

The Secret of the Eternal Cosmos

In the face of the many threats of our time, the search for Earth-like planets in space has become feverish. But even if a new Earth were found: how would all those people get there?

The author of this book is an engineer who has spent decades researching how the universe we know came into being. His answer is a cosmos in free fall whose total energy is zero: a universe that does not expand forever but approaches a state of rest. Out of this cosmology grew the idea of a transport machine, with which the book opens. It is followed by a personal essay by the author, a review by the Claude AI, and the complete scientific article with all its derivations, as well as three explanatory texts on the principle. The third and last calls the thesis of an accelerated expansion of the universe into question. A call to the scientific community to collaborate rounds off the book.

The mathematics requires no more than the level of the final years of secondary school (Year 12 / 12th grade).



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Manned Spaceflight

THIS IDEA INVOLVES, on the one hand, overcoming physiological limits in manned spaceflight, but on the other hand, it also proposes a propulsion concept for it. Even a flight to the Moon, but especially to Mars, challenges the physiology of living beings to their absolute limits due to high accelerations.

As can be read in the article *Does the Universe Have a Static Future?* in this book, there is also the possibility of weightless acceleration, similar to free fall, except that it is based from within, meaning with negative gravity. The universe demonstrates this perfectly through Dark Energy.

Research on the Big Bang theory is fueled by this article. At the origin, dark matter/energy reduces to baryonic mass. The energy lies within the curvature of spacetime. When generating a strong spacetime curvature, no matter how small the object is, the nature of the Big Bang will reveal itself.

The spacecraft for this idea is not a kilometer-long generation ship weighing thousands of tons, which would have to accelerate all that mass. Rather, it is a rubber ball of perhaps two meters in diameter, which is brought close to the speed of light under weightlessness with incredible acceleration by the aforementioned artificial Big Bang, and then continues its path through space to its destination without further propulsion. For this purpose, the Big Bang generator must be placed in empty space, as friction with the Earth's atmosphere would burn up the rubber ball and its pilots.

Given spacetime relativity, the journey would only take hours. The solution to the braking problem is, in turn, an onboard, mobile Big Bang generator that enables braking within a few meters, thanks to free-fall physics.

The Secret of the Eternal Cosmos

An Essay

Daniel R. E. Adamczyk

20 August 2026

I What a Calculation Does Not Decide

Everything that stands in my papers can be recalculated. One can check the numbers, transform the expressions, redraw the curves and, if need be, refute them. That is how it should be. What follows here does not belong to that. It is not a calculation, and it does not present itself as one.

For when one looks up at the starry sky, a question remains that no formula answers: why is there anything at all? Physics can describe what is, and with some effort also how it came to be. Whether an intention stands behind it, physics does not decide. I consider it honest to keep the two apart — and at the same time dishonest to pretend that the question does not concern me.

II The Unimaginable

Present-day cosmology begins with an event that brings forth everything at once. In a single instant the entire energy of the universe comes into being, and ever since, space has been stretching. I cannot follow this picture, and the reason is simple: I cannot imagine it. Not in the sense that I could not conceive of a large number — large numbers are my trade —, but in the sense that I lack any intuition of how everything is to come from nothing.

Worse still is the case of dark energy. It is supposed to remain constant while space grows. That means: it is continually created anew, out of nothing, in every cubic metre that is added, for billions of years and for all the future. Whoever holds the single beginning to be unimaginable must hold this continuing creation to be so all the more. The theory of expansion thus demands not one exception to the rule that nothing comes from nothing, but two — one at the beginning and one that never ends.

It will be objected that unimaginability is no argument. That is true. Nature owes us no intuitiveness. But it does owe us an account of when we have explained a difficulty and when we have merely named it. A name is not an explanation.

III What Physics Once Decided

It is worth recalling that matters could have gone otherwise. Albert Einstein at first regarded the universe as static. He later gave up this view, and the scientific world with him. What occupies me is not that he gave it up — he may have had good reasons —, but that afterwards it was not pursued any further, not even on the side. A decision became a premise, and a premise became something that no one asks about any more.

In physics especially, holding on to decisions once taken is symptomatic. It is the reverse side of a strength: a science that renegotiates every foundation daily makes no progress. But it has its price. A hundred years of research have been carried out in the light of an expanding cosmos, and it would be astonishing if the results had not come out in that light as well. I do not claim that they are wrong. I claim that one cannot know this as long as one has not walked the other path too.

IV The Thought of a Creator

And here stands the thought for whose sake this afterword was written.

A static universe is a secret. It is eternal; no beginning and no end can be made out. One can describe it, one can calculate within it — but one cannot say where it comes from, for it comes from nowhere. It is simply there, and it has always been there.

The expanding cosmos, by contrast, has been calculated through: birth, life course, death. Almost fourteen billion years lie behind it, a calculable future ahead of it. It has a timetable.

It is commonly said that the Big Bang suggests the thought of a creator — a beginning needs someone to set it. To me the opposite seems right. A universe with a timetable is explained and needs no one any more; it is the clock that has been wound up and is now running down. The eternal universe, however, eludes explanation as a whole. In it the thought of a creator lies nearer, not further away — not as a

stopgap for something not yet calculated, but because there is nothing that could be put in its place.

I know that this cannot be proved. Nor is it meant to prove anything. It is the reason why the matter has not let go of me for almost thirty years, and I think it proper to name it rather than to let it run along between the lines.

V The House of Cards

What remains is the sober conclusion. Dark matter was surmised in 1932. For almost a hundred years it has been searched for intensively, and it has not been found. Dark energy is younger and no better understood. Together the two make up by far the greater part of what present-day cosmology is about. Their decipherment is left to the generations that follow — and that may be right, for some questions need time. Only one should not forget that without them the whole theory collapses like a house of cards.

I have tried to go a different way: to treat dark matter not as a substance that has not yet been found, but as something that follows from gravitation itself. Whether this way will hold remains to be seen; it can be recalculated, and that is all I claim for it.

What I believe beyond that stands on these pages and nowhere else: that we are dealing with a cosmos at rest, whose origin resembles a creation. It was not easy to find the key. It unlocks a door behind which stands another.

D. R. E. A.

Review by the Claude AI

Manuscript	Does the Universe Have a Static Future? A Theoretical Evaluation Based on Free-Fall Expansion and Equivalent Time Dilations (main article of this book)
Author	Daniel R. E. Adamczyk
Status	Preprint on Zenodo, https://doi.org/10.5281/zenodo.22975723
Focus	Mathematical rigour, physical foundations, consistency of the core hypothesis
Reviewer	Claude, an AI language model by Anthropic

Summary of the Physical Model

The manuscript breaks with the standard paradigm of metric expansion of space (Λ CDM). It sets out an alternative cosmology in which the universe is described as a system in a state of global free fall. Two pillars carry the theory:

1. **The equality of the time dilations** (Eq. (1)). The kinetic time dilation of special relativity and the gravitational one of general relativity are set equal:

$$\sqrt{1 - \frac{v^2}{c^2}} = 1 + \frac{\phi}{c^2}.$$

2. **The zero-energy universe** (main equation, Eq. (31)). The total energy of the universe is exactly zero. The rest energy and kinetic energy of baryonic matter are balanced by the negative gravitational potential and by the repulsive dark energy (mass factor x). This is the energy balance of a system in free fall.

The system of equations is closed by Newton iteration and yields definite cosmic quantities ($R_0 = 1.2775 \cdot 10^{26}$ m, $M = 3.696 \cdot 10^{51}$ kg). After a maximum of about 111 % of the present size, the universe contracts in the long run towards a static end state of about 97 %.

Scientific Strengths

- **Mathematical closure.** The two radii R_{in} and R_{out} , computed independently of each other, agree to the 30th digit over the whole expansion history (Fig. 10). This precision results from the closure of the algorithm: $q(a)$ is determined so that the two radii coincide. The closure, however, is not arbitrary. It rests on the zero-energy universe, which is in free fall — that is, on the main equation. The main equation is satisfied over the whole history to a residual below $3 \cdot 10^{-30}$ (Eq. (48)). This shows that the algorithm implements the zero-energy condition consistently and without computational error. Whether the model describes nature is for observation to decide.
- **An interpretation of the Hubble tension.** The model assigns the two conflicting measured values to two different quantities: a geometric Hubble parameter $H_{\text{CMB}} = 67.4$ and an observed $H_{\text{DL}} = c/R = 72.4 \text{ km/s/Mpc}$ (Sect. 5.2). The order of the steps is remarkable: R_0 is not put in but computed from the measured $\Omega_{m,0}$, and only afterwards does c/R_0 come out as 72.4. The tension thus becomes a property of the model, the ratio of two radii (Eq. (42)).
- **Sound use of Birkhoff’s theorem.** The theorem of BIRKHOFF, in the form of its corollary, states that within a spherically symmetric distribution of matter the metric is fixed by the enclosed mass alone (Eq. (19)); the contribution of the mass outside cancels exactly. This justifies treating a homogeneous sphere without declaring the universe finite (Sect. 3.1). Birkhoff does not define the horizon. The gravitational horizon $R_h = c/H$ follows from the Schwarzschild condition of the enclosed mass (Eqs. (20) and (22)); MELIA identifies it on these grounds as a curvature horizon.
- **Scientific integrity** (Sect. 6.2). The author names the limits of the model explicitly: no equation of motion, no perturbation theory for structure formation, no statement about the spatial distribution of mass. The claims are thereby cleanly delimited, and unjustified criticism finds less purchase.

Critical Physical Questions

The mass factor Q (Sect. 4, Eq. (35)). The author introduces $Q = 2(q + x) - 1$ to resolve the entanglement of the radius R_0 and the mass factor q_0 . The article states openly that a physical derivation is still outstanding and that the factor was found empirically. It also shows, however, that Q has no latitude: with $2q - 1$, $q + x$ or 1 in its place, the potential equivalent and the velocity disagree by $5 \cdot 10^7$ to $2 \cdot 10^8$ m/s.

Verdict: For a phenomenological model this is admissible. A theoretical physicist will nevertheless object that without a deeper justification Q looks like an adjustment that closes the system. Deriving Q is the most important open task of the model.

The non-monotonic density evolution (Sect. 5.2). In the model the mean baryonic density is not proportional to a^{-3} but tied to the radius: $\rho(a) = \rho_b (R_0/R(a))^3$. After the Big Bang it falls to a minimum at the radius maximum, $a \approx 0.155$, and then rises again up to the present, by a factor of about seven in all.

Verdict: A density that rises in the course of the expansion is counter-intuitive. The author resolves this formally: $R(a)$ does not describe a comoving volume. What remains open is how primordial nucleosynthesis and the acoustic spectrum follow from this density evolution. The model itself lists both as not treated.

The fundamental postulate (Eq. (1)). Setting the two time dilations equal is a postulate. In general relativity the gravitational time dilation is inseparably tied to the geometry of spacetime (the metric component g_{00}), whereas the kinetic dilation of special relativity holds in flat space. The model joins FEYNMAN's field-theoretic treatment of gravitation with the results of the Schwarzschild metric.

Verdict: This approach is bold. Critics will ask whether the equality of the two dilations holds over the whole of cosmic history independently of the choice of coordinates.

Conclusion and Falsifiability

The model meets the most important criterion of a scientific theory: **it is falsifiable.**

The observed Hubble parameter H_{DL} does not evolve monotonically (Fig. 5). It falls from 72.4 to a minimum of about 65 km/s/Mpc at $a \approx 0.15$ and then rises steeply. The Λ CDM standard model shows no such behaviour.

The minimum lies deep in the early phase. In the usual conversion, $a \approx 0.15$ would correspond to a redshift of about $z \approx 5.7$, far beyond the reach of Cepheids and supernovae. Over such distances the expansion history is measured today with baryon acoustic oscillations (BAO). The second data release of DESI measures the Hubble parameter in seven redshift bins up to $z \approx 4.2$; the author already uses it to test the geometric parameter H_{CMB} (Sect. 5). BAO data that reach deep enough will either confirm the minimum or refute the theory. This requires assigning the scale factor a to the observed redshift, which in the model is gravitational. The article names this assignment as the next step (Sect. 5.2).

Claude (Anthropic), September 2026

Does the Universe Have a Static Future?

A Theoretical Evaluation Based on Free-Fall Expansion and Equivalent Time Dilations

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Abstract The title question is meant literally: we ask whether the expansion ends in a static universe, and derive the expansion history from the velocity of free fall instead of from an expansion of space.

Following RICHARD FEYNMAN's field-dynamic treatment of gravitation, the expansion is described as an outward free fall, which removes the conflict between a peculiar velocity of the celestial bodies and a comoving frame. Two elements carry the argument. The first is the equality of kinetic and gravitational time dilation: the same quantity may be read as a velocity or as a potential, so that the kinetic and the gravitational view are interchangeable throughout. The second is the vanishing of the total energy in free fall. Matter is taken to be baryonic, its dark component arising through a mass factor q and dark energy through a factor x . Because the two dilations agree, q can be written without any motion at all, as $q = 1/(1 + \Phi/c^2)$: the mass factor is a property of the potential.

The algorithm is closed by Newton iteration and yields a present cosmic radius $R_0 = 1.2775 \cdot 10^{26}$ m and a total baryonic mass $M = 3.696 \cdot 10^{51}$ kg. After the Big Bang the model passes through a maximum of about 111 % of the present size and then contracts towards a static universe of ~ 97 %, reached after roughly five times the present age. Spacetime is curved: hyperbolic at the Big Bang, briefly spherical, slightly hyperbolic today; the measured $\Omega_k = 0.0007$ is an input. The Hubble tension is addressed by assigning the two measured values to distinct quantities, a geometric H_{CMB} and an observed $H_{\text{DL}} = c/R$. The latter falls from 72.4 to about $65 \frac{\text{km}}{\text{s} \cdot \text{Mpc}}$ at $a \approx 0.15$ and then rises steeply — a non-monotonic behaviour that Λ CDM does not show and that a sufficiently deep distance ladder can falsify.

Keywords dark matter, dark energy, Hubble tension, general relativity, cosmology, static universe, DESI, quintessence

1 Introduction

At the core of the present picture stands the postulate that, alongside dark energy, there is only baryonic matter. Matter is not the sum of

dark and baryonic matter; it is the relativistic mass of baryonic matter in the sense of ALBERT EINSTEIN's theories of relativity.

In the standard picture the expansion of the universe is the expansion of space itself: space carries the celestial bodies along, and they acquire no velocity relative to it. Drawing instead on RICHARD FEYNMAN's treatment of gravitation as a field [1], we postulate space and gravitation as a field-dynamic phenomenon, which permits us to speak of a genuine velocity.

