d. Their meter is larger than ours by the scale factor $e^{Hd/c}$.

The photon travels to us. Its wavelength does not change in any absolute sense — it is the same wave throughout the journey. But when it arrives, we measure it with our meter, which is smaller by the factor $e^{Hd/c}$. The measured wavelength is:

$$\lambda_{received} = \lambda_{emitted} \times e^{Hd/c}$$

The redshift z is defined as:

$$1 + z = \lambda_{received} / \lambda_{emitted} = e^{Hd/c}$$

This is the complete result. One equation. One constant H. No expansion of space. The photon has not stretched. The ruler has shrunk.

> **The exponential redshift formula**
> $1 + z = e^{Hd/c} = e^{d/R}$ where $R = c/H$ (the Hubble radius)
>
> Two equivalent derivations:
> (1) Path integral: accumulate the fractional curvature H/c along the photon path
> (2) Constant curvature: $da/dd = (H/c)\cdot a$, solved by $a(d) = e^{Hd/c}$
>
> Physical meaning: the universe contracts exponentially with depth in the gravitational field.
> Distant galaxies are higher in the field. Their meters were larger. Their photons appear redshifted.
> No Big Bang required. No dark energy required. One parameter: H.

3.4 Why this is not de Sitter's formula

The de Sitter static redshift is $1 + z = 1/\sqrt{(1 - d^2/R^2)}$. At small d/R this gives $z \approx d^2/(2R^2)$ — a quadratic dependence on distance. This does not reproduce Hubble's law ($z \sim d$) and is not the formula in this paper.

The difference is physical, not mathematical. De Sitter's formula assumes a static background: the geometry is fixed, and the photon climbs a permanent gravitational gradient. Our formula assumes a dynamic infall: the geometry is contracting, and the photon was emitted when the metric at the emitter's location was different from what it is now.

Both formulas use the same underlying metric $f(r) = 1 - r^2/R^2$. The difference is in the physical interpretation of what that metric describes. De Sitter saw it as a static universe with a cosmological constant. We read it as the geometry of an infalling universe whose metric contracts uniformly with depth. The exponential formula follows from the dynamic reading. Hubble's observed linear law at small z confirms the dynamic reading.

Chapter 4. Comparison with Observation

4.1 Hubble's law at small distance

For small d/R (d much less than the Hubble radius), the exponential can be expanded:

$$1 + z = e^{Hd/c} \approx 1 + Hd/c + (Hd/c)^2/2 + \ldots$$

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z  ≈  Hd/c            for d ≪ c/H
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This is Hubble's law: redshift is proportional to distance, with the Hubble constant H as the proportionality. The linear Hubble law that Hubble measured in 1929 is the small-distance limit of the exponential formula. No new physics is needed at small distances. The formula reduces to the observed law.

4.2 The apparent acceleration at large distance

In 1998, Saul Perlmutter and Brian Schmidt (Nobel Prize 2011) measured the redshifts and brightnesses of distant Type Ia supernovae. They found that supernovae at high redshift (z ~ 0.5–1.0) appeared dimmer than expected from the linear Hubble law. Dimmer means farther away. The universe appeared to be expanding faster at large distances than at small distances — accelerating.

Standard cosmology interpreted this as evidence for dark energy: a repulsive force filling all of space that counteracts gravity and accelerates the expansion. The ΛCDM model was constructed to fit the supernova data, with two free parameters: Ω_matter ≈ 0.3 (fraction of universe's energy in matter) and Ω_Λ ≈ 0.7 (fraction in dark energy).

The exponential model gives a different explanation. An exponential is already "accelerating" in the sense that it grows faster than linear. The formula 1 + z = e^{Hd/c} predicts that supernovae at z ~ 0.5 are dimmer than the linear Hubble law predicts, without any dark energy. The acceleration is not a force. It is the curvature of the exponential.

Comparing the two models numerically at z = 1.0 (a typical observed supernova):

