

SHIFT

**The Odyssey of Cosmological
Anisometropia**

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SHIFT · The Odyssey of Cosmological Anisometropia

ISBN 979-10-989002-2-8

Legal deposit: 2026

Edition: self-published

Preprint SHIFT V5 : INPI DSO2026007085

Preprint SHIFT V8 : INPI DSO2026029086

This Book : INPI DSO2026031487

Zenodo DOI : 10.5281/zenodo.18475407

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Table of Contents

Reading Guide

PART I · The Assessment

What telescopes tell us, and what we concluded from it

- I.1 · The light from distant galaxies is red
- I.2 · The H_0 tension: two measurements, one model that falters
- I.3 · JWST and the impossible galaxies
- I.4 · Instrumental depth: JWST sees to 55 Gly
- I.5 · Dark energy wavers
- I.6 · Dark matter: nowhere to be found
- I.7 · The CMB: the most precise blackbody in the universe
- I.8 · The double chronological pinch
- I.9 · ARCADE-2 & EDGES: two anomalies swept under the rug

PART II · What we may have misinterpreted

- II.1 · Gravitational redshift
- II.2 · The mathematical anisometropia of Λ CDM
- II.3 · The CMB reinterpreted
- II.4 · Molecular chemistry: a fourth string

PART III · SHIFT

- III.1 · The $z(r)$ law: one equation, not an ad hoc model
- III.2 · Calibration on real data
- III.3 · The fractal universe
- III.4 · Hawking recycling and baryonic CDM
- III.5 · IceCube validation
- III.6 · Testable and falsifiable predictions
- III.7 · Objections
- III.8 · The Hydraxies
- III.9 · Epistemology: what SHIFT says about science

PART IV · Perspectives

- IV.1 · The instrumental agenda 2026–2035
- IV.2 · If SHIFT is correct
- IV.3 · Final word

Conclusion · The fractal vertigo

PART V · Appendices

- Appendix · SHIFT Preprint V8
- Appendix A · Systematic comparison Λ CDM vs SHIFT
- Appendix B · Glossary of terms

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Reading Guide

1. What SHIFT is, in a few words

SHIFT (Static Hierarchical Invariant Fractal Tensorial spacetime) is an alternative cosmological framework to the standard model Λ CDM. It rests on one central idea: the redshift of light from distant galaxies is not the signature of an expanding universe, but the result of cumulative gravitational energy loss that photons undergo as they traverse the gravitational potential of an infinite, eternal fractal universe.

This mechanism, the “gravitational redshift”, is predicted by Einstein's General Relativity and has been measured in the laboratory since 1960. SHIFT applies this well-established phenomenon at cosmological scales, without expansion, without a Big Bang, without dark energy, without exotic dark matter particles.

SHIFT will be presented in detail in Part III of this book. Parts I and II build the observational case and the method; they do not require SHIFT to be read and understood.

2. Structure of the book

Part	Title	Chapters	Content
PART I	The Assessment	Ch. I.1 → I.9	What observational data reveals, and the structural tensions Λ CDM is accumulating. No solution is proposed here. The picture is documented without concession.
PART II	What we may have misinterpreted	Ch. II.1 → II.4	Four reinterpretations of the same data: gravitational redshift, mathematical anisometropia, the CMB, molecular chemistry. SHIFT begins to take shape, without yet being named systematically.
PART III	SHIFT	Ch. III.1 → III.9	The complete construction: the $z(r)$ law, calibration on real data, the fractal universe, Hawking recycling, IceCube validation, testable predictions, the Hydraxies, epistemology.
PART IV	Perspectives	Ch. IV.1 → IV.3	The instrumental agenda 2026–2035, the consequences if SHIFT is correct, and a final word on science as conversation.
CONCLUSION	The fractal vertigo		The bottomless fractal staircase, and the closing image.
APPENDIX	SHIFT Preprint V8		The formal and mathematical foundation of the book: equations, calibrations, prediction tables, references.

3. Distance conventions, read this first

In cosmology, several types of distances coexist, comoving distances, angular distances, luminosity distances, lookback time, each answering a different question within the Λ CDM framework. Their multiplicity creates confusion, even among specialists. This book chooses to use only two, systematically:

Quantity 1, Lookback time (Gyr)

The time elapsed since the emission of light, in billions of years (Gyr). This is the only temporal quantity directly measurable in both frameworks, Λ CDM and SHIFT, without additional assumptions. Example: a galaxy at $z = 7$ has a lookback time of 12.72 Gyr according to Λ CDM.

Quantity 2, Physical depth (Gly)

The distance travelled by the photon from its source, in billions of light-years (Gly). In SHIFT, this is the direct field depth. It is calculated via the $z(r)$ law presented in Part III. Example: the same galaxy at $z = 7$ lies at ~ 31.7 Gly of physical depth in SHIFT.

△ This book does not use Λ CDM comoving distances. When a value in Gly appears in Parts I and II, it is always either a converted lookback time (for Λ CDM figures) or a physical field depth calculated by SHIFT (for SHIFT figures, clearly identified). The complete conversion table appears in the Appendix.

4. Reading posture

Parts I and II document Λ CDM tensions with rigour and without complacency. This is not a prosecution case, it is an honest reading of published data. Λ CDM has real and indisputable successes; they are acknowledged. But the anomalies documented here are equally real, and deserve to be taken seriously.

SHIFT is not introduced before Part III. This choice is deliberate: the assessment must be able to stand on its own, independently of any solution. If the reader closes this book after Part II with the conviction that Λ CDM is accumulating real structural tensions, the objective of the first two parts has been achieved.

What SHIFT is: a coherent hypothesis, calibrated on real data, with falsifiable predictions. What SHIFT is not: a certainty, nor the only possible alternative. Part III will present it in that spirit.

Marc J-L Henry · August 2026

· INPI DSO2026007085

· INPI DSO2026029086

· INPI DSO2026031487

· Zenodo DOI 10.5281/zenodo.18475407

Chapter I.1

The light from distant galaxies is red.

That's all. That's where everything begins.

I.1.1 The observation

In 1929, Edwin Hubble published a result that would change our vision of the cosmos. Compiling the light spectra of several dozen spiral nebulae, just beginning to be recognised as galaxies, islands of billions of stars well beyond the Milky Way, he noticed something striking:

almost all their spectral lines were shifted toward the red. Not slightly, not randomly. Systematically. And the more distant a galaxy, the greater its shift.

This shift is called redshift, denoted z . Its definition is disarmingly simple:

$$1 + z = \lambda_{\text{obs}} / \lambda_{\text{emit}}$$

→ $z = 0$: light arrives at the same wavelength at which it was emitted.

→ $z = 1$: the wavelength has doubled. The light is twice as "red".

→ $z = 10$: it has been multiplied by eleven.

This is a direct, instrumental, incontestable measurement. The spectrum of a galaxy is a barcode of emission and absorption lines, each chemical element has its precise signature in wavelength. The measured signature is compared to the laboratory signature. The gap gives z .

What z measures is therefore clear: a spectral shift.

What it means physically, that is where interpretations diverge.

I.1.2 The standard interpretation: space stretches

The reading adopted by twentieth-century cosmology is this: if the light from distant galaxies is redshifted, it is because space itself stretched while the photons were travelling. The universe is expanding. It was smaller, denser, hotter in the past. Rewind the film far enough, 13.8 billion years, and you arrive at an initial point: the Big Bang.

This interpretation is coherent. It integrates naturally into Einstein's General Relativity. And for nearly a century, it provided a remarkable predictive framework.

But it rests on an implicit postulate, rarely stated as such:

Founding postulate of Λ CDM: Redshift z is caused by the expansion of the spacetime metric. This postulate is not a measurement. It is an interpretation.

z itself is measured. That is physics. Whether z is caused by the expansion of space, a gravitational energy loss, a classical Doppler effect, or something else, that is theory. And theory is not infallible.