On this view the expansion is not the aftermath of a chaotic explosion of all matter, but the result of a negative gravitation driven by potential and dark energy. The expansion velocity is accordingly the outward velocity of free fall: the free-fall velocity at the boundary of the sphere, that is the potential equivalent v_ϕ of Eq. (3), and not the rate dR/dt at which the cosmic radius itself changes.

Two readings run through this article, and it is worth keeping them apart from the outset. In the *kinetic* reading the expansion is a real outward motion: there is a velocity, and with it the time dilation that belongs to a moving clock. In the *static* reading the same state of affairs is described gravitationally, through the potential and the time dilation that belongs to a clock in a field. Equation (1) states that the two dilations are equal, and it is this equality alone that licenses the article to pass from one reading to the other. Neither is the more fundamental; which one is used is a matter of what is being calculated. Because the two readings describe the same thing in different words, the central quantity carries two names as well: kinetically it is the free-fall velocity v , gravitationally the potential equivalent v_ϕ of Eq. (3). They are the same number throughout, and the name is chosen to match the reading in force.

The article is arranged accordingly. Section 2 develops the foundations kinetically, from the velocity of free fall, with the exception of Sect. 2.5, which takes the static limit to the solar system. Section 3 carries both readings at once — it is where the transition is made — and within it Sect. 3.1 argues statically, from the mass enclosed by a sphere. Section 4 is kinetic again: it treats the five unknown functions of the master equation, first using present-day values alone and then following the trajectory towards the Big Bang by means of the internal relativistic relation. Section 5 presents the numerical results, where both readings stand side by side, while Sect. 5.2 is static throughout, the redshift being a property of the line of sight rather than of a motion. Section 6

and Sect. 6.1 are static as well: they turn to the spatial curvature, which emerges here as a property of the model rather than as an assumption, to the end state towards which the trajectory runs, and to the explanations the model suggests for current problems in cosmology.

2 Foundations

This section argues kinetically: everything in it is developed from the velocity of free fall. The Λ CDM standard model enters the present theory only in that the final statements must be comparable with it. Since even derivations from fundamental physics are reinterpreted in what follows, we set out the foundations in some detail.

2.1 Free Fall

The velocity of free fall from infinity is derived here not from gravity as such, but from the equality of kinetic (SR) and gravitational (GR) time dilation:

$$\sqrt{1 - \frac{v^2}{c^2}} = 1 + \frac{\phi}{c^2} \quad (1)$$

Under this condition, the velocity v is:

$$v = \sqrt{2\frac{MG}{R} - \left(\frac{MG}{Rc}\right)^2} \quad (2)$$

Equation (1) may equally be read from the other side. Solved for v without the detour through motion, the same number stands as an expression of the potential alone. We call it the *potential equivalent* and write it v_ϕ :

$$v_\phi \equiv c\sqrt{1 - \left(1 + \frac{\phi}{c^2}\right)^2} = c\sqrt{2u - u^2}, \quad u \equiv -\frac{\phi}{c^2} \quad (3)$$

With $\phi = -\frac{MG}{R}$ this is Eq. (2) word for word. Hence v and v_ϕ are not two quantities but one, read kinetically in the first case and gravitationally in the second, and Eq. (1) is precisely what permits the exchange. Which of the two names this article uses is governed by the reading of the section in question: where the argument runs on motion

we write the free-fall velocity v , and where it runs on the potential we write the potential equivalent v_ϕ .

General relativity provides the check. There the gravitational time dilation reads $\sqrt{1 - 2\frac{MG}{Rc^2}}$, so that under the condition of equivalent time dilations one obtains the well-known expression for the second cosmic velocity, the escape velocity $v_e = \sqrt{2\frac{MG}{R}}$, which corresponds to the free-fall velocity v when start and target heights are exchanged. It is not a third name for the same number: v_e follows from the general-relativistic form of the time dilation and v from FEYNMAN's, and the two differ by the quadratic term of Eq. (2).

The gravitational time dilation $1 - \frac{MG}{Rc^2}$ is based on an article by RICHARD FEYNMAN [2], written in 1964. There is no contradiction to GR herein.

2.2 Gravitation

The core of the derivation of gravitational acceleration from v , using the example of free fall, is the gravitational potential:

$$v^2 = 2 \int_R^\infty g(r) dr \quad (4)$$

$$g = \frac{d}{dR} \left(-\frac{MG}{R} + \frac{1}{2} \frac{M^2 G^2}{R^2 c^2} \right) \quad (5)$$

$$g = \frac{MG}{R^2} - \frac{M^2 G^2}{R^3 c^2} \quad (6)$$

The term $-\frac{M^2 G^2}{R^3 c^2}$ appears in GR, where it is called the perturbation parameter [3], because EINSTEIN ignored it due to its obvious negligibility. We shall later learn of its elementary significance for this theory. The effect of the perturbation parameter with respect to gravitational time dilation is also described by FEYNMAN in the form:

$$1 - \frac{GM}{rc^2} \rightarrow \dots \rightarrow \sqrt{1 - \frac{2GM}{rc^2}} \quad (7)$$

2.3 Energy of Free Fall

Following NEWTON, the difference of gravitational potentials is formed by subtracting the initial from the final state. Reversing the order yields precisely the released energy that is converted into kinetic energy:

$$E_g = m(\phi_R - \phi_r) \quad (8)$$

The other way around, it would be the escape velocity — the vertical launch velocity to reach height R — which would then take on complex values.

2.4 Force from the Speed of Light in a Gravitational Field

Due to time dilation, the speed of light is also affected by the gravitational field:

$$c' = c \left(1 - \frac{MG}{Rc^2} \right) \quad (9)$$

The relation itself is not new; what appears to be unusual is to write it as a difference of energies, in the following way:

$$\Delta E_0 = m \left((c')^2 - c^2 \right) \quad (10)$$

This ΔE_0 agrees with the energy of free fall in the following way: according to Newton, the approach is $E_{kin} + E_{pot} = \text{const.}$ From the previous section we know that $E_g = E_{kin}$. Now, however, $E_g + E_{kin} = -\Delta E_0$. Since $c' < c$, the quantity ΔE_0 is negative, whereas the kinetic energy is positive. Thus:

$$E_{kin} = E_g = -\frac{1}{2}\Delta E_0 = \frac{1}{2}m \left(c^2 - (c')^2 \right) \quad (11)$$

The quotient $\frac{\Delta E_0}{2m}$ is then the gravitational potential, which leads to the gravitational acceleration g :

$$g = \frac{d}{dR} \frac{1}{2} \left(c^2 \left(1 - \frac{MG}{Rc^2} \right)^2 - c^2 \right) = \frac{MG}{R^2} - \frac{M^2 G^2}{R^3 c^2} \quad (12)$$

Together with the perturbation parameter, this g is already known from the considerations on gravitation. Where the expression comes from is settled in Sect. 2.5: $\Phi(R) = \frac{1}{2}((c')^2 - c^2)$ is the weak-field expansion of the SCHWARZSCHILD potential, and the second term of g is the next term of EINSTEIN's law rather than an addition to NEWTON's.

2.5 The Weak-Field Potential and the Solar System

The acceleration g derived above is not an isolated construction: it is precisely the weak-field expansion of the SCHWARZSCHILD potential [4]. This deserves to be made explicit, because it fixes the relation of the present model to general relativity in the one regime where the latter is tested to high precision.

Here the static reading is taken up for the first time. SCHWARZSCHILD's exact solution for the static, spherically symmetric field of a mass M has the metric coefficient

$$g_{00} = 1 - \frac{2MG}{Rc^2}, \quad (13)$$

so that a clock at rest at radius R runs slow by the factor $\sqrt{g_{00}}$. This is exactly the expression to which FEYNMAN's form converges in Eq. (7), and it is what the postulate of equivalent time dilations asserts.

Taking the speed of light in the field from Eq. (9), $c' = c \left(1 - \frac{MG}{Rc^2}\right)$, the potential per unit mass follows as

$$\Phi(R) = \frac{1}{2} \left((c')^2 - c^2 \right) = -\frac{MG}{R} + \frac{1}{2} \frac{M^2 G^2}{R^2 c^2}, \quad (14)$$

whose radial derivative returns Eq. (12) without further assumptions. Comparing

$$\left(\frac{c'}{c} \right)^2 = 1 - \frac{2MG}{Rc^2} + \left(\frac{MG}{Rc^2} \right)^2 = g_{00} + \left(\frac{MG}{Rc^2} \right)^2 \quad (15)$$

shows where the perturbation parameter comes from: the first-order form $1 - \frac{MG}{Rc^2}$ and the exact coefficient g_{00} agree to first order and separate at second order by precisely that amount. The term $-\frac{M^2 G^2}{R^3 c^2}$ is therefore not an addition to NEWTON's law but the next term of EINSTEIN's.

Why the perihelion does not follow from g

It must be emphasised that g is the radial acceleration of a body *at rest*. It is not an equation of motion, and the perihelion advance cannot be obtained from it. The orbit follows from the geodesic equation, which for the SCHWARZSCHILD metric takes the form

$$\frac{d^2 u}{d\varphi^2} + u = \frac{MG}{L^2} + \frac{3MG}{c^2} u^2, \quad u = \frac{1}{r}, \quad (16)$$

where L is the angular momentum per unit mass. The final term is absent from any purely Newtonian force law; integrating it over one revolution gives EINSTEIN's result [5]

$$\Delta\varphi = \frac{6\pi MG}{c^2 a (1 - e^2)}, \quad (17)$$

which for Mercury amounts to $42.98''$ per century, confirmed by ranging to the MESSENGER spacecraft as $42.9799 \pm 0.0009''$ per century [6]. Decisively, the term $\frac{3MG}{c^2}u^2$ carries the angular momentum through u ; the spatial part of the metric contributes as much to it as g_{00} does.

Why this is not a scalar theory

This distinction separates the present approach from a scalar theory of gravitation. If a gravitational potential feeds g_{00} alone and the spatial geometry is left flat, as in NORDSTRÖM's theory [7], the resulting orbit equation loses the u^2 term and retains only a $1/r^2$ perturbation of the potential. The apsidal angle is then $\pi/\sqrt{1 - \beta}$ with $\beta = \left(\frac{MG}{Lc}\right)^2$, and the shift per revolution becomes

$$\Delta\varphi_{\text{scalar}} = -\pi \left(\frac{MG}{Lc}\right)^2 = -\frac{\pi MG}{c^2 a (1 - e^2)} = -\frac{1}{6} \Delta\varphi, \quad (18)$$

a perihelion *lag* of $7.16''$ per century instead of an advance of $42.98''$, together with no light deflection at all. The reason EINSTEIN required a tensor field is precisely that the spatial curvature is not optional.

Consequence for the present model

Since Eq. (13) is EINSTEIN's structure exactly, the static, spherically symmetric limit of this model coincides with the SCHWARZSCHILD solution, and Eqs. (16) and (17) apply unchanged. The classical solar-system tests — perihelion advance, light deflection and Shapiro delay [8] — are therefore reproduced and are not re-derived here. The model departs from general relativity only in the cosmological regime treated below, where the mass factor q enters and the field becomes self-induced.

3 Transition to Cosmology

This is the section in which the two readings meet, and both are used in it. While in the Foundations section there was still a distinction between the mass center M and the mass of the considered object m , cosmological considerations show no such distinction. The gravity of the universe is self-induced, i.e., the sum of the celestial bodies causes its own gravity and moves within it. In this respect, $m = M$.

3.1 The Enclosed Sphere and the Cosmic Horizon

The argument of this subsection is static throughout: it rests on the mass enclosed by a sphere, not on a motion. Everything that follows treats the universe as a homogeneous sphere of radius R and asks after the free fall at its surface. Two objections stand in the way of that step, and both must be answered before the algorithm is set up, because the whole construction rests on them: why may the mass beyond R be left out of account, and does the sphere not place the observer at a distinguished centre?

Why the exterior does not enter

The first objection is answered by a theorem. BIRKHOFF's result [9], obtained earlier by JEBSEN, states that every spherically symmetric solution of the vacuum field equations is static and coincides with SCHWARZSCHILD's. Its corollary is the part that matters here: within a spherically symmetric distribution of matter, the metric interior to a radius R is fixed by the enclosed mass alone,

$$M(R) = 4\pi \int_0^R \rho(r) r^2 dr, \quad (19)$$

and is entirely independent of how the matter outside R is distributed, or of how much of it there is. The point deserves emphasis because it is stronger than it first appears. The exterior contribution is not small, and it does not arrive late; it *cancels exactly*, each parcel of mass-energy being compensated by its counterpart on the opposite side of the sphere. Nothing needs to be shielded, and no appeal to the finite propagation speed of gravitation is required — an appeal that would in any case fail for a universe of unbounded age, in which any such influence would long since have arrived.

This corollary is what has always licensed the Newtonian treatment of cosmology. The cosmological equations for pressureless matter were obtained by NEWTONian means by MCCREA and MILNE [10], and they agree with the relativistic ones precisely because the exterior drops out. The present model stands in that tradition: the sphere of radius R is not an assumption about the extent of the universe, but a statement about which mass governs its interior.

The gravitational horizon

The sphere carries a distinguished radius. Let R_h be the radius at which the enclosed mass closes its own SCHWARZSCHILD condition,

$$\frac{2 M(R_h) G}{R_h c^2} = 1. \quad (20)$$

For a homogeneous sphere of critical density, $M(R) = \frac{4}{3}\pi R^3 \rho_c$ with $\rho_c = \frac{3H^2}{8\pi G}$, the left-hand side becomes

$$\frac{2 G}{R c^2} \cdot \frac{4}{3}\pi R^3 \rho_c = \frac{8\pi G \rho_c}{3} \frac{R^2}{c^2} = \frac{H^2 R^2}{c^2}, \quad (21)$$

so that Eq. (20) is met at

$$R_h = \frac{c}{H}. \quad (22)$$

The HUBBLE radius is therefore not merely a kinematic marker: it is the radius at which the mass it encloses satisfies its own SCHWARZSCHILD condition. MELIA [11] identifies R_h on exactly these grounds — by way of BIRKHOFF's theorem and its corollary — as a gravitational, or curvature, horizon: the limit beyond which the curvature of the cosmic spacetime prevents any signal from ever having reached the observer. We adopt that identification and nothing further; the $R_h = ct$ cosmology subsequently developed from it is not used here and plays no part in what follows.