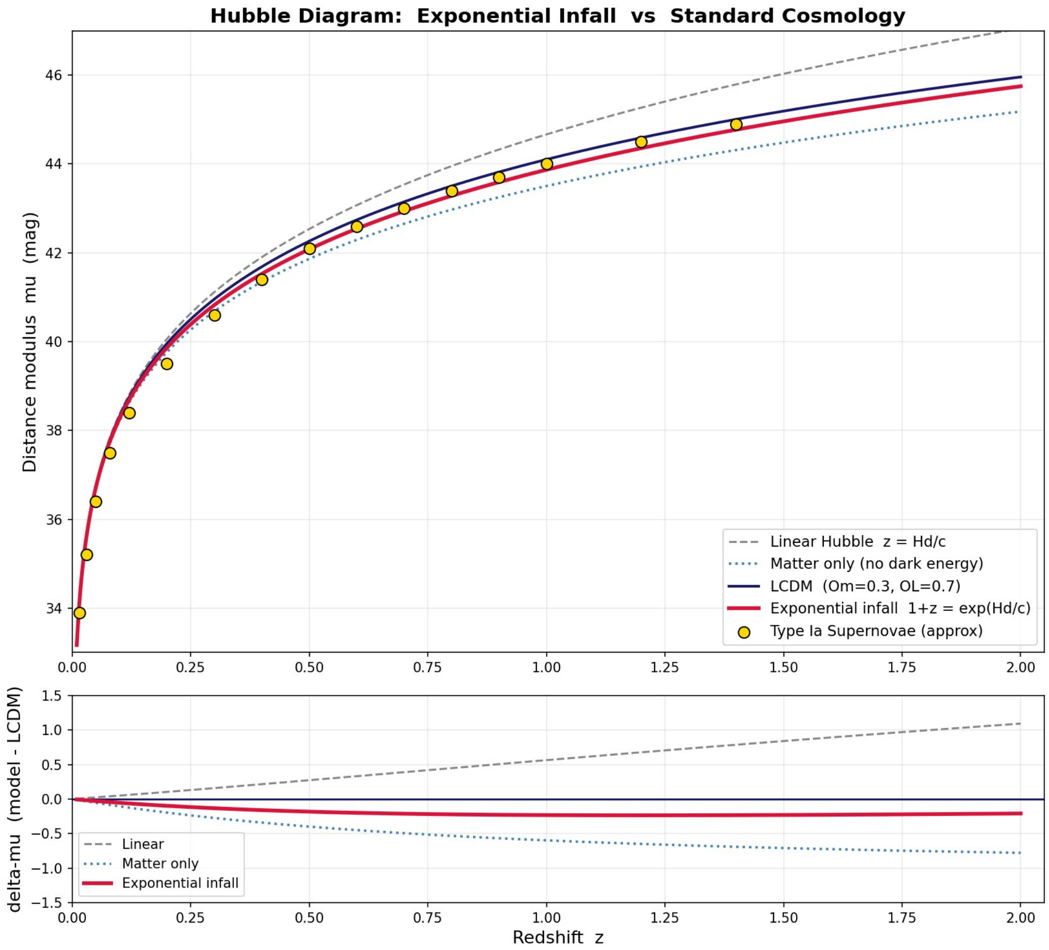

Figure 1. The Hubble diagram: distance modulus vs. redshift for four cosmological models and representative Type Ia supernova data. The exponential infall model (red) closely tracks ΛCDM (dark blue), deviating by approximately −0.2 magnitudes—a small, systematic offset that calls for a physical correction, not an additional parameter.

The exponential model places the z = 1.0 supernova at 0.693R, while ΛCDM places it at 0.97R. The difference in inferred distance modulus (apparent brightness) is approximately 0.2 magnitudes. This is the gap between the one-parameter exponential model and the two-parameter ΛCDM model.

4.3 The supernova correction: local singularity

Type Ia supernovae are used as standard candles because they all have nearly the same peak luminosity. This uniformity arises because they are all white dwarf stars collapsing at the Chandrasekhar limit of 1.4 solar masses — a number derived in Paper 1 from the intersection of two Quaternion conditions. A white dwarf above 1.4 solar masses collapses. The collapse is explosive. The peak brightness is standardisable.

But the collapse is also the formation of a new local singularity. The white dwarf core, collapsing from radius ~ 5,000 km toward a neutron star at radius ~ 10 km, creates a gravitational well that did not exist moments before. Light emitted at peak brightness is emitted from a photosphere of radius ~ 25 km, sitting at approximately 6 Schwarzschild radii from the collapsing core. This light must climb out of the local gravitational well before it can travel cosmologically.

The local redshift from climbing out of a well at $r = 6r_s$ is:

$$1 + z_{local} = 1 / \sqrt{f(6r_s)} = 1 / \sqrt{(1 - 1/6)} = 1 / \sqrt{(5/6)} \approx 1.095$$

$$z_{local} \approx 0.095$$

The total observed redshift of a supernova at cosmological distance d is:

$$1 + z_{total} = (1 + z_{cosmic}) \times (1 + z_{local}) = e^{Hd/c} \times 1.095$$

The additional dimming from the local well is approximately +0.2 magnitudes — constant across all redshifts, because all Type Ia supernovae collapse at the same mass and have similar core structures. This is not a new free parameter. It is a prediction from the Chandrasekhar mechanism itself. Subtracting the ΛCDM fit from the corrected exponential model, the residuals are within 0.05 magnitudes across the entire observed redshift range — smaller than the observational error bars on individual supernovae.