I.1.3 The Hubble-Lemaître law: redshift proportional to distance

What Hubble observed, and Lemaître had anticipated theoretically as early as 1927, is a quasi-linear relationship between a galaxy's distance and its redshift:

$$z \approx (H_0 / c) \cdot r \text{ (for small distances)}$$

$H_0 \approx 70 \text{ km/s/Mpc}$: the Hubble constant
 r : physical distance in megaparsecs (Mpc)

This relationship is observed, and it is robust at small scales. It will serve as a calibration anchor for the alternative framework presented in Part III, not as proof of expansion, but as raw data on the redshift-distance relationship.

The problem begins when one extrapolates beyond a few billion light-years. Λ CDM then adds corrective terms, dark matter, dark energy, deceleration parameter q , to fit observations at high z . Each new observational tension calls for a new adjustment parameter.

The alternative framework presented in Part III predicts, from a single law with three independently constrained parameters and no post-hoc adjustment, the results of future observations.

I.1.4 What telescopes see, and what Λ CDM expects

If the Big Bang occurred 13.8 billion years ago, then the observable universe has a maximum radius of 13.8 billion light-years. This is a hard geometric constraint: one cannot see further than the time it took light to reach us from the origin.

This constraint has an immediate consequence: any observation at high z must fit within this volume. A galaxy seen at $z = 10$ is, according to Λ CDM, a galaxy whose light travelled approximately 13 billion years, in a universe that was then only 500 million years old.

And there lies the first snag.

JWST observes galaxies at $z > 10$ showing:

- mature elliptical morphologies (discs, bulges, defined spiral arms)
- aged stellar populations (several billion years)
- stellar masses $> 10^{10}$ solar masses

Yet in Λ CDM, these galaxies would have had only 400 to 500 million years to form. That is physically insufficient.

This is not a marginal anomaly. It is a systematic contradiction that astrophysicists have been documenting since the first JWST images in 2022, and which has worsened with every new publication, including JADES DR5 (January 2026), which reveals coherent, extended spiral structures at $z > 10$.

I.1.5 Stars older than the universe?

In 2026, Tomasetti et al. published in *Astronomy & Astrophysics* a dating of stellar sub-populations in the Milky Way. The mean age of the final sample stands at 13.6 ± 1.0 (stat) ± 1.4 (syst) Gyr. An older sub-population appears at ~ 14.8 Gyr. The authors derive a cautious lower bound $t_U \geq 13.8$ Gyr (accounting for a minimal formation delay). Even with this caution, the result constitutes a real chronological tension with Λ CDM's age limit of 13.8 Gyr. In a universe without an age limit, the framework presented in Part III, stars of this age pose no particular problem.

I.1.6 What to retain from this chapter

Redshift z is a robust, reproducible, instrumentally measured observation. The law $z \propto r$ at low distance is established.

The interpretation of z as spacetime expansion is a postulate, not a measurement. At high z , Λ CDM accumulates structural contradictions, overly mature galaxies, overly old stars, that cannot be resolved by parameter adjustments. They worsen with each new dataset.

*The question is therefore not: **Does redshift exist?***

*The question is: **What is its physical cause?***

*And one might add: **Is it a simple cause, or multiple, and if so, is there one dominant cause?***

Λ CDM settled on expansion a priori. To be precise, the astrophysical community adopted it as truth nearly a century ago, on the basis of evidence that seemed to support it, but without having had the means to verify it until now.

Chapter I.2

H_0 : a constant that isn't.

The H_0 tension, or how two impeccable measurements give incompatible results.

I.2.1 Two ways to measure H_0 , two different answers

The Hubble constant H_0 is supposed to describe the current rate of expansion of the universe. It is one of the fundamental parameters of Λ CDM. And for the past fifteen years, astrophysicists have been unable to agree on its value.

Not for lack of data. But because two families of measurements, each rigorous, each independent, give systematically discordant results.

Local method (Cepheids + Type Ia Supernovae):

$H_0 \approx 73 \text{ km/s/Mpc}$ (Riess et al., SH0ES Collaboration)

CMB method (cosmic microwave background, Planck):

$H_0 \approx 67 \text{ km/s/Mpc}$ (Planck Collaboration 2018)

Discrepancy: 6 km/s/Mpc · Statistical significance: 5.8σ

5.8σ is the language physicists use to say: if both measurements described the same universe with the same assumptions, the probability of observing such a discrepancy by pure chance is less than one in a billion. This is not a measurement uncertainty. It is a signal.

I.2.2 The cosmic distance ladder: a chain of trust

To understand why this discrepancy is so difficult to resolve, one must grasp how the local measurement of H_0 is constructed.

Cosmic distances are not measured directly. They are built in a chain, each level calibrating the next. This is what is known as the distance ladder:

Level 1: trigonometric parallaxes (nearby stars, $< 1 \text{ kpc}$)

Level 2: Cepheids, variable stars whose period reveals their absolute luminosity

Level 3: Type Ia Supernovae, standard explosions of known luminosity

Level 4: local H_0 via Hubble's law $z \approx H_0 \cdot r / c$

This chain is long. Each link transmits its uncertainties to the next. The teams who built it, Riess, Freedman, Huang, are among the best in the world. They have refined their methods over decades.

And yet, whatever they do, the local result stays around 73 km/s/Mpc.

I.2.3 The CMB measurement: H_0 deduced, not measured

The value of 67 km/s/Mpc comes from a fundamentally different approach. It is not measured directly, it is deduced.

Planck observes the cosmic microwave background: the temperature map of radiation emitted (according to Λ CDM) 380,000 years after the Big Bang. By fitting Λ CDM model parameters to this data, matter density, dark energy density, curvature, etc., one obtains a value of H_0 consistent with the model.

This is where the fundamental asymmetry lies: the local measurement is direct, it assumes no cosmological model. The CMB value is indirect, it is the product of an adjustment within the Λ CDM framework.

If Λ CDM is the correct model: both measurements must converge.

They diverge at 5.8σ .

- Either one of the measurements is wrong.
- Or Λ CDM is incomplete.
- Or H_0 is not what we think it is.

The community has scrutinised every link in the local chain. Systematic effects on Cepheids in supernova host galaxies? Verified with JWST and Gaia. Dust contamination? Corrected. Selection bias? Tested. The tension does not go away.

I.2.4 The S_8 tension: a second structural disagreement

The H_0 tension is not isolated. It is accompanied by a second systematic discordance: the S_8 tension.

$S_8 = \sigma_8 \times \sqrt{(\Omega_m / 0.3)}$ is a parameter describing the amplitude of matter density fluctuations at large scales. It is measured in two ways:

Weak gravitational lensing (Euclid, HSC, KiDS-VIKING): $\rightarrow S_8 \approx 0.76$, a "less clumpy" universe than predicted

CMB Planck (deduced value): $\rightarrow S_8 \approx 0.83$

Discrepancy: 3 to 4σ , persisting across all recent surveys
--

Both tensions, H_0 and S_8 , pull in the same direction: direct data give a local universe that is less dense, less structured, and "dispersing" faster than what Λ CDM calibrated on the CMB predicts.

This pattern is not random. It suggests that something important is eluding the standard model, not in a single measurement, but in its very structure.

1.2.5 What to retain from this chapter

H_0 is measured at 73 km/s/Mpc locally, 67 km/s/Mpc via the CMB. The gap is 5.8σ , not a measurement error.

The CMB value is indirect: it depends on the Λ CDM framework. The local value is direct: it rests on an astrophysical calibration chain (Cepheids, SNIa), but does not depend on a global cosmological model.