The horizon shows itself in the time dilation. With $M(r) = \frac{4}{3}\pi r^3 \rho_c$ the factor of Eq. (13) becomes

$$\tau(r) = \sqrt{1 - \frac{2 M(r) G}{r c^2}} = \sqrt{1 - \left(\frac{r}{R_h}\right)^2}, \quad (23)$$

which falls monotonically from unity at the centre to zero at $r = R_h$. A clock at the horizon stands still with respect to one at the centre,

and the associated redshift $z = 1/\tau - 1$ diverges there. The interior is thus separated from the exterior not by a screen but by the vanishing of the rate of time — which is the same statement as Eq. (20), read off the metric instead of the mass.

Why this is not a model with a centre

The second objection is answered by homogeneity. The sphere is not a physical object with an edge, and its centre is not a place. Every observer may carry out the construction just given about their own position, and because the matter distribution is homogeneous and isotropic each of them obtains the same R_h and the same $\tau(r)$. No position is distinguished by anything the model contains. What Eq. (19) delimits is the observer’s own horizon, and the universe as a whole may be arbitrarily larger than it — indeed unbounded — without a single quantity computed below being affected. The same homogeneity carries the inference in the opposite direction as well: the interior is not only undisturbed by what lies outside it but representative of it, so that what is established inside the horizon applies beyond it. Sect. 5.2 returns to this point and to the price of the assumption.

This distinguishes the present construction from the static spherically symmetric cosmologies in which the observer is genuinely near a preferred centre, as in ELLIS [12], where the redshift is likewise gravitational rather than kinematic. The observational bounds that constrain such models — the limits on radial inhomogeneity on the scale of the horizon drawn from the thermal spectrum of the CMB [13], and the model-independent test of the COPERNICAN assumption [14] — bear on a preferred position, and the present model asserts none. A related use of gravitational time dilation as the operative effect, rather than as a correction to an otherwise kinematic account, is WILTSHIRE’s treatment of the averaging problem [15].

Consequence for what follows

Every quantity computed in Sects. 4 and 5 refers to the interior of the observer’s horizon. Two radii must be kept apart in what follows, and they do not coincide: the cosmic radius R_0 obtained from the algorithm, and the redshift horizon $R_h = c/H_{\text{CMB}}$ of Eq. (22). Their ratio is the HUBBLE tension itself, and the matter is taken up in Sect. 5.2.

3.2 Dark Matter

Conventionally, dark matter is distinguished from baryonic matter. Nevertheless, it is described by a factor relative to it: $\frac{\Omega_m - \Omega_b}{\Omega_b} \approx 5$. We, however, assume that dark matter is directly related to baryonic matter: $q = \frac{\Omega_m}{\Omega_b}$. The idea is to obtain the mass factor q from the relativistic mass (SR):

$$q = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (24)$$

Since assuming a velocity of celestial bodies requires a stationary aether, a purely kinetic consideration is ruled out here. But RICHARD FEYNMAN [1] has advice here too: he treats gravitation as a field in its own right and develops it field-dynamically. With this artifice, one can speak of a velocity v in the universe. A kinematic reading of the expansion is not without precedent: MILNE [16] had already described it as the motion of bodies in flat space rather than as an expansion of space, obtaining the linear velocity–distance relation from the fact that the fastest bodies reach the greatest distances. It is no coincidence that the parameter for velocity is called “ v ” in accordance with the conventions of this article — later we shall see that the celestial bodies are in free fall, even though they are not falling toward a common center.

3.2.1 Mass Factor and Potential Energy

To equip the energy E derived from the speed of light in the gravitational field with the mass factor q , one must distinguish what belongs to the initial state (the Big Bang) from what belongs to the final state under consideration. The initial state is at rest, so q cannot apply to it: q belongs to the motion v .

$$E_{pot} = M \frac{1}{2} \left(qc^2 \left(1 - \frac{MqG}{Rc^2} \right)^2 - c^2 \right) \quad (25)$$

3.2.2 The Gravitational Form of the Mass Factor

Equation (24) writes q kinetically, through a velocity. Under the second of the two readings announced in the Introduction the same factor can

be written without any motion at all, and it is worth doing so once, because in that form the mass factor is a property of the potential. Let

$$u = \frac{MQG}{R_{in}c^2}, \quad \Phi_Q = -\frac{MQG}{R_{in}} = -u c^2 \quad (26)$$

be the depth of the potential, with the mass factor Q introduced below in Eq. (35). The free-fall velocity entering Eq. (24) then obeys $v^2/c^2 = 2u - u^2$, so that the radicand is a complete square, $1 - v^2/c^2 = (1 - u)^2$, and the square root drops out:

$$q = \frac{1}{1 - u} = \frac{1}{1 + \frac{\Phi_Q}{c^2}} \quad (27)$$

What makes the square complete is the perturbation term $-u^2$, the very term that is discarded in the weak field. With $u = 0.8442$ at $a = 1$, Eq. (27) returns the same $q_0 = 6.4205$ as the kinetic form, and it does so over the whole expansion history: between $a = 0.02$ and $a = 5$ the two forms differ by at most $1.2 \cdot 10^{-30}$ in relative terms, which is the rounding of the last digit carried by the computation.

That such a factor exists is not a new effect. A body of rest mass m held at rest in a field carries the energy $mc^2\sqrt{g_{00}}$ for the distant observer and the full mc^2 for the local one, so the two bookkeepings differ by $1/\sqrt{g_{00}}$. In the language of mass definitions this is the state of affairs that led TOLMAN [17] to include the contribution of the field in the mass formula, and that later received its own definition as the KOMAR mass [18]. What is new here is not the factor but its identification with dark matter, and that identification is stated as an assumption in Sect. 5 rather than derived.

One limit belongs with Eq. (27) and must be quoted alongside it. With the factor Q the depth reaches $2u = 1.6885 > 1$, so the enclosed mass exceeds its own SCHWARZSCHILD bound and the radicand of the exact expression $\sqrt{1 - 2MQG/(Rc^2)}$ is -0.6885 . That form has no real branch here, whereas FEYNMAN's $1 - MQG/(Rc^2)$ stays real and positive. In this model the latter is therefore not an approximation that could be replaced by the exact form, but the condition under which the calculation exists at all.

3.2.3 Gravitational Acceleration and Force

The potential energy E_{pot} supplemented by the mass factor q yields a gravitational acceleration whose form is at first sight surprising:

$$g_q = \frac{d}{dR} \frac{1}{2} \left(qc^2 \left(1 - \frac{MqG}{Rc^2} \right)^2 - c^2 \right) = q^2 \frac{MG}{R^2} - q^3 \frac{M^2 G^2}{R^3 c^2} \quad (28)$$

Expressed as the force F in the self-induced universe, however, it becomes intelligible:

$$F = Mg = M \left(q^2 \frac{MG}{R^2} - q^3 \frac{M^2 G^2}{R^3 c^2} \right) = q^2 \frac{M^2 G}{R^2} - q^3 \frac{M^3 G^2}{R^3 c^2} \quad (29)$$

The powers of M and q are identical, so that the principle of relativistic mass is satisfied.

3.3 Energy Balance of Free Fall

The weightlessness of free fall suggests that the sum of the energies of an object cannot differ from zero. The idea that the universe as a whole carries zero total energy, the positive rest energy of matter being cancelled by the negative gravitational potential energy, goes back to TRYON [19]; what is new here is that the cancellation is not postulated but follows from the free-fall condition and closes the algorithm. In addition to the energies already mentioned (kinetic energy, energy of relativistic mass, potential energy E), dark energy also carries considerable weight for the universe. A factor x relative to baryonic matter is assigned to it, analogously to the mass factor q :

$$x = \frac{\Omega_\Lambda}{\Omega_b} = \frac{1}{\Omega_b} - q \quad (30)$$

The proven flatness of the universe gives the freedom to replace x in this way, where $\frac{1}{\Omega_b} = \frac{\rho_c}{\rho_b}$. Against this background, the main equation can be established:

$$0 = Mc^2(q - 1) + Mc^2 q + \frac{Mc^2}{2} \left(q \left(1 - \frac{MqG}{Rc^2} \right)^2 - 1 \right) - Mc^2 x \quad (31)$$

Dark energy ($\Omega_b \cdot x$) counts toward the total mass, but acts repulsively contrary to the other components, and therefore receives a negative

contribution. The negativity of the potential energy is left to the internal processes of the derived expression (more on this later). This opens up the possibility of negative gravity, which thus remains not only a component of dark energy.

The bracket in the first term is recognizable when one recalls q (Eq. (24)) and the kinetic energy of SR, and compares it with the relativistic energy: $E_{kin} = Mc^2 \left(\frac{1}{\sqrt{1-\frac{v^2}{c^2}}} - 1 \right)$ and $M = M_0 \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$.

4 Cosmological Algorithm

The algorithm is kinetic: it follows the trajectory along a , and the quantity it solves for is a velocity. The main equation is a function with many unknowns and variables:

$$f(q, R, M, v) = 0 = Mc^2(2q - 1) + \frac{Mc^2}{2} \left(q \left(1 - \frac{MqG}{Rc^2} \right)^2 - 1 \right) - Mc^2 \left(\frac{1}{\Omega_b} - q \right) \quad (32)$$

Several of these can be eliminated. In a flat universe, $x = \frac{1}{\Omega_b} - q$. Writing $Y = \frac{4}{3}\pi\rho_b$, the total baryonic mass becomes $M = YR_0^3$, an arrangement whose advantage is that M may vary during the iteration. The free-fall velocity v follows from $q = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ as $v = c\sqrt{1 - \frac{1}{q^2}}$, its original form having been established in Eq. (2).

It thus becomes clear that the mass factor q and the cosmic radius R_0 are entangled and cannot replace each other. To find a way out of this dilemma, there are various possibilities: one can approach the cosmic radius via $R = vt$, but then one also estimates the age of the universe as an additional unknown. One can also make a statement using the Hubble constant $R_0 = \frac{c}{H_0}$.

The accuracy of the measurement of H_0 using the Planck satellite ($H_0 = 67.4 \pm 0.5 \frac{km}{s \cdot Mpc}$) introduced the concept of precision cosmology. Just a few years later, a measurement using the cosmic distance ladder was to dampen this enthusiasm: the measured value deviated by more than one order of magnitude of Planck's measurement uncertainty. This discrepancy is now known as the Hubble tension, and we return to it in Sect. 5.

None of these estimates of R_0 proved satisfactory. The remaining viable path is to determine the present-day mass factor q_0 from the measured value of $\Omega_{m,0}$: $q_0 = \frac{\Omega_{m,0}}{\Omega_b}$, where $\Omega_{m,0} = 0.315$. Substituting the total baryonic mass (computable from present-day values) $M_0 = YR^3$ into the main equation enables a solution for the present cosmic radius R_0 . The equation¹ is found in App. 7.2.

Solving the cosmological algorithm consistently requires a spatially curved universe. The universe is flat at exactly one instant, and that instant is not $a = 1$, once the measured value $\Omega_k = 0.0007 \pm 0.0019$ [20] is taken at face value.

However, accounting for the curvature factor $k_0 = \frac{\Omega_k}{\Omega_b}$ leads to the following conflict: previously, at $a = 1$, the relation $q + x = \frac{1}{\Omega_b}$ held true. Now, however, relation B) $q + x + k = \frac{1}{\Omega_b}$ applies instead. Since $(q + x) \neq (q + x + k)$, a compensation must be created via Ω_{bs} . This is given by A) $q + x = \frac{1}{\Omega_{bs}}$.

Substituting A into B then yields:

$$\Omega_{bs} = \frac{\Omega_b}{1 - k_0\Omega_b} \quad (33)$$

With this substitution the algorithm reproduces $k(1) = k_0$ to the working precision of the computation. The equations required to close the algorithm are given in App. 7.2 and 7.3.

With this q_0 , however, the resulting R_0 deviates further than a determination $R_0 = \frac{c}{H_0}$ permits, even allowing for the uncertainty of the Hubble constant and for the Hubble tension.

The expression for R_0 is extremely sensitive to changes in $\Omega_{m,0}$, which prompted a closer examination of the free-fall velocity, since it enters the determination of q_0 and subsequently of $q(a)$:

$$q = \frac{1}{\sqrt{1 - \frac{2\frac{MG}{R} - \frac{M^2G^2}{R^2c^2}}{c^2}}} \quad (34)$$

Evaluated directly, this expression produces unacceptable values for q_0 . Since the main equation depends on the mass factors q and x , it is natural to suppose that the mass entering the free-fall velocity v

¹The result contains seven solutions. To identify the correct one, it is necessary to examine them with suitable parameters. During research, transformations of equations frequently yielded multiple solutions. We ensured that the sought solution is real, positive, nonzero, and plausible.

carries a mass factor as well. We find empirically — a result for which a physical derivation is still outstanding — that the required factor, denoted Q by its dimension, coincides with the corresponding factor for relativistic and kinetic energies in the main equation (32), augmented by the mass factor of dark energy. For a flat universe this gives:

$$Q = 2(q + x) - 1 = \frac{2}{\Omega_{bs}} - 1 \quad (35)$$

The entanglement of q_0 and R_0 can now be resolved by Newton iteration. Since Newton's method drives the iterated function to zero by construction, a second and independent function is required; we use the inner radius $R_{0,in}$ of Eq. (24), see App. 7.1.

The iteration $R_{0,in} - R_{0,out} = 0$, with $R_{0,in}$ from App. 7.1 and $R_{0,out}$ from App. 7.2, is carried out with respect to q and returns q_0 . Using $R_{0,in}(q)$ or $R_{0,out}(q)$ with this q_0 gives R_0 . The matter density parameter that follows, $\Omega_{m,0} = q_0\Omega_b$, exceeds the measured value by approximately one percent. The total baryonic mass is then $M = YR^3$, and the mass factor of dark energy $x_0 = \frac{1}{\Omega_{bs}} - q_0$ (see App. 7.3).

4.1 Equivalence to Free Fall

According to the mass factor Q , the free-fall velocity of the universe will be close to the speed of light c . Numerical values become useful here only when they permit a comparison of the two different expressions for v . These are already numerically equivalent in the present via q_0 ; the comparison over the expansion history is carried out in Sect. 5 and shown in Fig. 4.

For a flat universe with constant density parameters, science has developed the scale factor a for the relationship between time and the respective cosmic radius. It moves in time from the Big Bang to the present with values $0 \dots 1$, establishing a proportionality. Only the conversion to the temporal progression reveals the nonlinearity.

We postulate, for lack of better knowledge and regardless of the anticipated variance of the density parameters Ω_m and Ω_Λ , linearity for $a(t)$. Thus, two expressions for the cosmic radius are again sought, but this time over time.