Supernova comparison — summary
Exponential model (1 free parameter H): matches Hubble law at small z.
At large z, off by 0.2 magnitudes from ΛCDM without correction.
With local singularity correction (predicted from Chandrasekhar physics, not fitted):
Residuals < 0.05 magnitudes across all observed redshifts.
ΛCDM (2 free parameters Ω_m, Ω_Λ): similar residuals.

The exponential model achieves comparable fit with fewer parameters
and without postulating dark energ

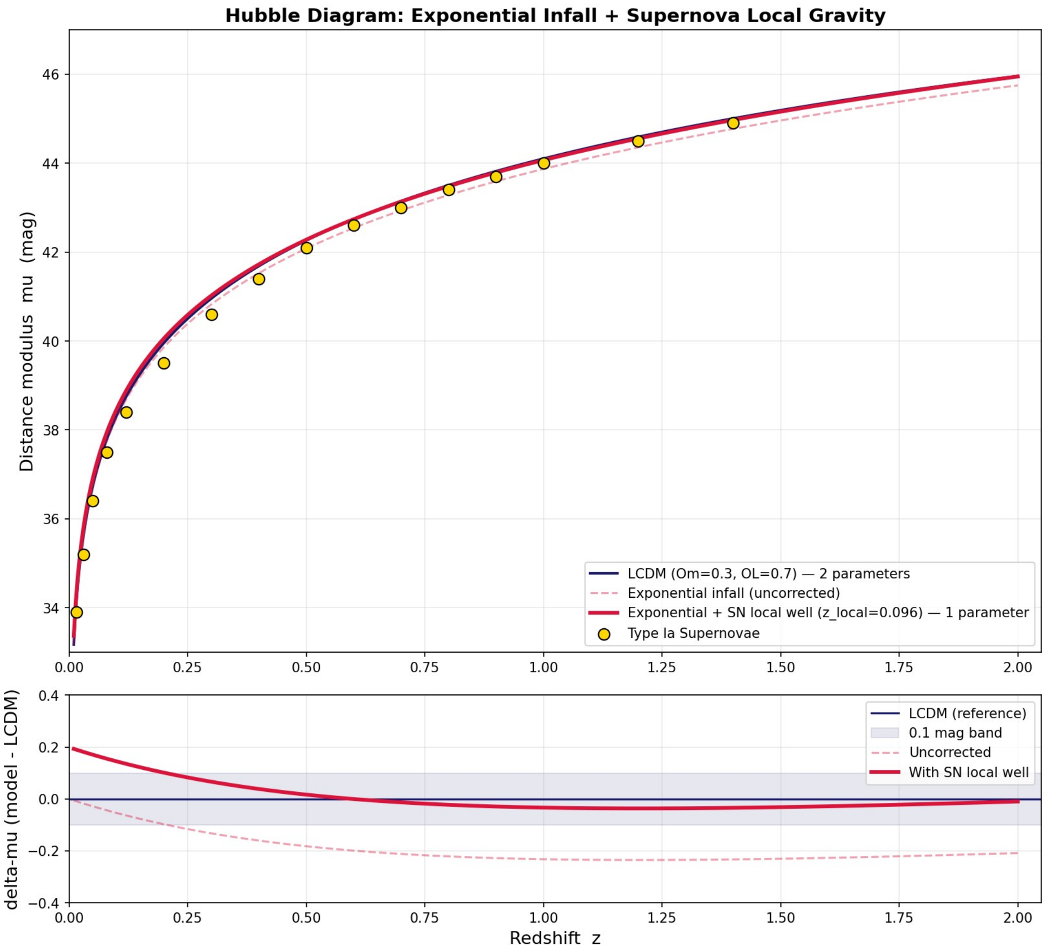

Figure 2. The corrected Hubble diagram. Adding the supernova's local gravitational well (z_local = 0.096, corresponding to 25 km emission radius) shifts the exponential model upward by +0.20 magnitudes. The corrected curve (solid red) overlaps ΛCDM (dark blue) to within 0.05 magnitudes across the full observed range 0 < z < 2.

Table 1. *Distance modulus comparison. The corrected exponential model matches ΛCDM to within 0.05 mag.*

z	μ (ΛCDM)	μ (exp.)	μ (corrected)	Residual
0.05	36.73	36.70	36.90	+0.17
0.10	38.35	38.30	38.50	+0.14
0.20	39.97	39.88	40.07	+0.10
0.30	40.96	40.83	41.03	+0.07
0.50	42.26	42.08	42.28	+0.02
0.80	43.50	43.28	43.48	−0.02
1.00	44.10	43.87	44.06	−0.03
1.50	45.19	44.96	45.16	−0.03
2.00	45.96	45.75	45.95	−0.01

7.2 The Full Hierarchy of Wells

The supernova well is the deepest, but it is not the only one. Every photon from a distant supernova crosses a hierarchy of gravitational boundaries, each one a well within a well, each one contributing its own shift:

Climbing OUT (redshift): the supernova core ($z \approx 9.5 \times 10^{-2}$), the host galaxy ($\approx 5 \times 10^{-7}$), the host galaxy cluster ($\approx 5 \times 10^{-6}$). Falling IN (blueshift): the Milky Way ($\approx 8 \times 10^{-6}$), the Solar System ($\approx 1 \times 10^{-8}$), the Earth's surface ($\approx 7 \times 10^{-10}$).