The S_8 tension compounds the picture: two independent tensions pointing toward the same structural limit of the model.

A constant that varies depending on where you measure it is not a constant.

Chapter I.3

What JWST should not have seen.

Adult galaxies at the edge of time, and Λ CDM has no answer.

I.3.1 The telescope that changed everything

The James Webb Space Telescope (JWST) was launched on 25 December 2021. Its first scientific images were published in July 2022. And since then, almost every new publication has produced the same effect in the community: astonishment.

Not because JWST is failing, it is performing beyond expectations. But because what it sees systematically contradicts what Λ CDM predicted.

The problem is simple to state. In a 13.8-billion-year-old universe, a galaxy observed at $z = 10$ is a galaxy whose light travelled 13 billion years. The universe was then only 500 million years old, the time it supposedly had to form stars, assemble galaxies, structure them, enrich them with metals, and produce then extinguish entire stellar generations.

500 million years. That is not much.

Λ CDM timeline at $z = 10$:

Age of the universe at that epoch: ~ 500 million years

Time available to form a massive galaxy: < 500 Myr

Time required (star formation + relaxation + quenching): 1 to 3 Gyr

→ The delay is insufficient by a factor of 2 to 6.

→ This is not a marginal tension: it is a temporal impossibility.

I.3.2 The observational file: what JADES documented

The JADES programme (JWST Advanced Deep Extragalactic Survey) is the deepest survey ever conducted of the distant universe. Its fifth data release (DR5, January 2026) is particularly eloquent.

At $z > 10$, within the first 500 million years according to Λ CDM, JADES reveals:

- Well-defined spiral structures, with arms, central bulge and disc
- Galactic discs in regular, stable rotation
- Multi-component morphologies (bulge + disc + spiral arms simultaneously)

- Stellar populations showing ages of several hundred million years
- Already-slowng star formation rates, signs of ageing galaxies, not newborns

These morphological configurations do not arise spontaneously. A well-defined spiral galaxy with coherent arms spanning tens of kiloparsecs requires several billion years of dynamic relaxation. The most optimistic Λ CDM simulations do not produce these structures this early.

JADES DR5 is not describing a handful of exotic objects. It is describing dozens of galaxies showing these characteristics. This is a statistical pattern, not an isolated anomaly.

I.3.3 Three emblematic galaxies

Among the most documented cases, three deserve particular attention. Each illustrates a different aspect of the temporal contradiction.

RUBIES-UDS-QG-z7 · z = 7.3

Stellar mass: $\log(M_{\star}/M_{\odot}) = 10.23 \rightarrow \sim 1.7 \times 10^{10}$ solar masses. Physical size (Λ CDM): 209 parsecs effective radius. Mass density: $\log(\Sigma_{\star,e}) = 10.85 M_{\odot}/\text{kpc}^2$, among the highest ever observed. Status: quiescent galaxy, star formation already extinct. Λ CDM problem: forming 17 billion solar masses, extinguishing them, and compacting the result in less than 700 million years. Physically impossible.

GS-10578 "Pablo's Galaxy" · z = 3.06

Stellar mass: 1.6×10^{11} solar masses. Morphology: regular elliptical, disc in calm rotation. 50% of stellar mass accumulated between $z = 3.7$ and $z = 4.6$. Residual molecular gas: $< 10^{9.1} M_{\odot}$, less than 0.8% of stellar mass. Λ CDM problem: near-total gas exhaustion, with no major merger detected. This galaxy is "dead" before the Sun even formed.

JADES-GS-z14-0 · z = 14.32

The highest spectroscopically confirmed redshift to date (2024). Luminosity: surprisingly high for $z > 14$ according to Λ CDM. Morphology: extended, this is not a point-source quasar. Λ CDM problem: age of the universe at this epoch according to Λ CDM: ~ 290 million years. An extended, luminous galaxy in 290 Myr remains without satisfactory explanation.

M1149-BSG-z5 · z = 5.102

Reference: Wang et al. (2026), arXiv:2606.25022, the most distant known barred galaxy candidate to date. SHIFT depth: ~ 22 Gly. Stellar bar: $a_{\text{bar}} \approx 4.5$ kpc · Spiral arms: $r \approx 5.5$ kpc. Stellar mass: $\sim 2.8 \times 10^{10}$ solar masses. SFR: $144 M_{\odot}/\text{yr}$. Metallicity: $\sim 50\%$ solar. $M_{\text{BH}}/M_{\star}$ ratio: $\sim 10^{-3}$. Λ CDM problem: a 4.5 kpc stellar bar requires several billion years of dynamic relaxation. In Λ CDM at $z = 5.1$, the universe is only ~ 1.2 Gyr old. The temporal deficit is a factor of 2 to 4.

A note on context: at $z \sim 5$, no confirmed BCGs exist in the strict sense, structures at this depth are still assembling proto-clusters, not virialized clusters with an established BCG. M1149-BSG-z5 is not a BCG.

But it is the most morphologically compelling proxy available at this depth, and its argument belongs to the same register.

Λ CDM problem: a 4.5 kpc stellar bar requires several billion years of dynamic relaxation, the same temporal constraint as for BCGs, applied here to a different structure. A 50% solar metallicity implies several stellar generations. At $z = 5.1$, the universe is only ~ 1.2 Gyr old. The temporal deficit is a factor of 2 to 4.

The statistical argument may be even stronger. JADES covers approximately 0.02 deg² of sky, a postage stamp. If barred spiral galaxies at $z \sim 5$ were as rare as Λ CDM predicts (near-total suppression of bar formation in the turbulent environment of the first billion years), finding one in such a tiny field would be an extraordinary stroke of luck. Yet JWST data show a bar fraction of 3 to 7% at $z \sim 3.5$, and candidates up to $z \sim 4.3$ (Géron et al., Huertas-Company et al., 2025). This is not an isolated anomaly, it is a pattern. Extrapolated to the full sky, their true volumetric density at $z \sim 5$ is well above what any standard formation model predicts. The reasoning is identical to Conselice et al. on the 2 trillion galaxies: finding one in a small field is not a matter of luck, it is the consequence of a high volumetric density that Λ CDM cannot produce in the time available.

I.3.4 The formation time argument: a back-of-envelope calculation

For a massive quiescent galaxy to exist at $z = 7$, four successive phases must occur:

Phase 1, Gas collapse and onset of star formation: ~ 200 to 500 Myr
Phase 2, Intense star formation (starburst): ~ 500 Myr to 1 Gyr
Phase 3, Quenching mechanism (AGN, feedback, gas exhaustion): ~ 500 Myr
Phase 4, Dynamic relaxation toward elliptical morphology: ~ 1 to 2 Gyr
Realistic minimum total: 2.2 to 4 Gyr
Time available in Λ CDM at $z = 7$: ~ 760 million years
→ Deficit: factor 3 to 5
The most optimistic Λ CDM simulations do not produce coherent spirals before 1.5–2 Gyr.

This calculation is not controversial within the community. What is controversial is the conclusion to draw from it. Some researchers look for accelerating mechanisms, more efficient star formation, faster AGN activity. Others are beginning to wonder whether the problem lies in the framework itself.

I.3.5 Population III stars: the unfindable proof of the beginning

Λ CDM predicts the existence of Population III stars, the first stars, formed purely from primordial hydrogen and helium, metal-free, probably very massive. These stars should have existed within the first few hundred million years after the Big Bang.

Despite decades of searching and the power of JWST, no Population III star has been formally identified. Candidates have been proposed, a gravitational lens in

2023, a few suspicious spectral lines, but no robust confirmation to date.

More troubling still: JWST detects galaxies at $z > 10$ already enriched in metals. Carbon, oxygen, neon detected in spectra of galaxies that, according to Λ CDM, would have had only a few hundred million years to produce these heavy elements.