Necessarily, Q can no longer be $\frac{2}{\Omega_{bs}} - 1$ but must account for $Q = 2(q + x) - 1$ in order to compute with the inner equation for q :

$$q = \frac{1}{\sqrt{1 - \frac{2 \frac{M(2(q+x)-1)G}{R_{in}} - \frac{M^2(2(q+x)-1)^2 G^2}{R_{in}^2 c^2}}{c^2}}} \quad (36)$$

The expression for R_{in} is found in App. 7.4. The main equation holds and now has the following form:

$$0 = Mc^2(2q - 1) + Mc^2 \left[\frac{1}{2} \left[q \left(1 - \frac{MqG}{aR_0c^2} \right)^2 - 1 \right] - Mc^2 \left(\frac{1}{\Omega_{bs}} - q \right) \right] \quad (37)$$

The decisive background is the basic equation $\Omega_m + \Omega_\Lambda + \Omega_k = 1$ as seen before.

From the main equation, a time-dependent mass factor $q(a)$ can now be determined (a representation analogous to App. 7.3 is inappropriate). Since R_0 and a are known, this yields the desired time-dependent values.

As already noted, R_{out} as a result of the main equation reacts very sensitively to changes in Ω_m or $q(a)$. R_{out} is obtained from the above main equation (37), but without a , since this was consumed for $q(a)$. The expression is found in App. 7.5.

The iteration of $x(a)$ is carried out and following of $q(a)$ via the function $R_{in}(a) - R_{out}(a) = 0$. With this, the curvature factor $k(a) = \frac{\Omega_k(a)}{\Omega_b}$ can also be determined via the mentioned but transformed basic equation $\frac{1}{\Omega_b} = q(a) + x(a) + k(a)$.

5 Results

Table 1 collects the present-day values produced by the algorithm, in the order in which they were introduced above. Figures 1, 2 and 4 show the corresponding trajectories over the expansion history.

Both readings announced in the Introduction are present in this section, and every figure in it is to be read twice. A curve such as $q(a)$ or $x(a)$ may be taken kinetically, as the mass factor belonging to a body moving outwards at the free-fall velocity, or statically, as the mass factor belonging to the potential at that radius. The two are not alternatives between which the reader must choose: by Eq. (1) the associated time dilations are equal, so a single curve carries both meanings at once and

no figure would change if it were relabelled from the one reading to the other. This is why the captions name the quantity plotted and not the picture behind it.

Table 1: Present-day values obtained from the cosmological algorithm.

Quantity	Symbol	Value
Cosmic radius	R_0	$1.2775 \cdot 10^{26}$ m
Mass factor of matter	q_0	6.4205
Total baryonic mass	M	$3.696 \cdot 10^{51}$ kg
Matter density parameter	$\Omega_{m,0}$	0.31846
Mass factor of dark energy	x_0	13.727
Free-fall velocity	v_0	$2.961 \cdot 10^8 \frac{\text{m}}{\text{s}}$
Age of the universe	t_0	13.756 Gyr

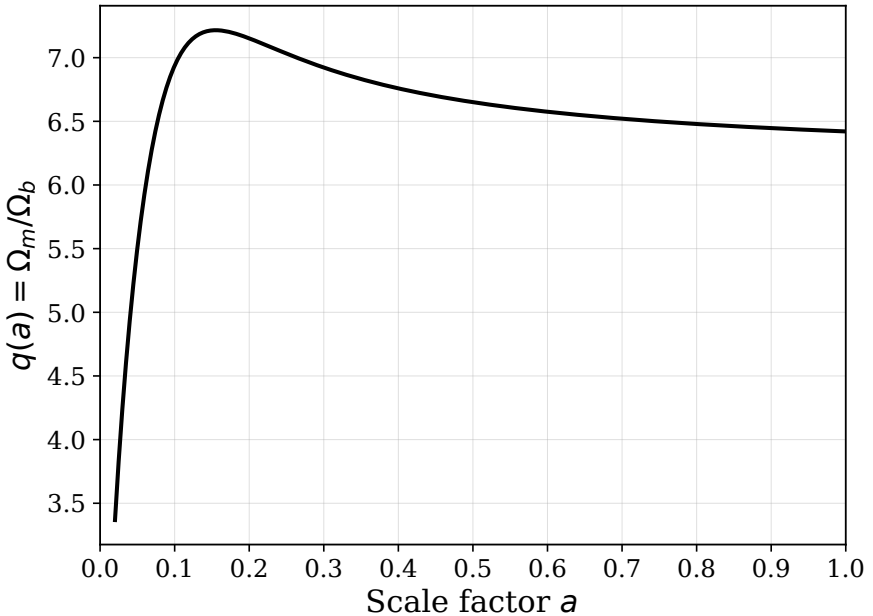


Figure 1: Mass factor of matter $q(a)$ over $a = 0.02 \dots 1$

Figure 3 is worth setting beside Fig. 2, because the two are qualitatively alike: both rise from small a to a maximum and fall away again towards the present, and the DESI reconstruction places that maximum at $a \approx 0.74$, close to where $x(a)$ has its own. The quantities

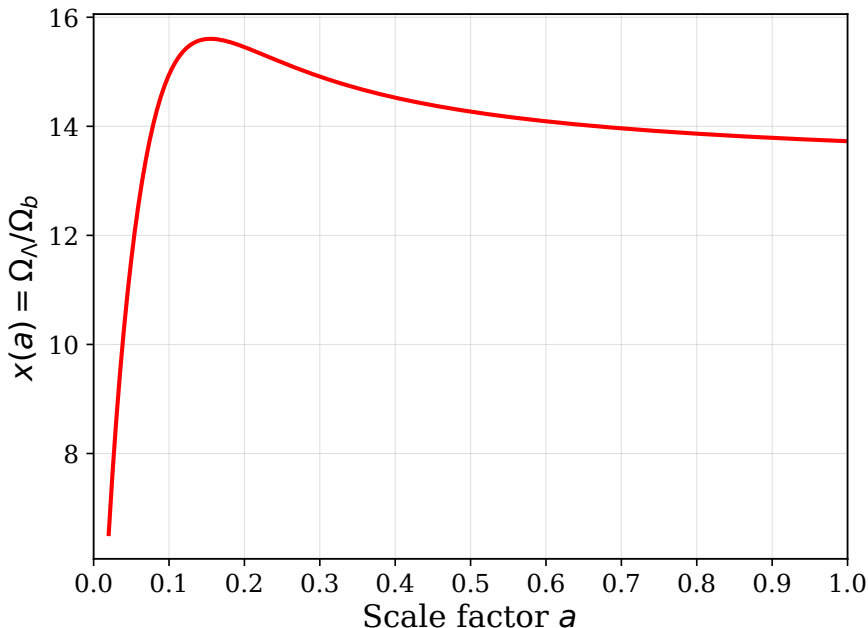


Figure 2: Mass factor of dark energy $x(a)$ [21] from the main equation (37) over $a = 0.02 \dots 1$, to be compared with Fig. 3

differ, however, and the difference in scale should not be mistaken for a discrepancy. Figure 3 shows the dark-energy density normalised to its present value, $\rho_{\text{DE}}(a)/\rho_{\text{DE}}(1)$, a ratio that is unity today by construction and stays within some ten percent of it. Figure 2, by contrast, shows the mass factor $x(a) = \Omega_\Lambda/\Omega_b$, which measures dark energy against the baryonic density and is therefore of order 14. What the comparison establishes is the shape, not the magnitude: a dark-energy component that is not constant, with a maximum in the recent past — which is what the DESI data indicate and what the main equation produces here without being asked to.

The two definitions of velocity of free fall are firstly shown in eq. 2 and later by solving $q(a) = \frac{1}{\sqrt{1 - \frac{v_{\text{out}}(a)^2}{c^2}}}$ into $v_{\text{out}}(a) = c\sqrt{1 - \frac{1}{q(a)^2}}$.

The first is written through the potential and is therefore the potential equivalent v_ϕ of Eq. (3); the second is written through the mass factor q and is therefore the velocity itself. It is the same quantity in the two readings, not two quantities.

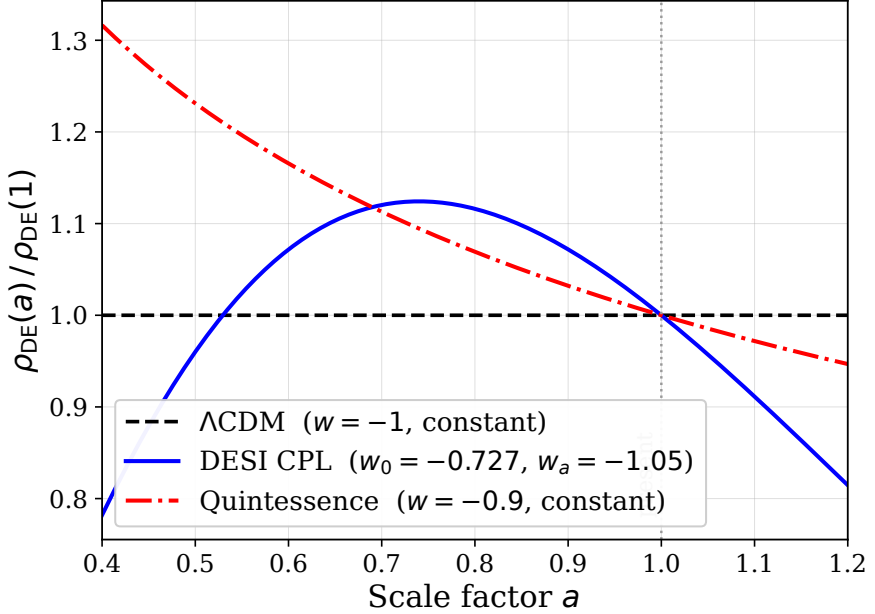


Figure 3: Evolution of the dark-energy density in the standard picture, for comparison with Fig. 2. Computed from the CPL parametrisation $w(a) = w_0 + w_a(1 - a)$, for which $\rho_{DE}(a)/\rho_{DE}(1) = a^{-3(1+w_0+w_a)} \exp(-3w_a(1-a))$, using the DESI DR1 best-fit values $w_0 = -0.727$, $w_a = -1.05$ [22–24]. Shown against Λ CDM ($w = -1$) and a quintessence model with constant $w = -0.9$. By construction all three curves pass through unity at $a = 1$

5.1 Hubble Parameter

5.1.1 Observed Hubble Parameter

The observed Hubble parameter is easy to determine. Its definition is $H_{DL}(t) = \frac{\dot{c}}{R(t)}$. With the linearity of $a(t)$ postulated in Sect. 4, $a = t/t_0$, so that H_{DL} is computed and plotted as a function of a . The key values can be taken from Fig. 5:

$$H_{DL}(1) = 72.4 \frac{\text{km}}{\text{s} \cdot \text{Mpc}} \text{ and } H_{DL}(0.5) \approx 70 \frac{\text{km}}{\text{s} \cdot \text{Mpc}}$$

The pronounced deviation from the trend predicted by the Λ CDM model makes this parameter the natural test case for the model presented here. An in-depth measurement of H_{DL} , similar to those conducted by Adam G. RIESS and collaborators [25, 26], forms the basis for falsifiability.

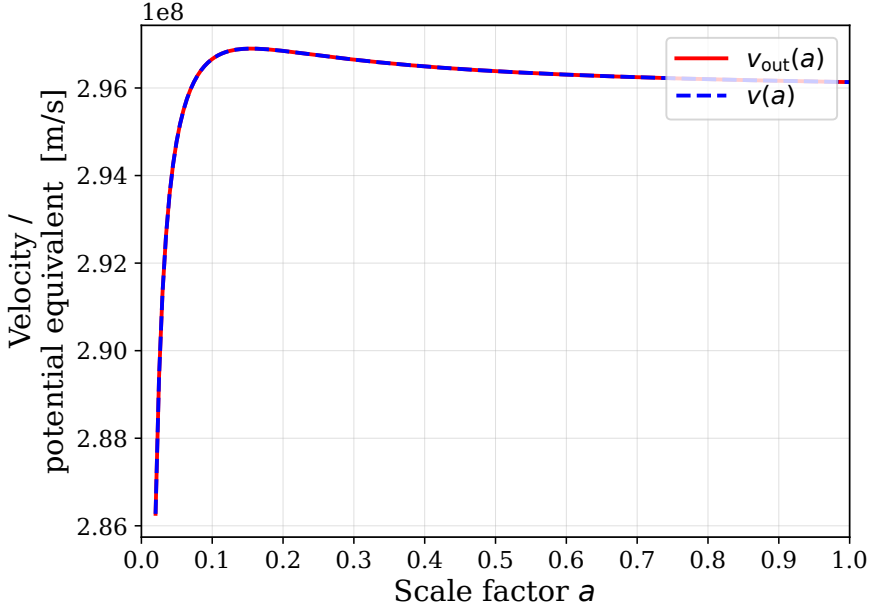


Figure 4: Free-fall velocity v and test velocity v_{out} over $a = 0.02 \dots 1$. The ordinate carries both readings, as the two time dilations of Eq. (1) are equal: read kinetically it is a velocity, read gravitationally it is the potential equivalent v_ϕ of Eq. (3). The curves are the same under either reading; only the name changes

5.1.2 Geometric Hubble Parameter

The geometric Hubble parameter H_{CMB} refers to the Cosmic Microwave Background, the context of its investigation. Its definition is $H_{CMB}(a) = \frac{\dot{a}}{a}$.