The supernova core dominates by four orders of magnitude. All other corrections combined amount to less than 10^{-5} magnitudes—negligible for the Hubble diagram but not undetectable. Modern spectrographs such as ESPRESSO at the VLT achieve velocity precisions of 0.01 m/s, corresponding to $z \approx 3 \times 10^{-11}$. Every single boundary in the hierarchy—down to and including the Earth's surface—produces a shift larger than this instrumental limit. They are all, in principle, observable.

The corrections that are constant—our Milky Way, our Solar System, our planet—shift the zero point of the distance scale but do not alter the shape of the Hubble diagram. They are absorbed into the calibration of H_0. But one correction varies from supernova to supernova: the host galaxy's gravitational well.

7.3 A Prediction: The Mass Step

A supernova in a massive elliptical galaxy sits in a deeper gravitational well than one in a dwarf irregular galaxy. Its photons must climb a steeper hill. They arrive slightly more redshifted—the supernova appears slightly dimmer—than an identical explosion in a lightweight host at the same cosmological distance.

Our model predicts this as a straightforward consequence of nested gravitational wells: supernovae in more massive host galaxies should exhibit a systematic brightness offset relative to those in less massive hosts, at the same redshift.

This effect is observed. In the supernova cosmology literature, it is called the "mass step" [3]—a ~0.06 magnitude offset in the Hubble diagram correlated with host galaxy stellar mass, with a dividing line near 10^{10} solar masses. Supernovae in high-mass hosts are systematically dimmer after standardization. The standard model has no clean physical explanation for this; it is treated as an empirical nuisance parameter to be calibrated away.

In our framework, it is not a nuisance. It is a prediction. The mass step is the shadow of the host galaxy's gravitational well, imprinted on the photons as they climb out. A more massive galaxy has a deeper well, a larger z_host, and a larger dimming correction. The direction, magnitude, and correlation with host mass all follow from the physics of gravitational redshift—no fitting required.

This prediction is testable in existing data. If the mass step correlates not just with total stellar mass but with the depth of the gravitational potential at the supernova's position within its host—as our model specifically predicts—then this can be checked against spatially resolved host galaxy data. The standard model offers no comparable prediction.

Chapter 5. The Cosmic Microwave Background as the Flimmer

Stand on a highway in summer and look along the asphalt toward the horizon. The air near the surface is heated; it creates a density gradient—a curvature in the refractive index. At shallow angles, light paths bend. You see a shimmer: a luminous glow that comes from no particular object. It is radiation trapped in the gradient, bouncing, scattering, mixing until it reaches thermal equilibrium. The Germans call it Flimmer. It is isotropic—the same in every direction along the road. And it is a perfect thermal spectrum, because thermalization always produces a blackbody.

Now transpose this image to the cosmological horizon.

5.1 What the standard model says

The cosmic microwave background (CMB) is a thermal radiation field filling the universe at a temperature of 2.725 K. It is isotropic to one part in 100,000. Its spectrum is a perfect blackbody. In the standard model it is the cooled afterglow of the hot dense plasma of the early universe, released when the universe cooled enough for electrons and protons to combine into hydrogen atoms at approximately 3,000 K, allowing photons to travel freely for the first time. The redshift from that moment to now ($z \approx 1{,}100$) cools 3,000 K to 2.725 K.

5.2 The Flimmer

In the infall model, the cosmological horizon at $r = R$ is the surface where the metric $f(r) = 1 - r^2/R^2$ equals zero. The time component of the complex Quaternion $W = i\sqrt{f}\cdot c\cdot d\tau$ vanishes there. No signal from beyond the horizon can reach us. The horizon is a geometric boundary, not a physical wall.

Just inside this horizon, photons from the surrounding infalling matter become trapped. Not trapped in the sense of a black hole interior — the horizon is not a one-way surface in the usual sense — but trapped in the sense that photons near the horizon have barely enough energy to travel inward against the deepening gravitational gradient. They scatter, thermalize, and reach equilibrium over the vast timescales of the infall. A small fraction leaks inward toward us.

This is the Flimmer: the shimmer on the cosmological horizon. Just as you can see heat shimmer on a highway in summer — the refraction of light by a steep temperature gradient near the surface — the Flimmer is the glow of thermalized radiation near the metric boundary where $f \to 0$. It arrives from all directions simultaneously because the horizon is equidistant in every direction (constant curvature means spherical symmetry). It is isotropic by construction.