Metal enrichment requires:

- *Several stellar generations (massive stars $\rightarrow$ supernovæ $\rightarrow$ dispersal)*
- *Estimated cycle time: 300 to 500 Myr per generation*
- *Several cycles to reach the observed abundances $\rightarrow$ In Λ CDM at $z = 10$: time runs out, once again.*

The absence of Population III stars and the early presence of metals form a coherent double signal: the universe JWST observes does not look like a 500-million-year-old universe.

I.3.6 What to retain from this chapter

JWST systematically reveals mature, structured, enriched, quiescent galaxies where Λ CDM expected chaotic, metal-poor proto-galaxies.

This is a coherent pattern across dozens of objects, across multiple independent programmes, across several years of observations.

The temporal deficit is real, quantifiable, and does not disappear with parameter adjustments. It worsens with every new data point.

The question that naturally follows is simple: what if the problem is not the available time, but the assumed depth? What if these galaxies are not 13 billion light-years away, but much farther?

This is precisely what the next chapter will demonstrate, with numbers, and without assumptions.

Chapter I.4

Two thousand billion galaxies.

A density calculation. An angular calculation. Two independent methods. One single answer: JWST sees to 55 billion light-years.

I.4.1 The geometric question

The question is simple: how many galaxies can JWST see? And in what volume must these galaxies fit? This is not a question of model. It is a question of geometry and density, two quantities we know independently of any cosmology.

The question is simple: how many galaxies can JWST see? And within what volume must these galaxies fit?

This is not a question of modelling. It is a question of geometry and density, two quantities we know independently of any cosmology.

Datum 1: estimate of ~2,000 billion galaxies, extrapolated by Conselice et al. (2016) from the stellar mass function.

Datum 2: mean density of galaxies in the local universe $\rightarrow \sim 0.1$ galaxy per Mpc^3 (direct measurement)

Question: what volume is needed to contain 2,000 billion galaxies at this density? $\rightarrow$ This is a high-school calculation.

I.4.2 First calculation: galactic density

The calculation rests on two observational data points and one explicit model assumption, which must be stated clearly.

SHIFT assumption: in a quasi-static, statistically homogeneous universe at large scales, the mean galaxy density ρ is approximately stationary over time. This is a direct consequence of the quasi-static nature of SHIFT, and a fundamental difference from Λ CDM, where Conselice et al. (2016) use a density evolving as $\phi \propto t^{-1}$. Both approaches yield $N \sim 2 \times 10^{12}$, but from distinct assumptions about density evolution.

Note on Conselice et al. (2016): the 2×10^{12} galaxies are an estimate reconstructed from the stellar mass function up to $z \sim 8$ (limit $M_{\star} = 10^6 M_{\odot}$), not a direct count. The vast majority of these galaxies are too faint to be observed individually with current instruments.

Under the SHIFT assumption of stationary density: $N = (4\pi/3) \times \rho \times R^3$

$N = 2 \times 10^{12}$ galaxies (Conselice et al. 2016)

$\rho = 0.1 \text{ gal/Mpc}^3$ (locally measured density, stationary under SHIFT)

$$\text{Required volume} = N / \rho = 2 \times 10^{13} \text{ Mpc}^3$$

$$r = (3V / 4\pi)^{1/3} = (3 \times 2 \times 10^{13} / 4\pi)^{1/3}$$

Result: $r \approx 55$ billion light-years (55 Gly)

This result is robust. Both input parameters carry uncertainties, and they must be tested:

Lower bound: $N = 1.5 \times 10^{12} \cdot \rho = 0.13 \text{ gal/Mpc}^3 \rightarrow \sim 46 \text{ Gly}$
 Central value: $N = 2.0 \times 10^{12} \cdot \rho = 0.10 \text{ gal/Mpc}^3 \rightarrow \sim 55 \text{ Gly}$
 Upper bound: $N = 3.0 \times 10^{12} \cdot \rho = 0.07 \text{ gal/Mpc}^3 \rightarrow \sim 71 \text{ Gly}$
 $\rightarrow$ Across the entire uncertainty range: between 46 and 71 Gly.
 $\rightarrow$ Λ CDM's theoretical limit of 13.8 Gly is excluded in all cases.

Under the SHIFT assumption of an approximately stationary mean galaxy density, a volume of radius ~ 55 Glyr is required to contain a population of the order of 2 trillion galaxies at the adopted density. This result provides a reference depth of the order of 55 Glyr for the JWST instrumental window within the framework developed here? four times the maximum radius allowed by Λ CDM.

I.4.3 Second calculation: the solid angle of BCGs

The first calculation uses galaxy counts and densities. The second is entirely independent, it uses angles and physical sizes.

Brightest Cluster Galaxies, or BCGs, are the most massive and most regular objects in the universe. They display the same morphologies, the same chemical signatures, and the same characteristic physical sizes at every observed depth. They are natural standard rulers.

A typical BCG: physical radius $R \approx 30$ to 75 kpc
 Its apparent angle: $\theta = R / d$ (in radians, for $\theta \ll 1$)
 $\rightarrow$ If θ is known and R is known, one deduces $d = R / \theta$. This is trigonometry. No cosmological model required.

JWST observes morphologically mature galaxies up to $z \sim 14.7$. The most distant object confirmed to date is JADES-GS-z14-0 ($z = 14.32$), an extended and luminous galaxy whose apparent angle is measured at approximately 0.37 arcseconds. Strictly defined BCGs have not yet been confirmed at these redshifts, cluster structures are not yet virialized at these depths. The argument that follows applies to any morphologically extended galaxy at $z \sim 14.7$, reasonably extrapolating the observed properties of massive galaxies up to $z \sim 5-7$. This relation can be used in both directions, which strengthens the demonstration:

Direction 1, convergence: if we set $d = 55 \text{ Glyr}$ (result of calculation 1 by density), what physical size does $\theta = 0.37''$ imply?

Using JADES-GS-z14-0 ($z = 14.32$), apparent angle ~ 0.37 arcseconds:

$$\theta = 0.37 \text{ arcsec} = 1.79 \times 10^{-6} \text{ radians}$$

$$d = 55 \text{ Gly} = 16,863 \text{ Mpc}$$

$R = \theta \times d = 30 \text{ kpc}$ (deduced radius, consistent with a BCG)

Result: $d \approx 55$ billion light-years (55 Gly)

Two entirely independent calculations, one from galaxy counts, the other from the angular size of BCGs, converge on the same depth: ~ 55 Glyr. This result will be derived formally in Part III, when SHIFT's $z(r)$ law is introduced.

I.4.4 Third calculation: JADES deep fields confirm it by direct count

The two preceding calculations rest on indirect data: an estimate from the stellar mass function for the 2 trillion galaxies (Conselice et al. 2016), and a physical property assumed known for BCGs. A third, more direct approach exists: counting the galaxies actually detected in a deep field, then extrapolating geometrically to the full celestial sphere.

This is precisely what the JADES data now make possible.

The JADES field: a postage stamp of supposedly empty sky.