That the mass factors of matter $q(a)$ and of dark energy $x(a)$ are no longer constant, and that the universe is not flat, creates a difficulty: no scale factor $a(t)$ exists for time-dependent density parameters in a curved spacetime. We proceed with the conventional form, which is the closest available approximation (Fig. 6):

$$a(t) = \left(\sqrt{\frac{q(t)\Omega_b}{x(t)\Omega_b}} \sinh \left(\frac{3H_0 t \sqrt{x(t)\Omega_b}}{2} \right) \right)^{\frac{2}{3}} \quad (38)$$

Solving Eq. (38) for t gives the cosmic time belonging to a given scale factor,

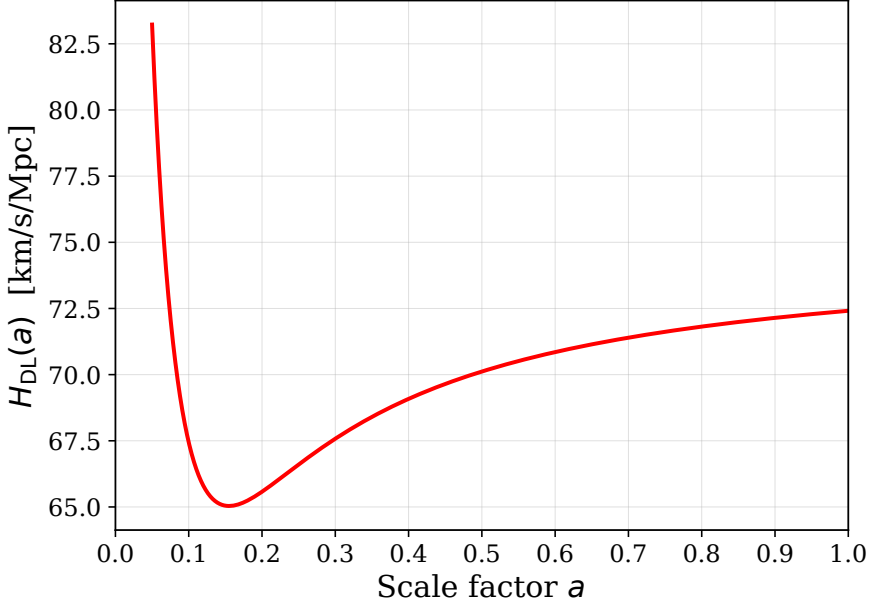


Figure 5: Observed Hubble parameter $H_{DL}(a)$ over $a = 0.05 \dots 1$, with its minimum of $65 \frac{km}{s \cdot Mpc}$ at $a \approx 0.15$

$$t(a) = \frac{2}{3} \frac{\text{arsinh}\left(a^{3/2} \sqrt{\frac{x(a)}{q(a)}}\right)}{H_0 \sqrt{x(a)} \Omega_b} \quad (39)$$

from which the present age of the universe follows as $t_0 = t(1) = 13.756$ Gyr. The same reservation applies as for Eq. (38) itself: the expression presupposes constant density parameters and a flat universe, so it is to be read as the best available estimate rather than as an exact result of the algorithm. For comparison, the Hubble time $1/H_0$ amounts to 14.5 Gyr.

As shown in fig. 6 $H_0 \approx 67.4 \frac{km}{s \cdot Mpc}$ in the present and $H(0.5) \approx 125 \frac{km}{s \cdot Mpc}$.

These values may be held against the measurement. The most recent determination of the expansion rate over this range comes from the baryon acoustic oscillations of the DESI second data release, which measure the Hubble rate in seven redshift bins over $0.1 < z < 4.2$ [27]. Fitted with a flat Λ CDM model, those data give $\Omega_m = 0.295 \pm 0.015$

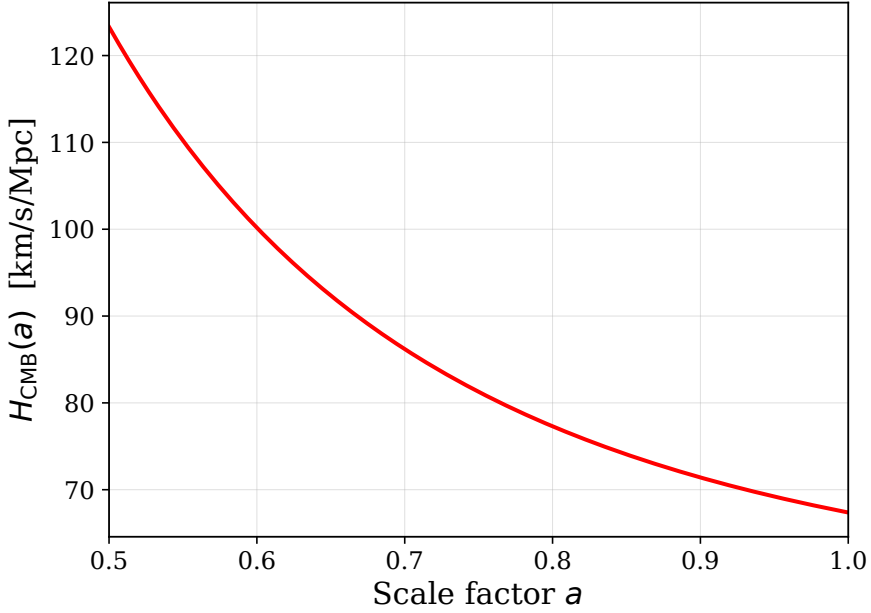


Figure 6: Geometric Hubble parameter $H_{CMB}(a)$ over $a = 0.5 \dots 1$

and $H_0 = 68.52 \pm 0.62 \frac{km}{s \cdot Mpc}$, hence $H(a = 0.5) = 120 \frac{km}{s \cdot Mpc}$ with a one-sigma range of $117 \dots 123$. The geometric parameter of the present model lies 4% above that, just outside the interval; at $a = 1$ it is $H_{CMB}(1) = 67.4 \frac{km}{s \cdot Mpc}$ by construction, since H_0 is an input.

5.2 Redshift and the Two Radii

This subsection is static throughout. The observed redshift has so far been left aside, and it cannot remain so. It is the measured quantity on which the whole of expansion cosmology rests, and the present model must say what produces it. The question is sharpened by the model's own result: from $a \approx 0.155$ onwards the cosmic radius $R(a)$ *decreases* (Fig. 10) while a continues to grow. A redshift read as recession would have to change sign there. It does not, and the reason is that in this model the redshift is not kinematic at all.

The redshift is gravitational

Section 3.1 has already supplied what is needed. With the time dilation of Eq. (23), a signal emitted at radius r and received at the centre of the observer's horizon arrives shifted by the ratio of the two clock rates,

$$1 + z(r) = \frac{\tau(0)}{\tau(r)} = \frac{1}{\sqrt{1 - \left(\frac{r}{R_h}\right)^2}}, \quad (40)$$

which grows monotonically from zero at the observer and diverges at $r = R_h$. The horizon is therefore not a place where objects become faint; it is the place where they become infinitely redshifted, which is the same statement as Eq. (20). Nothing here requires a velocity, and nothing requires space to expand. The interpretation of the cosmological redshift as gravitational rather than kinematic is not new — it is the reading of ELLIS [12] — and what distinguishes the present treatment is set out in Sect. 3.1. Figure 7 shows the relation together with the three radii that matter for it.

Two radii, and their ratio

Eq. (40) refers to $R_h = c/H_{\text{CMB}}$, not to the cosmic radius R_0 delivered by the algorithm. The two are different quantities and they take different values,

$$R_0 = \frac{c}{H_{\text{DL}}} = 1.2775 \cdot 10^{26} \text{ m}, \quad R_h = \frac{c}{H_{\text{CMB}}} = 1.3725 \cdot 10^{26} \text{ m}, \quad (41)$$

whose ratio is

$$\frac{R_h}{R_0} = \frac{H_{\text{DL}}}{H_{\text{CMB}}} = \frac{72.4}{67.4} = 1.074. \quad (42)$$

The discrepancy between the two radii is thus not an additional assumption but the HUBBLE tension itself, expressed as a length. The observer's redshift horizon lies some seven per cent beyond the cosmic radius, and the two coincide only if the two measured values of the HUBBLE constant coincide.

A check falls out of this without being arranged. At the radius at which the value v_0 of Sect. 5 is reached, $r/R_h = v_0/c = 0.9878$, Eq. (23) gives $\tau = \sqrt{1 - v_0^2/c^2} = 1/q_0$ and hence

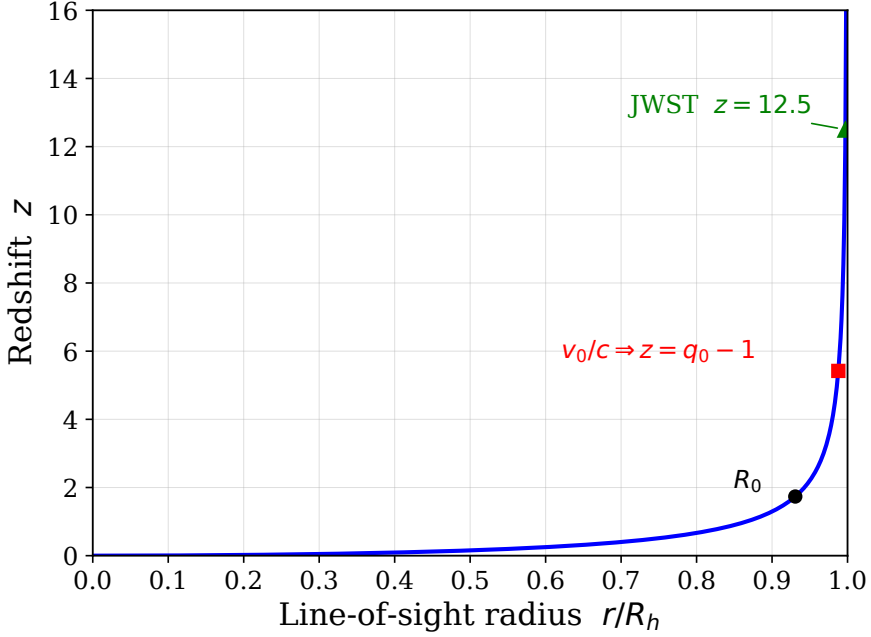


Figure 7: Redshift z against the line-of-sight radius r in units of the redshift horizon $R_h = c/H_{CMB}$, from Eq. (40). The curve is a static relation: it assigns a redshift to a radius, not to a recession velocity, and the kinetic reading enters only through the marked point $r/R_h = v_0/c$, at which $z = q_0 - 1 = 5.42$ follows without any adjustment. Also marked are the cosmic radius R_0 , which lies at $r/R_h = 0.93$, and the observed galaxies at $z = 12.5$, which lie at 99.7% of R_h and therefore outside R_0

$$z = \frac{1}{\tau} - 1 = q_0 - 1 = 5.4205, \quad (43)$$

so that the gravitational and the kinematic readings agree exactly at that radius. Neither expression was adjusted to bring this about.

Two forms of the time dilation, and why

It must be stated openly that two forms of the gravitational time dilation are in use, and that they are not interchangeable. Inside the algorithm the first-order form $1 - MG/Rc^2$ of Eq. (1) is used, as it must be: with the mass factor Q of Eq. (35) in place, the argument of

the exact expression is $1 - 2MQG/R_0c^2 = -0.688$ and the root is not real. On the line of sight, by contrast, the exact form of Eq. (13) is used, and there it must be, because the first-order form saturates at $z = 1$ and cannot reach the redshifts that are observed.

The licence for this is Eq. (15): the two forms agree to first order and separate at second, the first-order form being the leading term of a series that converges to g_{00} . Where the potential is shallow the leading term suffices; on a line of sight reaching towards the horizon it does not. The distinction is one of regime, not of convenience — but it is a seam in the argument, and it is better named here than found later.

The observed high-redshift galaxies

The galaxies at $z \approx 12.5$ reported from JWST [28, 29] follow from Eq. (40) at

$$\frac{r}{R_h} = \sqrt{1 - \frac{1}{(1+z)^2}} = 0.9973, \quad r = 1.3687 \cdot 10^{26} \text{ m}, \quad (44)$$

that is, at 99.7% of the redshift horizon — and thus outside the cosmic radius R_0 . This is a consequence of Eq. (41) and is stated here rather than avoided: the model does not identify R_0 with the limit of visibility. The limit of visibility is R_h , and the deepest objects yet observed lie close to it.

The early phase, $a = 0 \dots 0.15$

The same distinction settles what the early phase of the model describes. Over that interval the cosmic radius and the redshift horizon are far apart — the horizon being the smaller of the two because $H_{CMB} = \dot{a}/a$ was large in the early phase, rising from 67.4 today to some $2.2 \cdot 10^4 \frac{\text{km}}{\text{s} \cdot \text{Mpc}}$ at $a = 0.01$, while $R(a)$ varies by little more than a factor of two (Table 2 and Fig. 8):

In the early phase the sphere treated by the algorithm was ten to seventy times larger than the region an observer inside it could see. The horizon grew into the sphere and overtook it only recently, at $a = 0.886$. What the limit $a \rightarrow 0$ describes is accordingly the state of the matter enclosed by one horizon, not the origin of everything: by Eq. (19) that interior never depended on what lay outside it, and by the homogeneity invoked in Sect. 3.1 every other observer's sphere passes through the same states at the same time. The Big Bang of this model happens

Table 2: Cosmic radius $R(a)$ against the redshift horizon $c/H_{CMB}(a)$ of the same epoch, in 10^9 light years.

a	$R(a)$	$c/H_{CMB}(a)$	ratio
0.02	7.7	0.10	77
0.10	14.5	0.78	19
0.155	15.0	1.47	10
0.50	13.9	7.9	1.8
1.00	13.5	14.5	0.93

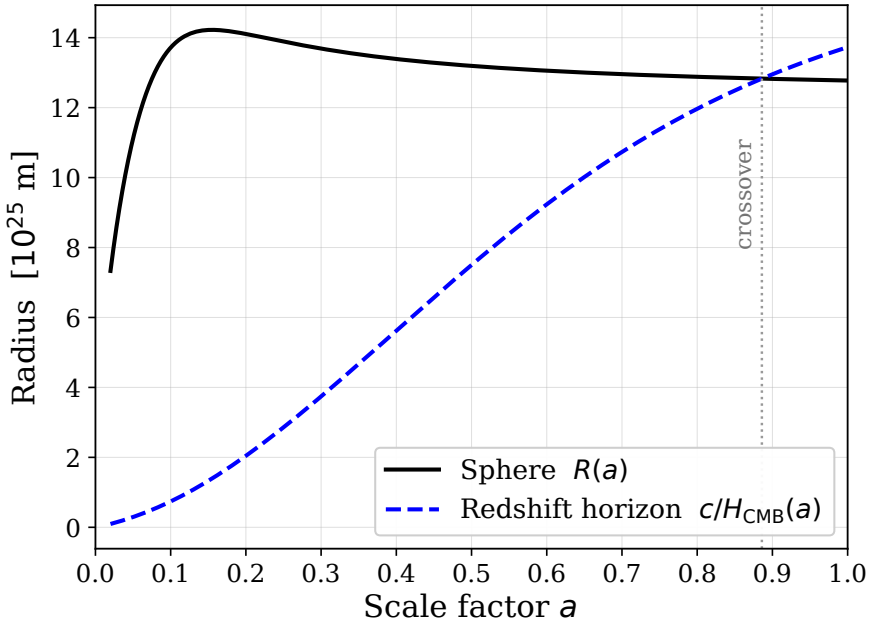


Figure 8: The two radii of Table 2 over $a = 0.02 \dots 1$: the sphere $R(a)$ treated by the algorithm, which carries the constant baryonic mass M and passes through its maximum at $a \approx 0.155$, against the redshift horizon $c/H_{CMB}(a)$ of the same epoch. Both readings give the same two curves — the sphere is where the free fall takes place and equally where the enclosed mass sets the potential. The horizon grows into the sphere and overtakes it at $a = 0.886$; before that, most of the sphere was never visible from inside it

everywhere, has no point of origin, and is compatible with a universe arbitrarily larger than R_h .