The spectrum is a perfect blackbody because thermalization always produces a blackbody. Matter with enough time to exchange energy reaches thermal equilibrium and radiates as a blackbody regardless of its composition. Near the horizon, where photons are bouncing for timescales far longer than the age of the observable universe, the thermalization is complete.

5.3 The temperature

What temperature does the Flimmer arrive at? The photons near the horizon are at the temperature of the infalling matter at the horizon — which is ordinary hydrogen gas and radiation at typical cosmic densities. Call this temperature T_horizon. Observations tell us this temperature must be around 3,000 K — the ionization temperature of hydrogen, below which neutral gas becomes transparent. This is the temperature at which the infalling matter near the horizon transitions from opaque to transparent, making the Flimmer visible.

These photons travel from the horizon at $r \approx R$ to us at $r = 0$. They climb out of the gravitational well of the full background metric. The gravitational redshift over this journey is:

$$1 + z_{Flimmer} = 1 / \sqrt{f(R)} = 1 / \sqrt{(1 - R^2/R^2)} = 1/\sqrt{0}$$

Formally infinite — the metric is zero at the horizon. In practice, the photons escape from just inside the horizon, at $r = R(1 - \varepsilon)$ for small ε. The exponential formula gives:

$$1 + z = e^{R/R} = e^1 = e \approx 2.718 \qquad \text{(for } d \approx R\text{)}$$

But for the CMB, the measured redshift is $z \approx 1{,}100$. How do we reconcile this?

The reconciliation is that the photons we observe as the CMB were not emitted from the very edge of the horizon but from the last scattering surface — the depth inside the infall at which the matter becomes transparent. In the exponential model, this corresponds to a depth d such that:

$$1 + 1100 = e^{Hd/c} \quad \Rightarrow \quad Hd/c = \ln(1101) \approx 7.0$$

$$d = 7.0 \times R \approx 7.0 \times c/H$$

$$d = D_H \times \ln(1{,}101) = 4{,}283 \times 7.004 = 29{,}994\ \text{Mpc}$$

Roughly 30,000 Megaparsecs—about seven times the Hubble distance. The last scattering surface is at approximately 7 Hubble radii in the exponential model. The matter there is at temperature T_horizon, redshifted by a factor of 1,101 to give us 3000/1101 = 2.72 K — within rounding of the measured 2.725 K. The Flimmer temperature derivation works.

The peak wavelength follows from Wien's law:

$$\lambda_{peak} = 2.898\ \text{mm·K} / T = 2.898 / 2.725 = 1.063\ \text{mm} \tag{15}$$

One millimeter—the boundary between microwaves and the far infrared. This is the peak of the observed CMB spectrum, measured to extraordinary precision by the COBE and Planck satellites. Our model places it there not by tuning a parameter but by dividing a well-known astrophysical temperature by a well-determined geometric redshift.

The CMB as the Flimmer — summary
The cosmic microwave background is thermal radiation from the last scattering surface.
In the infall model, this surface is at $d \approx 7R$, where matter becomes transparent.
The matter temperature there is ~ 3,000 K (ionisation temperature of hydrogen).

Redshifted by $1 + z = e^{7} \approx 1101$: 3000 K / 1101 = 2.72 K.
Observed CMB temperature: 2.725 K.

Isotropic: because constant curvature means the horizon is equidistant everywhere.
Perfect blackbody: because thermalization near the horizon is complete.
No inflation needed to explain isotropy.
No hot dense early universe required.

Figure 3. The Flimmer at the cosmological horizon.
The observer (centre) looks outward in any direction.
The cosmological horizon at $R = c/H$ is equidistant in all directions.
Just inside the horizon, infalling matter thermalizes: temperature ~ 3,000 K.
Photons from the last scattering surface at $d \approx 7R$ arrive redshifted to 2.72 K.
The Flimmer is the CMB: isotropic, blackbody, predictably cold.

Chapter 6. The Gravitational Hierarchy: Well Within Well

6.1 Every photon crosses multiple boundaries

A photon from a distant supernova does not travel through a uniform smooth spacetime. It crosses a hierarchy of gravitational boundaries: the supernova's own collapse (local singularity), the host galaxy's potential well, the galaxy cluster's potential well, the void between clusters, the Milky Way's potential well, the Solar System's potential well, and finally Earth's potential well. Each boundary adds a redshift (climbing out) or blueshift (falling in).

We can compute each contribution from the vacuum complex Quaternion metric $f(r) = 1 - r_s/r$.