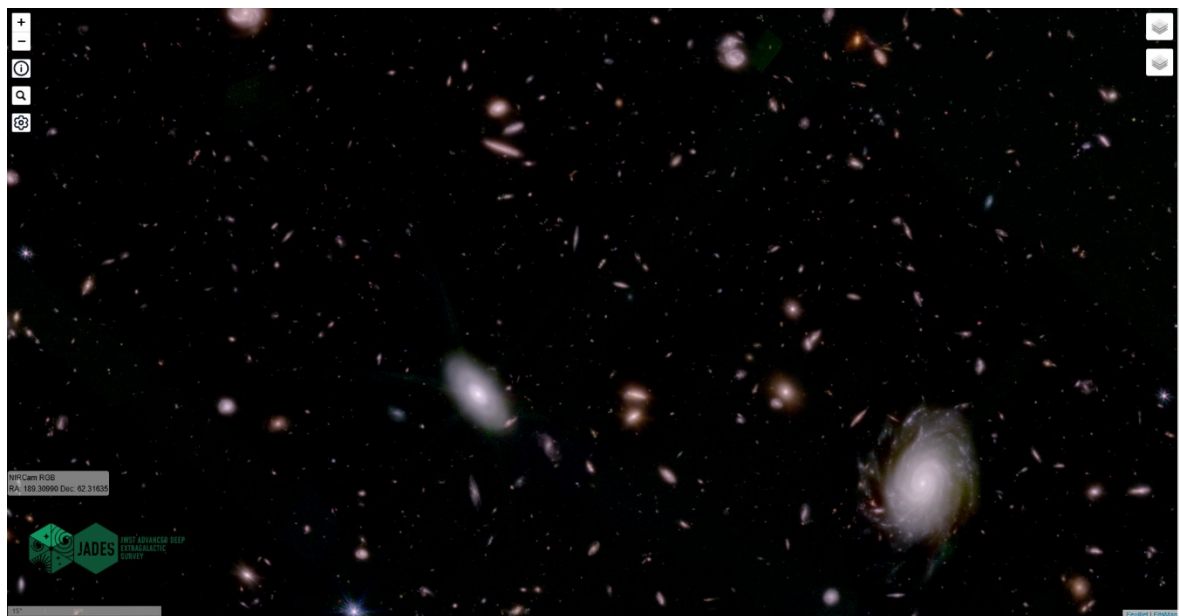
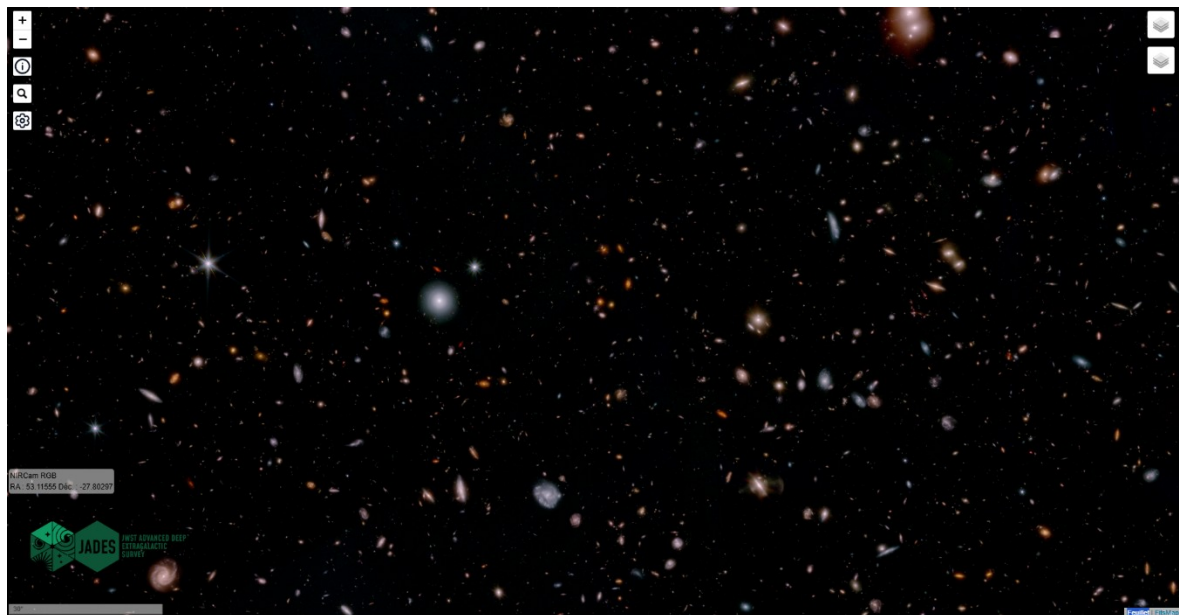
The JADES programme (JWST Advanced Deep Extragalactic Survey) is the largest deep survey ever conducted with JWST. It covers two fields: GOODS-South, centred on the Hubble Ultra Deep Field (HUDF) and the Chandra Deep Field South, and GOODS-North. These areas were deliberately selected because they appeared empty in visible light, windows through the Milky Way, free of bright foreground stars, minimising local contamination.

JADES DR5 · January 2026, consolidated data

- ▶ Total area covered: 469 arcmin² (245 arcmin² GOODS-S, 224 arcmin² GOODS-N)
- ▶ Full multi-filter coverage: 250 arcmin² in 8 NIRCам filters (F090W–F444W)
- ▶ Total exposure time: over 800 cumulative hours (NIRCам + NIRSpec)
- ▶ Photometric depth: down to 30.8 AB magnitude (5σ , F444W filter)
- ▶ Sources detected in the DR5 photometric catalogue: $\sim 500,000$ objects

To give a sense of scale: 469 arcmin² represents approximately 0.65 times the apparent area of the full moon (which covers ~ 720 arcmin²). In this postage stamp of sky, a field chosen for being nearly empty, JWST detects half a million objects.

The finding, in short, is that a field chosen to be empty is saturated with galaxies.



The extrapolation calculation

The principle is purely geometric: the angular density of galaxies in the JADES field is known, and the total area of the celestial sphere is known. We extrapolate.

JADES angular density: 500,000 sources / 469 arcmin ² $\approx$ 1,066 galaxies per arcmin ²
Surface of the celestial sphere: 4π steradians = 1.484×10^9 arcmin ²
Extrapolation: $N = 1,066 \times 1.484 \times 10^9 \approx 1,580$ billion galaxies

This raw result calls for three order-of-magnitude corrections, acting in opposite directions:

Bias 1 , galactic mask → upward. Approximately 20% of the sky is inaccessible (plane of the Milky Way). The JADES count covers only usable sky: the true total is therefore higher than the raw figure.
Bias 2 , field selection → upward. GOODS-S and GOODS-N were chosen for low local contamination, hence as slightly under-dense regions. The JADES angular density is conservative.
Bias 3 , fragmentation → downward. At 30-magnitude depth, JWST partially resolves the internal structure of nearby galaxies. One real galaxy may generate multiple catalogue entries.

These opposing corrections partially cancel. The realistic range lies between 1,000 and 2,000 billion galaxies, with a central value close to 1,500 billion.

Box · JADES DR5 data, Robertson et al. 2026, Johnson et al. 2026

Parameter	Value
Area covered	469 arcmin ² (GOODS-S + GOODS-N)
Total sources, DR5 catalogue	~500,000
Angular density	~1,066 gal./arcmin ²
Surface of celestial sphere	1.484×10^9 arcmin ²
Raw extrapolation	~1,580 billion
Realistic range (after corrections)	1,000–2,000 billion

The range of 1,000 to 2,000 billion obtained by direct counting and angular extrapolation is entirely consistent with the estimate of Conselice et al. (2016). The two approaches use data and methods with no common point, one rests on the stellar mass function, the other on simple geometric counting, and they bracket the same order of magnitude.

I.4.5 The convergence: what it means

Chapter I.4 has now produced three convergent arguments, by three entirely independent methods. It is the coherence of the three calculations:

- ✓ Calculation 1, galactic density $\times$ Conselice estimate $\rightarrow$ ~55 Gly (range 46–71 Gly)
 - ✓ Calculation 2, BCG solid angle $\rightarrow$ ~55 Gly
 - ✓ Calculation 3, direct JADES count $\times$ angular extrapolation $\rightarrow$ 1,000–2,000 billion, compatible with Conselice
- Three independent methods. Three distinct data sources.
JWST's instrumental depth is of the order of 55 Gly.
 Λ CDM's theoretical limit of 13.8 Gly is excluded in all three cases.