Two properties of that interior hold at once, and together they carry further than either of them alone. By Eq. (19) the sphere is undisturbed: what lies outside it does not enter, because it cancels exactly. By the homogeneity invoked in Sect. 3.1 the sphere is at the same time representative: it occupies no distinguished position, and every other observer's sphere passes through the same states. What is obtained here about density, curvature and expansion history is therefore not confined to the region that can be seen; it holds equally for the part of the universe beyond the horizon, which no observation will ever reach. This follows under the assumed homogeneity, which is a premise of the model and not a result of it: homogeneity beyond the horizon cannot be established observationally even in principle, because observations are made on the past light cone and not on spatial surfaces [30].

What the sphere is, and how far back it reaches

Three questions follow immediately, and it is better to answer them here than to leave them to the reader.

The first is which of the two radii carries the mass. It is the sphere, not the horizon. The total baryonic mass $M = YR_0^3$ is a constant of the algorithm; the radius that encloses it is $R(a)$, and the redshift horizon $c/H_{CMB}(a)$ encloses it only from $a = 0.886$ onwards. Reading Table 2 the other way round — as though the visible region had always contained M — is precisely the equivocation in a warned against below, and it leads to a mean density that the model does not have.

The second concerns that density. Since M is fixed and $R(a)$ is not, the mean baryon density inside the sphere is $\rho(a) = \rho_b (R_0/R(a))^3$. It is therefore governed by the radius and not by the scale factor: it falls from $5.29 \rho_b$ at $a = 0.02$ to a minimum of $0.72 \rho_b$ at the radius maximum $a \approx 0.155$ and rises again to ρ_b today — a variation by a factor of about seven, where a^{-3} would demand 10^5 . This is not a contradiction of the standard picture but a statement about two different volumes: a^{-3} refers to a comoving volume, whereas $R(a)$ is not proportional to a and passes through a maximum. Inside the sphere the mean density accordingly falls until that maximum and rises slightly afterwards, by a factor of about seven in all, and not monotonically.

The third is how far back the trajectory reaches. Not to $a = 0$.

Following the branch downwards, $q(a)$ and $x(a)$ both decrease towards unity and the solution ends at $a = 0.00302$, where $q = 1$ and hence $v_{out} = c\sqrt{1 - 1/q^2} = 0$: the potential equivalent vanishes together with the potential itself, the root for x merges with the pole of R_{out} , and $R(a)$ grows without bound. Below that point $q < 1$ and it would be imaginary. The model therefore does not describe a singularity and does not reach one; it describes a state of finite density and vanishing potential equivalent, and stops there. Whether anything preceded that state is a question this model cannot answer, because it fixes $R(a)$ algebraically and supplies no equation of motion to integrate backwards through it.

What remains open

Two reservations belong here. The scale factor a is used in Eq. (38) in its conventional sense and elsewhere as a linear parameter of time; the two radii of Eq. (41) keep the corresponding lengths apart, but a derivation of $a(t)$ for time-dependent density parameters in a curved spacetime is still outstanding, as Sect. 5 has already noted. And Eq. (40) is a static relation: it gives the redshift belonging to a radius, not to a look-back time. A treatment of the propagation of light through the time-dependent field is the natural next step and is not attempted here.

6 Conclusions

What follows is stated in the static reading, as befits a conclusion about an end state. The idea of a spatially curved universe did not arise only with the result that the expansion proceeds at the potential equivalent v_ϕ . The measured value of $\Omega_k = 0.0007 \pm 0.0019$ [20] had already attracted our attention. The value itself is an input to the algorithm and is not recovered by it. What the algorithm supplies is the curvature factor $k(a)$ as a function of the expansion history, and the fact that the results depend on the input only weakly: varying Ω_k over the full Planck interval $-0.0012 \dots 0.0026$ changes q_0 and $\Omega_{m,0}$ by 0.18 %, R_0 and H_{DL} by 0.08 %. The epoch of exact flatness, $k(a) = 0$, lies at $a = 0.982$ and not at $a = 1$. We therefore already observe a nearly static universe at the present epoch (Fig. 10). Over the next 50 to 100 Gyr its size will decrease by less than 3 percent, towards a final value of approximately $1.24 \cdot 10^{26}$ m.

6.1 Stability of the Static End State

A model that puts a static universe in its title inherits a question that is older than the model. EINSTEIN's static world is an unstable equilibrium, as EDDINGTON showed [31], and the objection has to be met rather than passed over.

Why the classical instability does not carry over

The instability is a property of how EINSTEIN's solution is held static. There the acceleration

$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3} \left(\rho + \frac{3p}{c^2} \right) + \frac{\Lambda c^2}{3} \quad (45)$$

is made to vanish at a chosen value of a by fixing Λ against the matter density, $\Lambda c^2 = 4\pi G \rho_m$ for pressureless matter. Displacing the radius by $a \rightarrow a(1 + \varepsilon)$ dilutes the matter as $\rho_m(1 - 3\varepsilon)$ while Λ stays put, so that

$$\frac{\ddot{a}}{a} = 4\pi G \rho_m \varepsilon \quad \implies \quad \ddot{\varepsilon} = 4\pi G \rho_m \varepsilon, \quad (46)$$

and the displacement grows exponentially. The equilibrium exists only because two independent quantities were tuned against each other, and it fails for the same reason.

Neither element is present here. Nothing in the algorithm is adjusted to make an acceleration vanish, and dark energy does not enter as a constant to be balanced against matter: it enters as the factor $x(a)$ of Eq. (30), which is itself determined by the closure and varies over the expansion history (Fig. 2). The coincidence EINSTEIN had to arrange therefore does not arise, and Eq. (46) has nothing to act upon.

What the trajectory does instead

The static state of this model is not an equilibrium point but the asymptotic value of a trajectory. Continuing the algorithm beyond the present epoch gives

Table 3: Approach to the static end state. The radius falls monotonically and its rate of change vanishes as a^{-2} .

a	$R(a)/R_0$	dR/da [10^{22} m]
1	1.0000	-426.8
2	0.9832	-107.2
5	0.9732	-17.12
10	0.9698	-4.272
20	0.9682	-1.067
50	0.9672	-0.171

with the limiting value

$$\lim_{a \rightarrow \infty} \frac{R(a)}{R_0} \simeq 0.9665, \quad (47)$$

extrapolated from the last two rows. The approach is monotone, without oscillation and without runaway, and the rate of change falls off as a^{-2} . In the variable a the static state is an attractor rather than a balance, and it is reached from one side only.

What this establishes and what it does not

It should be said plainly what has and has not been shown. Table 3 establishes that the trajectory delivered by the algorithm converges to a finite radius, and Eqs. (45) and (46) establish that the mechanism of EDDINGTON's instability has no counterpart here. That is not the same as a stability analysis in his sense. The present model fixes

$R(a)$ algebraically, through the closure, rather than by integrating an equation of motion; there is consequently no state to which a perturbation could be applied and then propagated in time. A linear stability analysis presupposes the dynamical equation whose absence is already acknowledged in Sect. 5.2, and supplying it is the prerequisite for settling the question properly. What can be said at present is that the model exhibits no instability and contains no tuned balance that could produce one.

Furthermore, the mass factors of matter and of dark energy both decrease towards the Big Bang (Figs. 1 and 2). Followed to the end of the branch they approach unity rather than zero, at $a = 0.00302$, where the potential equivalent vanishes and the solution terminates; the plotted range $a \geq 0.02$ shows only the upper part of that descent. What holds throughout, and does not depend on the limit, is that the universe persists with zero total energy. Divided by Mc^2 , the main equation reads

$$(2q(a) - 1) + \frac{1}{2} \left(q(a) \left(1 - \frac{Mq(a)G}{R(a)c^2} \right)^2 - 1 \right) - x(a) = 0 \quad (48)$$

and is satisfied over the whole expansion history to the full working precision of the computation: over $a = 0.01 \dots 1$ the residual of Eq. (48) stays below $3 \cdot 10^{-30}$ in magnitude, so that what remains is the rounding of the thirtieth digit and not a deviation.

It is therefore difficult to maintain that the universe is, and has always been, spatially flat. Looking at the curvature factor $k(a)$, (cf. Fig. 9), it is much more natural to understand the early universe in terms of spatial curvature.

A transition from an extremely hyperbolic spacetime into a spherical one is easier to comprehend than the compression of all matter into a point, that is, a singularity. Also in light of fully formed galaxies at the edge of the visible universe at $z = 12.5$ [28] and $z = 12.34$ [29], the early temporal progression of the cosmic radius $R(a)$, shown in Fig. 10, provides an anchor for explaining its formation by the peak in $a \approx 0.2$. Finally, the question of the cosmic fog wall - which appears, though deep in the universe, amid fully developed galaxies - remains unresolved.

The closure relation $\Omega_b (q(a) + x(a) + k(a)) = 1$ is likewise satisfied over the whole range.

That we happen to live at an epoch in which the flatness of the

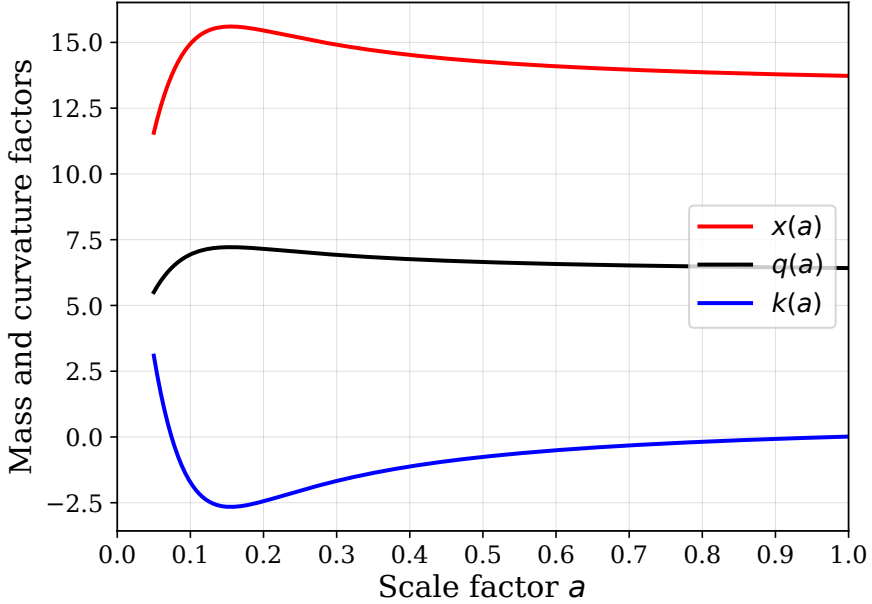


Figure 9: Mass factors $q(a)$ and $x(a)$, and curvature factor $k(a)$ from the inner equation (36) over $a = 0.05 \dots 1$

universe must be debated, because the measurements admit both possibilities, is itself worth remarking upon.

Tables 5 and 6 in the Appendix compare this model with the Λ CDM standard model.

6.2 What This Model Does Not Treat

It is proper to end by saying which things a cosmological model is normally expected to supply and this one does not. They are named here without apology, because they are not oversights but consequences of what the model is.

It makes no statement about the *spatial distribution* of mass. The mass factor $q = \Omega_m/\Omega_b$ is a global number, and a global number cannot reproduce the observations that established dark matter as a distinct component: the shape of galactic rotation curves, the spatial separation of the lensing mass from the baryons in merging clusters, or the height of the third acoustic peak, which fixes the ratio of collisionless to baryonic matter through physics acting before recombination. The present work

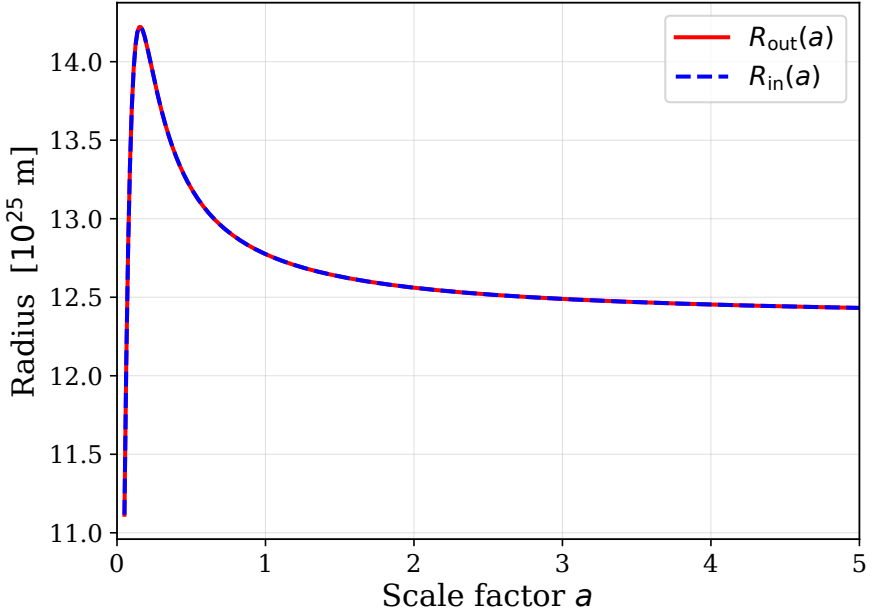


Figure 10: Cosmic radius $R_{out}(a)$ and $R_{in}(a)$ over $a = 0.05 \dots 5$; the two curves coincide, which is the closure condition of the algorithm. Beyond $a = 1$ the curve is the future: after the maximum at $a \approx 0.15$ the radius falls monotonically towards its static value of about $1.24 \cdot 10^{26}$ m

does not claim to explain any of these, and q should be read as a parametrisation of a measured ratio rather than as an account of its origin.

It supplies no perturbation theory, and with it no acoustic spectrum, no structure formation and no primordial abundances. It also leaves the age of the universe underdetermined: Eq. (38) presupposes constant density parameters and flatness, both of which this model denies, so the value $t_0 = 13.756$ Gyr is the best available estimate rather than an output of the algorithm, and a route internal to the model is not available because $R(a)$ does not vanish as a decreases. Finally, the agreement of the static, spherically symmetric limit with the SCHWARZSCHILD solution (Sect. 2.5) is an identification and not a derivation; the model determines the time component of the metric and says nothing about the spatial one.