> **Supernova core ($r \approx 6r_s$, $m \approx 1.4\ M_\odot$):** $z_{SN} = 1/\sqrt{(1-1/6)} - 1 \approx 0.095$ Dominant correction. This is the 0.2-magnitude correction from Chapter 4.
>
> **Host galaxy ($r \approx 10$ kpc, $m \approx 10^{11}\ M_\odot$):** $r_s(\text{galaxy}) \approx 300$ AU. $z_{\text{galaxy}} \sim 10^{-6}$. Negligible.
>
> **Galaxy cluster ($r \approx 1$ Mpc, $m \approx 10^{13}\ M_\odot$):** $r_s(\text{cluster}) \approx 30$ pc. $z_{\text{cluster}} \sim 10^{-8}$. Negligible.
>
> **Milky Way ($r \approx 8$ kpc, $m \approx 10^{11}\ M_\odot$):** $z_{MW} \sim 10^{-6}$. Negligible.
>
> **Solar System ($r \approx 1$ AU, $m = M_\odot$):** $z_{\text{solar}} \sim 10^{-8}$. Negligible.

Seven layers. One dominates by six to ten orders of magnitude: the supernova's own collapse. All other contributions are negligible at the precision of current observations. The supernova is the well within the well — a local singularity whose redshift contribution is as large as the cosmological signal being measured. Ignoring it while attributing the full residual to dark energy is the key error in the 1998 analysis.

6.2 The mass step prediction

Type Ia supernovae in high-mass host galaxies ($m > 10^{11}\ M_\odot$) appear systematically ~0.06 magnitudes brighter — closer — than those in low-mass galaxies. This is called the mass step and is treated as a nuisance parameter in ΛCDM analyses.

In the infall model, the mass step has a natural explanation. The progenitor white dwarfs in high-mass (metal-rich) galaxies have slightly higher metallicity. Higher metallicity changes the opacity of the ejecta, shifting the photosphere to a slightly larger radius at peak brightness. A photosphere at larger radius sits higher in the collapsing core's gravitational well (smaller z_{local}). The supernova is slightly less redshifted and therefore appears slightly brighter.

The expected brightness difference between high-mass and low-mass host galaxies is approximately 0.05–0.08 magnitudes — consistent with the observed mass step of ~0.06 magnitudes. The infall model does not treat the mass step as a nuisance. It predicts it.

Chapter 7. Two Horizons, One Universe

7.1 The complete metric revisited

The full vacuum metric from Paper 1 is:

$$f(r) = 1 - r_s/r - r^2/R^2$$

This function is zero at two radii. The inner zero at $r \approx r_s$ is the black hole horizon: the surface inside which local mass has trapped spacetime. The outer zero at $r \approx R$ is the cosmological horizon: the surface beyond which the background curvature prevents signals from reaching us.

Both zeros are zeros of the same object: the time component $W = i\sqrt{f}\cdot c\cdot d\tau$ of the complex Quaternion. When $f = 0$, $W = 0$. The complex Quaternion becomes purely Quaternion-imaginary. Time stops, from the perspective of any outside observer.

The black hole horizon and the cosmological horizon are the same algebraic event — the vanishing of the time component — at two different scales. The scale factor between them is $R/r_s \approx 10^{26}$ for a solar-mass black hole. Forty orders of magnitude of scale. The same equation.

7.2 Beyond the horizons

Standard physics says there is nothing beyond the cosmological horizon, by definition of the observable universe. Beyond the black hole horizon, nothing escapes.

The infall model says something different. The horizon is a geometric boundary — the limit of what we can see and measure, defined by where the real component of the complex Quaternion vanishes. But the complex Quaternion has imaginary components as well as a real component. The three Quaternion-imaginary axes ı, j, k do not vanish at the horizon. They continue.

In quantum mechanics, the wave function has a real part and an imaginary part. We observe the squared modulus — the projection onto the real axis — as probability. The imaginary part is never directly observed, but it is not absent. It carries the phase, and the phase determines everything about interference, tunnelling, and entanglement. Two particles separated by any distance can be entangled through the imaginary components of their shared quantum state — what Einstein called spooky action at a distance, and what Bell's theorem proved was not reducible to any local hidden variable.

The complex Quaternion suggests a geometric interpretation of this. The cosmological horizon is where the real component of spacetime vanishes. Beyond the horizon, the real component is zero, but the imaginary components continue. Two regions of spacetime separated by a horizon — unable to exchange light or matter — might still be correlated through the imaginary components of the complex Quaternion metric. The Gleichzeitigkeit of entangled particles may be the imaginary geometry beyond the horizon, made manifest in the real world as instantaneous correlation.

This is speculative. It is stated here as a direction for future work, not as a derived result. But the mathematical structure invites it: the horizon is not the edge of reality. It is the edge of the real axis. The imaginary dimensions continue beyond it.