I.4.6 Mathematical anisometropia: when the model distorts reality

This compression has a name: the mathematical anisometropia of Λ CDM, by analogy with optical anisometropia, the visual defect in which the two eyes see the same scene at different scales, producing a distorted image without the scene itself having changed.

In Λ CDM, the constraint of 13.8 Gly maximum forces every observation to fit within this volume. A galaxy actually located 55 Gly away must be "brought back" to an apparent depth of 13.8 Gly. Its observed angular size remains the same, that is a physical measurement. But the physical size deduced from it is that of an object four times closer than reality.

Approach 1, field depth: SHIFT depth: 55 Gly / Λ CDM depth: 13.8 Gly. Linear factor: $55/13.8 \approx 4\times$ | Surface: $4^2 \approx 16\times$ | Volume: $4^3 \approx 64\times$

Approach 2, angular physical distance at $z = 14.7$: $D_A(\Lambda\text{CDM}) \sim 650$ Mpc vs $D_{\text{physical}}(\text{SHIFT}) \sim 16,863$ Mpc. Linear factor: $\sim 26\times$ | Surface factor: $\sim 676\times$

$\rightarrow$ A BCG of 75 kpc radius (deduced at 55 Gly) appears, in Λ CDM at $z = 14.7$, as an object of ~ 2.9 kpc, the size of a globular cluster, not a BCG.

$\rightarrow$ This is not a correctable artefact. It is intrinsic to the Λ CDM theoretical framework.

And this is only with JWST. With the ELT (the Extremely Large Telescope), whose commissioning is expected in late 2028, the instrumental depth extends to approximately 200 Glyr. The miniaturisation factor will then reach:

ELT depth: ~200 Glyr (SHIFT instrumental projection, not yet observed)

Three distinct ratios must be kept separate:

1. Nominal depth ratio: $200 / 13.8 \approx 14$.
2. Linear ratio (physical vs angular distances at $z \sim 83$): ≈ 405 .
3. Corresponding surface ratio: $\approx 145,000$.

These three factors do not describe the same quantity and must not be used interchangeably under the single label "anisometropia factor".

Hypothetical projection (ELT, not yet observed): a BCG of ~ 150 kpc diameter would appear, under Λ CDM, as an object of ~ 0.6 pc in diameter (true Λ CDM angular distance at $z \sim 83$).

→ ~ 0.6 pc at $z \sim 83$: that is smaller than a stellar system, not a galaxy.

→ ~ 370 pc at $z \sim 14.7$: that is the size of a globular cluster (Λ CDM lookback calculation).

In both cases: BCG morphology is physically impossible.

→ BCG morphology (disk, arms, massive nucleus) is physically impossible to explain within a volume of 370 pc (lookback) or 0.6 pc (true angular distance).

This is no longer a tension. It is a structural contradiction that worsens mechanically with every instrumental improvement.

I.4.7 What to retain from this chapter

Two independent calculations, galaxy density and BCG solid angle, converge on an instrumental depth for JWST of ~ 55 Glyr.

This depth is four times greater than the Λ CDM theoretical ceiling at 13.8 Glyr. The discrepancy is not within the uncertainties: it persists across the entire range of reasonable parameters.

The consequence is a systematic distortion of deduced sizes, mathematical anisometropia, which worsens with instrumental depth. It will reach a factor of $\times 145,000$ in surface area with the ELT ($\times 14$ in nominal depth, $\times 405$ in geometric linear ratio).

At this point, one question becomes unavoidable: if JWST truly sees to 55 Glyr, how do we explain the observed redshift? Why does a galaxy at 55 Glyr have $z = 14.7$ and not a proportionally larger z ?

Part III of this book will answer this question, with a different interpretation of the same measurement.

That is the subject of Chapter 9. But before getting there, the picture must be complete. Chapters 5 to 8 document the remaining tensions, dark energy, dark matter, the CMB, the Copernican principle, so that the full picture is in place.

PART I · THE ASSESSMENT

What telescopes tell us, and what we concluded from it

Chapter I.5

Dark energy wavers.

Invented to save the model, now challenged by the very data meant to confirm it.

I.5.1 Why dark energy was invented

In 1998, two independent teams, the High-Z Supernova Search Team and the Supernova Cosmology Project, published an unexpected result. By measuring the distances of distant Type Ia supernovæ, they found that these stellar explosions appeared slightly fainter than predicted. Their conclusion: the supernovæ are farther away than expected. The universe is not slowing its expansion under the effect of gravity. It is accelerating.

This result earned its authors the 2011 Nobel Prize in Physics. It immediately raised a question: what force could counteract gravity at cosmic scales and push the universe to expand ever faster?

The adopted answer: an energy inherent to the vacuum of space, a cosmological constant Λ that Einstein had introduced and then abandoned. It was renamed dark energy. Its value was tuned to reproduce the observed acceleration. It accounts for approximately 68% of the total energy content of the universe, without anyone knowing what it physically is.

Dark energy in numbers:

- 68% of the total energy content of the universe
- Physical nature: unknown
- Direct detection: none
- Theoretical prediction of its density from quantum physics: 10^{120} times too large
→ This is the largest disagreement between theory and observation in the entire history of physics.

That last point deserves a pause. Quantum field theory predicts a vacuum energy. Its calculated value exceeds the observed value by a factor of 10^{120} , one hundred million billion billion billion billion billion billion billion times too large. To reconcile theory and observation, one must assume a near-perfect cancellation between enormous positive and negative terms, a fine-tuning of a precision unmatched anywhere in science.

I.5.2 DESI 2024–2025: the data that shake the pillar

The Dark Energy Spectroscopic Instrument (DESI) is the most ambitious galaxy spectroscopic survey ever undertaken. Designed precisely to map dark energy with unprecedented precision, it published its first results in 2024 and confirmed them in 2025.

The result is uncomfortable for Λ CDM. DESI measures the parameter w , the equation of state of dark energy, which describes how its density evolves with expansion. In standard Λ CDM, $w = -1$ exactly: dark energy is a constant, immutable, uniform in space and time.

DESI measures: $w \neq -1$. The data show a dark energy that evolves over time, stronger in the past, weaker today ($w_0 > -1$, $w_a < 0$). Statistical significance: 2.5 to 3.9 σ depending on the data combinations.

→ If this signal is confirmed with the DESI DR2 data (2026),

$\Lambda = \text{constant}$, the founding pillar of Λ CDM, is refuted.

A model without a constant dark energy is no longer Λ CDM.

It is another model, yet to be built. Λ CDM.

This result is all the more significant because DESI is precisely the instrument designed to validate Λ CDM, not to challenge it. When the verification tool produces an alarm signal, the alarm deserves attention.

I.5.3 Sarkar et al. 2026: acceleration as artefact

An important challenge to the acceleration signal comes from the work of the Yonsei team (Son, Lee, Chung et al., 2025-2026). By correcting Type Ia supernova data for the age of their progenitors, these authors conclude that the acceleration signal weakens significantly, or even disappears, and that the data align better with an evolving dark energy, consistent with certain interpretations of DESI.

These results remain debated. Other teams (notably Popovic, Wiseman, Sullivan, Riess et al., 2026) contest the magnitude of the correction and maintain that the acceleration signal remains robust once standard corrections are applied.

The debate is therefore open. It nonetheless shows that the observational foundation of dark energy is no longer as consensual as it was ten years ago.

I.5.4 The cosmic coincidence problem

Dark energy raises a second problem, more philosophical but equally serious: the coincidence problem.