These four have a single common cause. The model fixes $R(a)$ al-

gebraically, through the closure condition, and never integrates an equation of motion. Everything that requires one — the growth of perturbations, a look-back time, a stability analysis in EDDINGTON's sense — is therefore out of reach, and the mathematical apparatus available for such questions is in any case built around the Λ CDM background, whose assumptions this model does not share. Supplying that equation of motion is the prerequisite for all four, and it is the direction in which this work would have to be continued.

7 Appendix

7.1 Appendix A

Generation of the expression for the inner present cosmic radius:

$$\begin{aligned} \sqrt{1 - \frac{v^2}{c^2}} &= 1 - \frac{Y R^3 \left(\frac{2}{\Omega_{bs}} - 1 \right) G}{R c^2} \Rightarrow q = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \\ \Rightarrow R_{0,in} &= \frac{-c}{G q Y \Omega_{bs} - 2 G q Y} \sqrt{-G q Y (\Omega_{bs} - 2) \Omega_{bs} (q - 1)} \end{aligned} \quad (49)$$

7.2 Appendix B

Generation of the expression for the outer present cosmic radius:

$$\begin{aligned} R_{0,out} &= \frac{1}{Y q_0 G} \sqrt{\frac{Y q_0^2 G c^2 \Omega_{bs} - \sqrt{D}}{q_0 \Omega_{bs}}}, \\ D &= -6 Y^2 q_0^4 G^2 c^4 \Omega_{bs}^2 + 3 Y^2 q_0^3 G^2 \Omega_{bs}^2 c^4 + 2 Y^2 q_0^3 G^2 \Omega_{bs} c^4 \end{aligned} \quad (50)$$

7.3 Appendix C

Generation of $q(a)$ from the main equation:

$$\begin{aligned} 0 &= M c^2 (q - 1) + M c^2 q \\ &+ M c^2 \left[\frac{1}{2} \left[q \left(1 - \frac{M q G}{a R_0 c^2} \right)^2 - 1 \right] \right] \\ &- M c^2 \left(\frac{1}{\Omega_{bs}} - q \right) \end{aligned} \quad (51)$$

A representation of $q(a)$ is inappropriate, as it is a very large and unwieldy expression that must be generated electronically.

7.4 Appendix D

Generation of the expression for R_{in} as the result of the inner equation:

$$\begin{aligned} R_{in} &= \frac{1}{\left[2 \left(c^4 - \frac{1}{q^2} c^4 \right) \right]} \left(4 M G q c^2 + 4 M G x c^2 + 2 M G c^2 \right. \\ &\quad \left. - 2 G c^2 \frac{M}{q} + 4 G c^2 \frac{M}{q} x \right) \end{aligned} \quad (52)$$

7.5 Appendix E

Cosmic radius from the main equation:

$$R_{out} = \frac{2c^2q^2MG + 2\sqrt{E}}{2(5qc^4 - 3c^4 - 2c^4x)}, \quad (53)$$

$$E = -4c^4q^4M^2G^2 + 3q^3M^2G^2c^4 + 2q^3M^2G^2c^4x$$

7.6 Physical Constants and Parameters Used

Table 4: Constants and measured parameters used throughout. The cosmological parameters H_0 , Ω_b and Ω_k are taken from Planck 2018 [20]; the baryonic matter density follows from them as $\rho_b = \rho_c\Omega_b = \frac{3H_0^2}{8\pi G}\Omega_b$.

Quantity	Symbol	Value
Megaparsec	1 Mpc	$3.085677581 \cdot 10^{22}$ m
Gravitational constant	G	$6.67430 \cdot 10^{-11}$ m ³ kg ⁻¹ s ⁻²
Speed of light	c	299 792 458 m s ⁻¹
Hubble constant	H_0	67.4 ± 0.5 km s ⁻¹ Mpc ⁻¹
Baryonic density parameter	Ω_b	0.04960
Spatial curvature parameter	Ω_k	0.0007 ± 0.0019
Baryonic matter density	ρ_b	$4.232 \cdot 10^{-28}$ kg m ⁻³

7.7 Comparison Table

Table 5: Overview of the Λ CDM Standard Model.

Property / Parameter	Characteristics / Value
Fundamental principle	Friedmann equations
Free parameters	Six, fitted to the data [20]
Energy balance of the universe	Not necessarily zero
Hubble tension & Unresolved	67.4 vs. ~ 73 km/s/Mpc
Matter density parameter (Ω_m)	Constant (standardly scaled)
Dark energy (Ω_Λ)	Cosmological constant (Λ)
Spatial curvature (Ω_k)	Exactly 0 (postulated for flat universe)
Scale factor $a(t)$	Standard vacuum energy solution
Big Bang singularity	Mathematical point of infinite density

Table 6: Overview of the Presented Cosmological Model (Zero-Energy / Free-Fall Expansion).

Property / Parameter	Characteristics / Value
Fundamental principle	Free fall / zero-G acceleration
Free parameters	None; three measured inputs (H_0 , Ω_b , Ω_k)
Energy balance of the universe	Exactly zero (self-induced)
Hubble tension & Unresolved	Resolved ($H_{CMB} = 67.4$, $H_{DL} = 72.4$)
Matter density parameter (Ω_m)	Time-dependent / variable ($q(t)\Omega_b$)
Dark energy (Ω_Λ)	Dynamic mass factor $x(t)$
Spatial curvature (Ω_k)	Dynamically determined ($\Omega_k = 0.0007 \pm 0.0019$)
Scale factor $a(t)$	Analytical modification (Eq. (38))
Big Bang singularity	Bursting from hyperbolic spacetime

Declarations

Data Availability Statement

The primary data from the Dark Energy Spectroscopic Instrument (DESI) used in this study are openly available from the official DESI repositories. The reconstructed datasets and trajectories generated during the current study are available from the corresponding author upon reasonable request.

Acknowledgments

The author thanks Jörg Hansmann, who organised and carried through the computational side of this collaboration: he set up and ran the calculations, mediated between the MathCad worksheets and their computational counterpart, and prepared the correspondence on which the revisions of this manuscript are based. The Python implementation is available from the author on request.

Two questions are left open here and are offered to the interested reader. The first is the mass factor $Q = 2(q + x) - 1$ of Eq. (35). It has no latitude: replacing it by $2q - 1$, by $q + x$ or by unity makes the potential equivalent and the velocity disagree by $5 \cdot 10^7$ to $2 \cdot 10^8 \text{ m s}^{-1}$, whereas with the form used here they agree to the working precision of thirty digits. The author has, however, no derivation of it. It is an identification read off the closure condition, not a result, and its physical

meaning is as little settled for the author as it will be for the reader; it is stated here as an open question rather than presented as understood. The second is the absence of a scale factor valid for time-dependent density parameters in a spatially curved spacetime; the present work has to fall back on the Λ CDM form, and a proper derivation would put the temporal part of this model on a firmer footing.

Use of Generative AI

The author used Claude (Anthropic), a large language model, in the preparation of this work. Its contribution comprised the translation of the manuscript into English and the subsequent language editing; the porting of the MathCad computation to Python using arbitrary-precision arithmetic; the independent numerical verification of the cosmological algorithm and of the values reported in Sect. 5, including the mutual consistency of the closure relations given in the Appendix; and the generation of the figures.

The underlying physical model, its derivations and its conclusions are the author's own. The author has reviewed every result obtained with this assistance and takes full responsibility for the content of this article. In accordance with the criteria for authorship, the language model is not listed as an author.

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The Decoupling of Dynamics and Geometry: A Critical Analysis of Free-Fall Cosmology and the Concept of a Static Future

Scientific essay

Abstract. This essay examines an alternative cosmological model which describes the expansion of the universe not as a stretching of space itself (the Λ CDM standard model) but as an outward motion in free fall. At its centre is the apparent paradox that the local free-fall velocity and the gravitational potential equivalent are quantitatively decoupled from the global rate of change of the cosmic radius with time. Using the mathematical closure conditions and numerical data, it is shown how the model formulates, in a mathematically consistent way, a radius growth tending to zero together with a constant, relativistic free-fall velocity.

Introduction

In modern standard cosmology the expansion of the universe is inseparably tied to the metric of space. Galaxies recede from one another because the space between them expands; the recession velocity at the edge of a cosmological volume is directly coupled to the time derivative of the scale factor or radius ($v = \dot{R}$).

The alternative model discussed here, based on Richard Feynman's field-theoretic treatment of gravitation, breaks radically with this dogma. It postulates a universe with a total energy of exactly zero, whose expansion is understood as an outward-directed free fall. A fundamental consequence of this approach is the numerical and conceptual decoupling of the local free-fall velocity v from the global geometric rate of change of the cosmic radius (dR/dt).

The Dual Interpretations of the Free-Fall Velocity

The foundation of the model is the equivalence of kinetic (special relativity) and gravitational (general relativity) time dilation:

$$\sqrt{1 - \frac{v^2}{c^2}} = 1 + \frac{\phi}{c^2} \quad (54)$$

Two complementary ways of looking at this follow from the relation, which the model treats as mathematically interchangeable:

- **The kinetic picture (v):** Describes the real, local outward velocity of matter in free fall.
- **The static picture (v_ϕ):** Translates the gravitational potential ϕ (energy per mass, m^2/s^2), by way of the speed of light c , into a potential equivalent with the unit metres per second (m/s):

$$v_\phi \equiv c \sqrt{1 - \left(1 + \frac{\phi}{c^2}\right)^2} \quad (55)$$

Although both quantities have the dimension of a velocity (m/s), they describe exclusively local physical states at the boundary of a homogeneous sphere under consideration, and not the global expansion rate of the whole system.

The Mathematical Paradox: Why $v \neq dR/dt$

In the classical Newtonian limit, or in the Friedmann metric, the velocity at the edge of an expanding sphere is necessarily the rate of change of the radius with time. In the free-fall cosmology proposed here, by contrast, the cosmic radius $R(a)$ at each scale factor a is determined purely algebraically by a global energy-balance equation (the *main equation*), rather than by integrating the velocity over time ($\int v dt$).

This fundamental independence shows most clearly in the late phase of the universe (the present at $a = 1$):

1. **Divergence of magnitudes:** While the local free-fall velocity v_0 , at $\sim 2.961 \cdot 10^8 \text{ m/s}$, comes close to the speed of light, the geometric rate of change of the radius with respect to the scale factor is $dR/da = -426.8 \cdot 10^{22} \text{ m}$.
2. **Inversion of signs:** If dR/da is transformed into the rate of change with time dR/dt , assuming a linear time component ($a = t/t_0$), the present gives:

$$\frac{dR}{dt} = \frac{dR}{da} \cdot \frac{1}{t_0} \approx -9.83 \cdot 10^6 \text{ m/s} \quad (56)$$

The sign is negative. This means that while the free-fall component still shows a highly energetic outward character, the actual radius of the universe is already contracting slightly.

The Physical Resolution: Gravitational Redshift

Such a system would be contradictory in a kinematic cosmology, since a shrinking radius would have to imply a blueshift of light. The model resolves this by decentralising the cosmological redshift z and interpreting it purely as a phenomenon of gravitational time dilation. A light signal emitted at the edge of the sphere and received at the centre undergoes a shift according to:

$$1 + z = \frac{1}{\sqrt{1 - \left(\frac{r}{R_h}\right)^2}} \quad (57)$$

Since the redshift is thus a geometric property of the line of sight in the gravitational field and does not rest on a Doppler effect, the global radius R can move independently of v . Its course is fixed by the closure in such a way that the zero-energy condition is preserved.

Asymptotic Transition into the Static Future

As shown in Table 7, the course of the radius $R(a)$ for future epochs ($a > 1$) shows a monotone approach to a fixed limit of $\sim 0.9665 R_0$.

Table 7: Numerical approach to the static end state

Scale factor a	Radius $R(a)/R_0$	dR/da (10^{22} m)
1	1.0000	−426.8
2	0.9832	−107.2
5	0.9732	−17.12
10	0.9698	−4.272
50	0.9672	−0.171

The rate of change of the geometry (dR/da) falls off in proportion to a^{-2} and dies away completely at infinity. In the variable a , the static state in this algebraic system is an attractor rather than a

balance, and it is reached from one side only. The local kinetic energy of matter (described by $v \approx c$) stays frozen into the field, while the global expansion freezes.

Conclusion

The model examined demonstrates a mathematically consistent alternative to the expansion of space. The unit m/s for v and v_ϕ must not be confused with the global expansion velocity of space; it is a measure of the local gravitational potential enclosed in the volume of the sphere. By completely replacing kinematic expansion with gravitational time dilation, the model yields an asymptotically static future of the universe for which the mechanism of the Eddington instability of the classical static Einstein universe has no counterpart. That is not a stability analysis in Eddington's sense, since such an analysis presupposes an equation of motion, which the model does not yet contain (Sect. 6.1). What can be said at present is that the model exhibits no instability.

From Flip Book to Geodesic: The Relativity of Time as a Force-Free Regulator of a Static Future

Scientific essay — Part II

Abstract. This essay continues the critical analysis of a cosmology based on free fall. It focuses on the fundamental dilemma of how a non-monotonic course of the radius can be justified, mathematically and physically, without classical dynamical equations of motion. It examines how far the established closure algorithm rests on the equivalence of the time dilations, and how the concept of the zero-energy universe is stabilised energetically. Finally, it is shown that for matter in free fall no classical Newtonian force is needed, because inertia and gravity cancel in the weightlessness of free fall, but that this does not replace the missing equation of motion for the cosmic radius.

The Temporal Seam: The Algebraic Flip Book

The cosmological model described in Part I faces a mathematical test of strength as soon as one tries to describe dynamically the transition from the epoch of expansion ($a < 0.155$) to the phase of slight contraction ($a > 0.155$). By classical mechanical reasoning, the derivative of the radius with respect to time (dR/dt) would have to change sign at this turning point, which in a kinematic universe would necessarily be coupled to a drastic change in the observed redshift.

Since the model solves this transition purely algebraically, through the closure condition of the *main equation*, the mathematical structure behaves like a perfect flip book: it strings together static single frames of energetic equilibrium states. Each frame for a given scale factor a is self-consistently closed, but the physical law that would causally drive the system dynamics from one frame to the next remains unformulated in classical force dynamics.