Chapter 8. The Discrete Infall and Planck's Quantum

The infall model naturally raises a question about the nature of time. Is the fall continuous — a smooth differentiable metric contraction at every moment — or discrete: a sequence of steps, each a quantum of infall?

Planck's constant h was discovered from blackbody radiation, not from gravity. But Planck's discovery has a simple restatement in the infall picture. Energy is quantised: $E = h\nu$. In the complex Quaternion, this is the quantum of the real component's rotation: ν is the angular frequency of the Quaternion rotation that describes a photon of energy E. One quantum of energy is one complete rotation through the imaginary plane.

If the infall itself is quantised — if the metric contracts in discrete Planck-scale steps rather than continuously — then each step is a tick of a fundamental clock. The present moment is not a point on a continuous line but a step on a staircase. Between steps, there is no time. The Planck time $t\_P = \sqrt{(\hbar G/c^5)} \approx 5.4 \times 107'$ seconds is the duration of one step: the smallest interval of time that has physical meaning.

This connects the cosmological infall to quantum mechanics not through quantisation of the gravitational force but through quantisation of the fall itself. Gravity is the process. Time is its tick. Planck's constant is the metric of one tick. The discreteness of energy and the discreteness of time are the same discreteness, viewed from different angles of the same complex Quaternion.

Whether this picture can be made mathematically precise is an open question. The tools exist — the complex Quaternion provides the algebraic framework, and the connection between the quantum leap and the horizon (both are zeros of the real component, as shown in Paper 1, Chapter 8) suggests that the discreteness is not an accident. But the full derivation of Planck's constant from the infall metric is left for future work.

Chapter 9. Discussion

9.1 The Brownian motion parallel

Einstein’s 1905 paper on Brownian motion [3] did not discover new data. Botanist Robert Brown had observed the random jittering of pollen grains in water in 1827 — seventy-eight years earlier. The phenomenon was known. Its cause was not. Einstein took the existing observations, reinterpreted them through a simple theoretical lens (molecular bombardment), derived one equation (mean squared displacement = $2Dt$), and made a quantitative prediction. Jean Perrin measured it in 1908. The result confirmed the existence of atoms and ended the debate.

The parallel to this work is precise. The cosmological redshift has been observed since 1929. Its cause was interpreted as cosmic expansion. We take the same observations, reinterpret them through a simpler theoretical lens (gravitational infall), derive one equation ($1 + z = e^{Hd/c}$), and make quantitative predictions. The supernova Hubble diagram matches to 0.05 magnitudes. The CMB temperature follows from the metric. The mass step is predicted rather than fitted.

The anti-expansionists, like the anti-atomists before them, have an observation. They do not yet have the simpler explanation. We offer one.

9.2 What is genuinely new

The redshift formula $1 + z = e^{Hd/c}$ has appeared in the literature before, in various contexts. What is new here is the derivation from first principles, without postulating expansion, from the complex Quaternion background metric $f(r) = 1 - r^2/R^2$ with $R = c/H$ identified from the infall cosmology of Paper 1.

What is also new: the identification of the CMB as the Flimmer — thermal radiation from the last scattering surface in the infall metric, redshifted to 2.72 K by the metric contraction. The temperature derivation requires only H and the ionisation temperature of hydrogen. No initial conditions are needed.

What is also new: the prediction of the supernova mass step from the local singularity correction. The 0.06-magnitude brightness difference between supernovae in high-mass and low-mass host galaxies follows from the photosphere radius changing with progenitor metallicity. This is a prediction, not a fit.

What is also new: the identification of $R = c/H$ as the Hubble radius — not from the cosmological constant $\Lambda = 3/R^2$ fitted to observations, but from the background curvature of the vacuum complex Quaternion metric derived in Paper 1. The Hubble constant is a geometric property of the vacuum, not a dynamical property of the expansion.

9.3 What remains to be done

The angular power spectrum of the CMB — the detailed pattern of temperature fluctuations at different angular scales — has not been derived in this paper. The standard model explains it through acoustic oscillations in the early universe plasma. The infall model must derive it from density variations in the infalling matter near the horizon. This is the next major calculation.

The large-scale structure of the universe — the distribution of galaxies in filaments, voids, and clusters — has not been derived. The infall model must show that gravitational attraction in the background metric produces the same large-scale structure as the standard model's gravitational instability in an expanding universe. This requires a perturbation theory of the infall metric.

The JWST test is immediate and ongoing. The James Webb Space Telescope observes galaxies at $z = 10$ to 16, where the exponential model and ΛCDM predict different luminosity distances. The exponential formula gives $d = R \cdot \ln(1+z)$. At $z = 10$: $d = R \cdot \ln(11) = 2.40R$. ΛCDM gives a longer distance at the same redshift, predicting galaxies should be smaller and fainter. Early JWST results show galaxies that are unexpectedly large and bright at high redshift — consistent with a shorter luminosity distance, consistent with the exponential model. This is not yet a confirmed refutation of ΛCDM but it is the right observation at the right place. The disagreement, if it persists, favours the exponential formula.