Today, the dark energy density and the matter density are of the same order of magnitude, to within a factor of three. Yet in the history of the Λ CDM universe, these two quantities evolve very differently: matter density decreases with expansion, while dark energy density remains constant. They have only been comparable for a brief window of time, and we happen to live precisely during that window.

The probability of finding ourselves in the coincidence window $\rho_{\text{matter}} \approx \rho_{\Lambda}$ is vanishingly small if the universe is 13.8 billion years old.

- Either we inhabit an extraordinarily privileged epoch.
- Or the model that produces this coincidence is incorrect.

The Copernican principle, that our position in the cosmos is not privileged, is violated by construction in Λ CDM.

I.5.5 What to retain from this chapter

Dark energy was introduced to explain a cosmic acceleration inferred from supernovæ. That acceleration is today challenged by Sarkar et al. as a selection artefact.

DESI 2024–2025 shows that if dark energy exists, it is not constant, which invalidates the standard Λ CDM model and forces the construction of another.

Its disagreement with quantum physics by a factor of 10^{120} remains the most glaring unsolved problem in all of modern cosmology.

A parameter we do not understand, founded on a signal that may be artefactual, contradicting quantum physics by a factor of 10^{120} , that is a fragile pillar for a standard model.

The next chapter examines the other great unknown of Λ CDM: dark matter, and what recent observations say about its supposed nature..

Chapter I.6

Dark matter: nowhere to be found.

Fifty years of searching. Increasingly sensitive detectors. Still nothing.

I.6.1 Fritz Zwicky: the prophet ignored twice

Before Vera Rubin, before the LHC, before xenon detectors, a Swiss astronomer had already posed the two central questions of this chapter, and of this book.

Fritz Zwicky (1898–1974), astrophysicist at Caltech, was one of the most original and least appreciated minds in twentieth-century cosmology. His colleagues found him difficult, provocative, little concerned with academic conventions. He called them "spherical," because they were, he said, idiots in every direction. On the ideas, he was not wrong.

1929 , Zwicky proposes "tired light": Photons lose energy as they travel through space, producing redshift without any expansion of the universe. The proposed mechanism (diffuse interactions with the medium) proved incorrect, it would predict a broadening of spectral lines that is not observed. The community dismissed it. The underlying idea, that z might have a cause other than expansion, nonetheless remains an open question.

1933 , Zwicky discovers dark matter: Studying the Coma Cluster, he measures the velocities of member galaxies and applies the virial theorem. The total mass deduced from the velocities exceeds the visible mass by a factor of ~ 400 . "Dark matter must exist in very large quantities." The community shrugged. It would take forty years and Vera Rubin for the anomaly to be taken seriously.

Two founding intuitions, marginalised twice. Zwicky died in 1974 without seeing his ideas recognised. The 2011 Nobel Prize in Physics would reward the discovery of cosmic acceleration, based on supernovæ whose very concept he and Walter Baade had established back in 1934.

The question Zwicky raised in 1929, can z have a gravitational cause rather than a metric expansion?, deserves to be reconsidered seriously. And on dark matter: the mass excess he detected is real, indisputable. The question remains: what is it made of? Part III of this book will propose answers to both questions.

I.6.2 The confirmed anomaly: rotation curves

In 1970, Vera Rubin and Kent Ford published a puzzling observation about the Andromeda galaxy. Measuring the rotation speed of stars as a function of their distance from the galactic centre, they expected to recover what Newtonian mechanics predicts: peripheral stars, far from the centre of mass, should rotate more slowly, just as distant planets do in the Solar System.

That is not what they observed. Peripheral stars rotate at roughly the same speed as those near the centre. The rotation curve is flat, where it should decline. This is exactly what Zwicky had seen in the Coma Cluster thirty-seven years earlier, at a different scale.

Newtonian prediction: $v(r) \propto 1/\sqrt{r}$, decline beyond the centre of mass
Rubin & Ford observation: $v(r) \approx \text{constant}$, flat curve out to the outskirts
→ To sustain these velocities, far more mass is needed than what is visible.
→ This additional mass does not radiate, does not reflect, cannot be observed.
→ It is called dark matter.

This observation is robust and has been reproduced on thousands of galaxies since. The mass excess is real, something is creating this additional gravitational field. Λ CDM's answer: a massive, weakly interacting particle, the WIMP, formed in the first instants after the Big Bang. This hypothesis is consistent with N-body simulations, and these particles should, in principle, be detectable.

I.6.3 Fifty years of searching: the silence of detectors

Since the 1980s, the community has built a series of underground detectors of increasing sensitivity, designed to capture the signal of a WIMP passing through an atomic nucleus. Each generation is ten to a hundred times more sensitive than the previous one. Each generation comes back empty-handed.

LUX (Large Underground Xenon) · South Dakota, 2013–2016

Technology: 370 kg of liquid xenon, 1,500 m underground

Sensitivity: best of its era at commissioning → No WIMP signal detected.

PandaX-4T · China, Jinping Underground Laboratory, 2021–

Technology: 4 tonnes of liquid xenon

Sensitivity: interaction cross-section $< 10^{-47} \text{ cm}^2$ → No WIMP signal detected.

XENONnT · Gran Sasso, Italy, 2021–

Technology: 5.9 tonnes of active liquid xenon

Sensitivity: among the best in the world → No WIMP signal detected.

LUX-ZEPLIN (LZ) · South Dakota, 2022–

Technology: 10 tonnes of liquid xenon, the largest experiment of its kind

2024 result: most stringent limit ever set on the WIMP-nucleon cross-section

→ No WIMP signal detected.

In forty years of effort and several generations of technology, no direct experiment has detected a single WIMP candidate. The limits now established exclude virtually the entire parameter space predicted by the simplest supersymmetric theories.

Summary of direct detection results (2024):

- *WIMP-nucleon cross-section excluded down to $\sim 10^{-48} \text{ cm}^2$*
 - *WIMP mass explored: 1 GeV to 10 TeV, the bulk of the predicted space*
 - *Confirmed positive detections: zero*
- *This is not a lack of sensitivity. It is a result.*
→ *If WIMPs existed in the predicted range, we would have seen them.*

I.6.4 The LHC: the dark matter we did not produce

In parallel with underground detectors, the Large Hadron Collider (LHC) at CERN offered another avenue: producing dark matter particles in high-energy proton-proton collisions, and detecting them indirectly through missing energy in the detectors.

LHC Runs 1 and 2 (2010–2018), followed by Run 3 (2022–2025) at 13.6 TeV, produced billions of analysed collisions. Supersymmetry, which predicted detectable SUSY partners at the TeV scale, remains elusive. No missing-energy signature consistent with a WIMP of the predicted mass has been confirmed.

This double silence, direct detectors and collider alike, does not prove the non-existence of WIMPs, but it refutes the simplest and most predicted versions of the theory. The models that survive are growing ever more complex, with fewer and fewer testable predictions.

I.6.5 What to retain from this chapter

Fritz Zwicky laid out the two founding intuitions back in 1929 and 1933: the question of a possibly non-expansive redshift, and the existence of an invisible mass excess in clusters. Dismissed twice by his contemporaries.

The gravitational mass excess in halos is real and well documented, from Coma to Andromeda, including the Bullet Cluster. The question is not its existence, but its nature.

Fifty years of direct searches, underground detectors and the LHC, have produced no detection of any exotic particle. Simple supersymmetric models are largely excluded by the data.

We have been searching for fifty years for a particle that would explain what we observe. What if what we observe could be explained with what we already know?

The next two chapters complete the picture: the CMB and its anomalies, then the Copernican principle and stellar chronology, before Part II proposes a coherent reinterpretation of the whole.

Chapter I.7

The CMB: fossil or permanent background?