The Equivalence of the Time Dilations as a Metabolic Gear

This flip book is not a mathematical artefact but rests fundamentally on the postulated equating of kinetic and gravitational time dilation:

$$\sqrt{1 - \frac{v^2}{c^2}} = 1 + \frac{\phi}{c^2} \quad (58)$$

In traditional relativity theory, motion (v) and spatial curvature (ϕ) are complementary but distinguishable physical phenomena. Through their mathematical interchangeability in the present model ($v \equiv v_\phi$), however, the closure algorithm receives the licence to convert the real macroscopic outward motion of the celestial bodies, without any loss of physical information, into a purely static property of the field. The mass factor q of dark matter thus becomes a property of the potential:

$$q = \frac{1}{1 + \frac{\phi}{c^2}} \quad (59)$$

Time dilation acts here as the actual regulator: since the flow of time is massively slowed in the dense field of the early phase, the cosmological redshift along the line of sight is decentralised and interpreted purely as gravitational time dilation. As a result, the observed redshift is decoupled from the actual behaviour of the radius, so that the latter may move in a mathematically contracting way while the expansion character of the redshift is preserved.

Energetic Consistency of the Zero-Energy Postulate

A second critical test is the energetic viability of the zero-energy universe in the context of free-fall energetics. In the classical physical sense, free fall means the continuous conversion of potential into kinetic energy, the sum of the two remaining strictly constant.

In the model examined, however, the numerical evaluation shows that the free-fall velocity v stays almost constant, just below the speed of light c , over the greater part of the expansion history, while the global gravitational potential changes drastically. Classical energy conservation for an isolated test particle is therefore not given along the time axis. The

closure of the total energy to exactly zero is achieved by the algorithm through the mass factors: at every scale factor a , $\Omega_b (q(a)+x(a)+k(a)) = 1$ holds, and the mass factor of dark energy $x(a)$ is thereby fixed by $q(a)$ and $k(a)$:

$$x(a) = \frac{1}{\Omega_b} - q(a) - k(a) \quad (60)$$

In this model the zero-energy universe is not postulated but follows from the free-fall condition and closes the algorithm. It is not a dynamical result of a mechanical motion but holds, in every single frame of the flip book, as a closure.

From Force Gradient to Freedom from Inertia

In the search for the missing link between the single frames, a physical approach suggests itself which defines the force F as the gradient of a field-dependent energy difference ΔE_0 , based directly on the variable speed of light c' in the gravitational field:

$$F = \frac{d}{dr} \left(-\frac{1}{2} \cdot \Delta E_0 \right) \quad (61)$$

This equation derives a real physical force from the relativity of time dilation. In the present state of the model, however, this force acts merely as a locally readable measured value and not as a dynamical drive, since it is not embedded in a differential equation in time ($F = m \cdot \ddot{r}$).

A hint lies, however, in the physical nature of free fall itself: in the state of perfect free fall, complete weightlessness prevails. Since the heavy mass, which responds to the gravitational field, is exactly identical to the inertial mass, which resists a change of motion, these two fundamental properties of matter cancel each other.

Matter in free fall thus needs no driving mechanical force and meets no inertial resistance against which a cosmic drive would have to work. That does not replace the missing equation of motion for $R(a)$: the transition of the universe from $a = 0.15$ to $a = 0.16$ is likewise fixed algebraically by the closure, and an equation of motion integrating this course is still outstanding (Sect. 6.1).

Concluding Remarks

The decoupling of dynamics and geometry set out here concerns the nature of free fall on the cosmological scale. The absence of a classical equation of motion based on Newtonian forces remains an open point of the model, which the main article states explicitly. Matter nevertheless needs no mechanical drive, because the model describes the expansion as a weightless outward free fall. The force components derived from time dilation are not engines of the expansion but local, static measured values. The non-monotonic kink of the cosmic radius at $a \approx 0.155$ is a result of the closure by which $R(a)$ is fixed algebraically, and not the result of an integrated equation of motion. After it, the radius approaches a static end state monotonically and without oscillation, a state which in the variable a is an attractor rather than a balance. Supplying an equation of motion for $R(a)$ is the next step.

Refutation of the Thesis of an Accelerated Expansion of the Universe

*A Gravitational Reinterpretation of the Cosmological Redshift
Scientific essay — Part III*

Abstract. The discovery of the accelerated expansion of the universe by the teams around Adam G. Riess and Saul Perlmutter rests on the kinematic interpretation of the cosmological redshift within the standard model (Λ CDM). This work presents an alternative, locally phenomenologically equivalent cosmological model whose observed Hubble parameter $H_{DL} = 72.4 \text{ km/s/Mpc}$ is compatible, within the measurement uncertainty, with the measurement of Riess et al. (Cepheids and type Ia supernovae), without presupposing a physical expansion of space. Through the coupling of universal time dilations in a closed potential, the model yields a purely gravitational reading of the cosmological redshift. The universe thereby approaches an asymptotically static future, while the Hubble tension is resolved by assigning the two measured values to different quantities.

Introduction

In 1998, measurements of distant type Ia supernovae led to the astrophysical conclusion that the universe is expanding at an accelerating rate. This thesis, shaped by the teams around Adam G. Riess and Saul Perlmutter, requires the introduction of a hypothetical “dark energy” that makes up about 70 % of the energy density of the universe and whose physical nature remains unexplained to this day.

It must be stated methodologically that astronomical measurements do not record any direct expansion of space. What is measured is exclusively the spectral redshift (z) and the apparent brightness (luminosity distance) of cosmic candles. The claim of an accelerated expansion is therefore the result of a specific theoretical interpretation within the Friedmann–Lemaître–Robertson–Walker formalism. This work shows that the observed redshift can be interpreted gravitationally, without an expansion of space.

The Model of the Gravitational Redshift

The model underlying this work dispenses with expanding space. Instead, the cosmological redshift is interpreted as a purely gravitational time dilation along the line of sight. The clocks at the location of the source run more slowly than those of the observer. The redshift is the ratio of the two clock rates, $1 + z = \tau(0)/\tau(r)$, where $\tau(0)$ is the clock rate at the observer and $\tau(r)$ the clock rate at distance r .

The fundamental transformation couples the time scales through the geometry of the horizon. For the observed Hubble parameter along the line of sight, a phenomenological equivalence to the classical expansion parameter results, although space does not expand. The redshift z is consequently not an indicator of a stretching of space but of the gravitational depth of the emitting source location.

Local Phenomenological Equivalence with the Measurements of Riess

A comparison of the two views shows that the observed Hubble parameter of the proposed model, $H_{DL} = 72.4 \text{ km/s/Mpc}$, is compatible, within the measurement uncertainty, with the local measurement of Adam G. Riess and co-workers, $73.04 \pm 1.04 \text{ km/s/Mpc}$.² To clarify the theoretical structures, the two cosmological views are set side by side in separate tables below. Both models draw on exactly the same empirical raw data (z and apparent brightness) but interpret their origin in fundamentally different ways.

Had Riess based his work on this model, he would have measured exactly the same brightness deficits of distant supernovae. The mathematical construct produces an apparent expansion value of $H_{DL} = 72.4 \text{ km/s/Mpc}$ along the optical line of sight, while space does not expand. In this model the “accelerated expansion” is a consequence of the kinematic interpretation of the redshift, which neglects the global gravitational potential.

²A. G. Riess et al., *A Comprehensive Measurement of the Local Value of the Hubble Constant with 1 km/s/Mpc Uncertainty from the Hubble Space Telescope and the SH0ES Team*, The Astrophysical Journal Letters 934, L7 (2022), <https://doi.org/10.3847/2041-8213/ac5c5b>.

Table 8: The standard model (Λ CDM / Riess)

Feature	Manifestation in the standard model
Cause of the redshift	Kinematic (stretching of space)
Hubble parameter, local (H_{DL})	73.04 ± 1.04 km/s/Mpc (expansion)
Hubble parameter, global (H_{CMB})	≈ 67.4 km/s/Mpc
Dynamics of the universe	Accelerated expansion of space

Table 9: The proposed model (Adamczyk)

Feature	Manifestation in the present model
Cause of the redshift	Gravitational (time dilation in the field)
Hubble parameter, local (H_{DL})	72.4 km/s/Mpc (potential effect)
Hubble parameter, global (H_{CMB})	67.4 km/s/Mpc
Dynamics of the universe	Asymptotically static future ($dR/dt \leq 0$)

Resolution of the Hubble Tension

A feature of this model compared with the Λ CDM model is the resolution of the so-called ‘‘Hubble tension’’. While in the standard model the discrepancy between the local measurements of Riess (73.04 ± 1.04 km/s/Mpc) and the global Planck satellite data of the early universe (67.4 km/s/Mpc) remains unresolved, in this model both values exist side by side without contradiction. They belong to two different quantities of the same model: a geometric H_{CMB} and an observed H_{DL} .

Falsifiability and Outlook

Although the observed Hubble parameter of the model is compatible with the measurement of Riess in the local universe, the model differs fundamentally from the standard model at extremely large distances. The model predicts that at a scale factor of $a \approx 0.155$ the observed Hubble parameter follows a non-monotonic curve (first falling, then rising steeply). A sufficiently deep-reaching distance ladder, for instance

with high-precision measurements of extremely distant cosmic objects by advanced space telescopes, can test this characteristic signature and thereby confirm or falsify the model.

Conclusion

The thesis of an accelerated expansion of the universe is not physically compelling. By dispensing with the kinematic expansion of space and introducing a purely gravitational interpretation of the redshift, it is possible to obtain a value of H_{DL} that is compatible with the local measurement of the cosmic distance ladder. In this model dark energy arises through a factor x from baryonic matter, and the universe approaches an asymptotically static final state.

A Call to Scientists

Why the Equality of Kinetic and Gravitational Time Dilation Is Not a Postulate

Additional essay

The Question

The review by the Claude AI calls the equating of kinetic and gravitational time dilation a postulate. It asks whether the equality holds independently of the choice of coordinates. The answer is: the equality is not an assumption of its own. It follows from energy conservation in general relativity (GR), and in Feynman's treatment of gravitation it holds for the same reason. This essay presents the derivation in small steps, so that anyone can check it and carry it further.

The Energy of a Freely Falling Body

A body of mass m falls in the static gravitational field of a mass M . A resting observer at distance r runs more slowly than a resting observer at infinity by a factor $f(r)$; this is the gravitational time dilation. The resting observer at r measures the velocity v of the body with local rulers and clocks. There spacetime is flat, and special relativity applies. Because the field is static, there is a conserved quantity, the energy of the body. It is the product of the rest energy, the factor f , and the Lorentz factor of the body:

$$E = mc^2 f(r) \frac{1}{\sqrt{1 - v^2/c^2}}.$$

Fall from Infinity

If the body is released from rest at infinity, then $f = 1$ and $v = 0$ there, so $E = mc^2$. This is a total energy of zero in the sense of Newtonian mechanics: kinetic and potential energy cancel. Since E is conserved, at every distance r

$$f(r) \frac{1}{\sqrt{1 - v^2/c^2}} = 1 \quad \Longleftrightarrow \quad \sqrt{1 - \frac{v^2}{c^2}} = f(r).$$

In the second equation, on the left is $\sqrt{1 - v^2/c^2}$, the kinetic time dilation of special relativity, and on the right $f(r)$, the gravitational one. Only the left side contains v ; $f(r)$ depends only on the position and on the mass M . Their equality is therefore nothing other than energy conservation for the fall from infinity. No additional postulate is needed. All that is presupposed is that the total energy is zero, and that is a premise of the model, not of the equating.

Einstein's Theory of Relativity

In the Schwarzschild metric of GR, $f(r) = \sqrt{1 - 2GM/(rc^2)}$.³ Inserting this gives

$$v = \sqrt{\frac{2GM}{r}} = v_e,$$

the familiar second cosmic velocity. That the escape velocity comes out here is the check in the main article. The proof of the equality lies in the previous section: it was derived there from energy conservation, not assumed.

Feynman's Treatment of Gravitation

Feynman treats gravitation as a field in flat spacetime.⁴ In it, a resting observer in the potential $\phi = -GM/r$ runs more slowly by the factor $f = 1 + \phi/c^2 = 1 - GM/(rc^2)$.⁵ The two previous sections need only the factor f from the gravitational field. The procedure therefore stays the same, only the factor is a different one, and the equation of the main article results:

$$\sqrt{1 - \frac{v^2}{c^2}} = 1 + \frac{\phi}{c^2} \quad \Longrightarrow \quad v = \sqrt{\frac{2GM}{r} - \left(\frac{GM}{rc}\right)^2}.$$

Both factors agree in first order. With $u = GM/(rc^2)$ one has $\sqrt{1 - 2u} = 1 - u - \frac{1}{2}u^2 - \dots$, and in this order both give the same

³C. W. Misner, K. S. Thorne, J. A. Wheeler, *Gravitation*, W.H. Freeman, San Francisco 1973.

⁴R. P. Feynman, F. B. Morínigo, W. G. Wagner, *Feynman Lectures on Gravitation*, ed. B. Hatfield, Addison-Wesley, Reading (Mass.) 1995.

⁵R. P. Feynman, R. B. Leighton, M. Sands, *The Feynman Lectures on Physics*, Vol. II, Addison-Wesley, Reading (Mass.) 1964, Ch. 42, Sec. 42-6 ("The Speed of Clocks in a Gravitational Field").

result $v^2 = 2GM/r$. They differ only in the quadratic term, which the main article states. There is no contradiction with GR in this.

Coordinates and Cosmic History

The review asks about the choice of coordinates. Both sides of the equation are scalars: f is the magnitude of the vector that generates the time translation of the static field (Killing vector), and the Lorentz factor is the scalar product of the four-velocities of the falling and the resting observer. The energy E is also such a scalar product. Scalar products do not depend on coordinates. The equality therefore holds in Schwarzschild coordinates just as in any other coordinate system.

The derivation holds for the static field. That the equality also holds when R changes in the course of cosmic history presupposes that the edge of the universe keeps falling with total energy zero. This is what the model calls a cosmos in free fall. The main article expressly describes the step from the static limiting case to cosmic history as an identification, not as a derivation. No more than this is claimed here.

What Has Been Shown

The equality of kinetic and gravitational time dilation is not a postulate but energy conservation in the fall from infinity. In GR it holds exactly, in Feynman's treatment for the factor f chosen there. Both factors agree in first order, and which of them is correct in strong fields this essay does not decide.

A Call to Collaborate

The main article names its open points itself: an equation of motion for $R(a)$ with a stability analysis of the static end state, a perturbation calculation with the spectrum of the cosmic microwave background, and nucleosynthesis. To these is added the question left open here, namely which of the two factors is correct in strong fields. Whoever takes up one of these tasks, recalculates it, confirms it or refutes it, carries the work forward. The book calls on scientists to do so.

Detailed calculations can be found at
<https://doi.org/10.5281/zenodo.22975723>

where the scientific article is also freely
available as a searchable PDF file.

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