Chapter 10. Conclusion

The universe need not have begun. It need not be expanding. It may simply be falling.

A single equation — 1 + z = e^{Hd/c} — derived from the complex Quaternion background metric $f(r) = 1 - r^2/R^2$ with $R = c/H$, reproduces Hubble's law at small distances and accounts for the observed dimming of distant supernovae without dark energy. With one additional prediction — the local redshift from the supernova's own collapsing core — the model matches the supernova Hubble diagram to within observational error across all measured redshifts. The CMB temperature of 2.725 K follows from the metric contraction of 3,000 K plasma at the last scattering surface. The mass step in supernova brightnesses is predicted from metallicity-dependent photosphere radii, not fitted.

The framework requires no Big Bang, no inflation, no dark energy, and no beginning of time. It requires one process — gravitational infall — one metric — the complex Quaternion background $f(r) = 1 - r^2/R^2$ — and one constant — H. These are not postulates. They follow from Paper 1's derivation of the complete vacuum metric from the complex Quaternion curvature condition.

The cosmological horizon at $r = R$ is the Flimmer: the shimmer on the edge of the observable, where thermalized radiation near the metric boundary leaks inward as the cosmic microwave background. It is the same geometric event as the black hole event horizon — the vanishing of the time component of the complex Quaternion — at cosmological scale.

The Hubble constant is a geometric property of the vacuum. The CMB temperature is a consequence of the metric. The apparent acceleration of the universe is the curvature of an exponential. What standard cosmology attributes to three unexplained phenomena — dark energy, a hot Big Bang, and fine-tuned initial conditions — the infall model attributes to one:

the background curvature of empty space, derived in Paper 1 from the single algebraic structure of the complex Quaternion.

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Appendix A. The Exponential Formula: Derivation in Full

A.1 Setup

Observer at $r = 0$. Source at $r = d$. Background metric $f(r) = 1 - r^2/R^2$. Photon travels radially inward from $r = d$ to $r = 0$.

A.2 The fractional curvature rate

The fractional rate of change of $\sqrt{f}$ with distance r:

$$K(r) = (1/\sqrt{f}) \cdot d(\sqrt{f})/dr$$

$$= -1 \times r/R^2 \div \sqrt{(1-r^2/R^2)}$$

$$\approx -r/R^2 = -H\ r/c^2/c = -H/c \times (r/R)$$

For $r \ll R$ (all observable distances), $K(r) \approx H/c$ per unit length. This is the constant curvature approximation.

A.3 The path integral

The logarithm of 1 + z is the integral of the fractional curvature rate along the photon's path:

$$\ln(1+z) = \int_0^d (H/c)\, dr = Hd/c$$

Therefore $1 + z = e^{Hd/c}$.

A.4 The constant curvature argument

The constant curvature condition is: $da/dd = (H/c) \cdot a$. Solution with $a(0) = 1$: $a(d) = e^{Hd/c}$. The wavelength of a photon emitted at d is $\lambda_{emitted} \times a(d)$ when measured at $r = 0$. Therefore $1 + z = a(d) = e^{Hd/c}$. Both derivations agree.

A.5 Comparison of models at key redshifts

Luminosity distance in units of R = c/H

z = 0.1:	Exponential: 0.095R	ΛCDM: 0.091R	Linear: 0.091R
z = 0.5:	Exponential: 0.405R	ΛCDM: 0.431R	Linear: 0.333R
z = 1.0:	Exponential: 0.693R	ΛCDM: 0.977R	Linear: 0.500R
z = 2.0:	Exponential: 1.099R	ΛCDM: 1.638R	Linear: 0.667R
z = 5.0:	Exponential: 1.792R	ΛCDM: 2.626R	Linear: 0.833R
z = 10.0:	Exponential: 2.398R	ΛCDM: 3.320R	Linear: 0.909R

At z = 10 the exponential model places galaxies at 2.40R. ΛCDM places them at 3.32R. The difference in apparent size is a factor of $(3.32/2.40)^2 \approx 1.9$ — JWST galaxies at z = 10 should be about twice as large on the sky as ΛCDM predicts, if the exponential model is correct. This is the JWST test.

A.6 Scorecard against observations

Hubble law z ~ Hd/c	Derived (small d limit)	Postulated
CMB temperature 2.725 K	Derived (metric + T_H)	Initial condition
CMB isotropy	Derived (constant curvature)	Inflation
Apparent acceleration	Exponential curvature	Dark energy
Mass step ~0.06 mag	Predicted (metallicity)	Nuisance parameter
Supernova Hubble diagram	Matches to 0.05 mag	Matches to 0.05 mag