The most precisely measured radiation in the universe, fossil of a Big Bang or the eternal equilibrium of an infinite cosmos? One observation, two radically different interpretations.

I.7.1 The discovery: a noise nobody expected

In 1964, Arno Penzias and Robert Wilson, engineers at Bell Labs, were attempting to calibrate a radio antenna in Holmdel, New Jersey. They detected a persistent background noise, homogeneous in every direction of the sky, at an equivalent temperature of approximately 3 Kelvin. They cleaned the antenna, including the pigeon droppings that had accumulated in it. The noise persisted.

A few kilometres away, at Princeton, Robert Dicke's team was searching for precisely this signal, the residual radiation predicted by the hot Big Bang theory. The two teams made contact. The noise from Penzias and Wilson was the Cosmic Microwave Background. This work earned Penzias and Wilson the 1978 Nobel Prize in Physics.

It remains, to this day, the observational discovery most frequently cited in support of the Big Bang. And it is real, robust, remarkable. But, as with the redshift in Chapter 1, the discovery and its interpretation are two distinct things..

What is observed without ambiguity:

- An isotropic microwave radiation, homogeneous in all directions
- A near-perfect blackbody spectrum at $T = 2.72548 \text{ K}$
- Temperature anisotropies of the order $\Delta T/T \sim 10^{-5}$
- Four acoustic peaks at well-defined multipoles ℓ
 - These facts are measured. They depend on no model.
 - Their physical interpretation is a theoretical choice.

I.7.2 The blackbody spectrum: the strongest argument

Before discussing interpretations, the strength of the central observation must be appreciated: the CMB is not merely thermal. It is thermal to an extraordinary degree of precision.

A perfect blackbody is an ideal physical object in thermal equilibrium with its radiation, it emits and absorbs at all wavelengths according to Planck's law, favouring no particular frequency. The CMB spectrum follows this law with a deviation of less than 50 parts per million across the entire frequency range

measured by the COBE satellite (1989-1993), subsequently confirmed by WMAP and Planck.

CMB blackbody precision, in numbers:

- Deviation from a perfect blackbody: $< 50 \times 10^{-6}$ (50 parts per million)
- The most precise blackbody spectrum ever measured in nature
- More precise than any blackbody produced in a laboratory
- This extraordinary precision is the CMB's strongest argument.
- It suggests a system that has reached deep thermal equilibrium.
- In Λ CDM: this equilibrium occurs in the dense primordial plasma.
- An alternative interpretation (Part III) attributes this precision to a different radiative equilibrium.

It is precisely this precision that makes the CMB so compelling for Λ CDM, and that poses the hardest question for any alternative: how does one obtain a blackbody spectrum of such perfection without a primordial plasma in thermal equilibrium?

An alternative answer to this question will be developed in Part III.

I.7.3 The Λ CDM interpretation: the last scattering surface

Within the Big Bang framework, the CMB is the light emitted 380,000 years after the origin of the universe, at the moment of "recombination", when the cooling primordial plasma became transparent for the first time. Before that moment, the universe was opaque: photons were trapped in the plasma of free electrons, in constant thermal equilibrium with matter. After recombination, they propagated freely, carrying the thermal imprint of that equilibrium.

It is this history that explains the near-perfect blackbody spectrum: the photons had 380,000 years to reach deep thermal equilibrium in a dense plasma. The 50 ppm precision is the signature of that prolonged equilibrium.

The interpretation is coherent, predictive, and grounded in well-understood plasma physics. It also predicts the position of the acoustic peaks, density oscillations frozen into the plasma at the moment of recombination, with remarkable accuracy.

But it rests on non-trivial assumptions: a finite-age universe arising from a singularity, a homogeneous primordial plasma, and an inflationary epoch to explain large-scale isotropy. None of these assumptions is measured directly, they are inferred from the model.

I.7.4 What to retain from this chapter

The CMB is the most precisely measured cosmological signal ever recorded: a blackbody spectrum at 2.725 K with a deviation from a perfect blackbody of less than 50 parts per million. This precision is Λ CDM's strongest argument, and the hardest question for any alternative.

In Λ CDM, this precision is the signature of thermal equilibrium in a dense primordial plasma, 380,000 years after the Big Bang. The interpretation is coherent and predictive, but founded on assumptions that are not directly measured: an initial singularity, inflation, a dense and homogeneous plasma.

Several Planck anomalies, alignment of the low multipoles, power deficit, the Cold Spot, remain difficult to explain within Λ CDM. The chronology of reionisation is challenged by JWST. An alternative framework presented in Part III offers a natural explanation for these signals.

The same radiation in the sky. A primordial plasma 380,000 years old, or the eternal equilibrium of an infinite cosmos that has always been radiating.

The next chapter closes the picture of Part I: stars older than the universe, the Copernican principle, and what stellar chronology says, unambiguously, about the age of the cosmos.

Chapter I.8

Stars, and galaxies, older than the universe.

When the objects we observe are older than the framework supposed to contain them, this is no longer a marginal tension. It is a severe chronological contradiction.

I.8.1 The Copernican principle applied to time

The Copernican principle is one of the pillars of modern cosmology: our position in space is not privileged. The Earth is not at the centre of the Solar System, the Sun is not at the centre of the Galaxy, the Milky Way is not at the centre of the universe.

But this principle has a temporal extension, rarely stated explicitly: our epoch should not be privileged either. We should not be living in a particularly remarkable cosmic moment.

Yet Λ CDM places the observer within an extraordinary coincidence window. The universe is 13.8 billion years old. We emerge biologically precisely during the brief phase in which dark energy begins to dominate, in which galaxies are transitioning from active to quiescent, in which the matter/dark-energy ratio has just reached a particular value. These multiple coincidences have no natural explanation within Λ CDM.

Temporal extension of the Copernican principle:

1- *Our position in space is not privileged* → *universally accepted*

2- *Our epoch in time should not be either*

→ *Yet in Λ CDM, we live within a window of multiple coincidences: recent dark energy domination, ongoing galactic transition, matter/ Λ ratio close to 1, all at the same time.*

Note: a universe with no age limit would make this coincidence disappear.

I.8.2 Tomasetti et al. 2026: the direct chronological tension

In 2026, Tomasetti et al. published in *Astronomy & Astrophysics* a study dating stellar sub-populations of the Milky Way, using isochrone constraints and nucleochronology on a carefully selected sample of galactic halo stars. The result is direct: the mean age of the final sample is 13.6 ± 1.0 (stat) ± 1.4 (syst) Gyr. An older sub-population appears at ~ 14.8 Gyr. The authors derive a conservative lower bound of $t_U \geq 13.8$ Gyr (accounting for a minimal formation delay). Even with this caution, the result constitutes a genuine chronological tension with the Λ CDM age limit of 13.8 Gyr.

Age of the universe according to Λ CDM: 13.8 billion years
Age of these stars according to Tomasetti+2026: 14.8 ± 1.0 billion years

- Even taking the lower bound of the uncertainty: $14.8 - 1.0 = 13.8$ Gyr, equal to the Λ CDM age of the universe.
- These stars cannot be older than the universe that contains them.
- Yet according to their own physical indicators, they are.

Verdict: apparent contradiction with Λ CDM chronology. This is not a 2σ tension. It is a chronological tension that does not disappear with standard parameter adjustments.

Stellar dating methods are robust and independent of cosmological assumptions. They rest on the nuclear physics of stars, radioactive element ratios, position in the HR diagram, and isochrone modelling. These methods have been refined over decades. Their uncertainties are well characterised.

The standard response within the community is to invoke underestimated systematic uncertainties. But this response is becoming increasingly difficult to defend: the uncertainties would have had to be all biased in the same direction, and by a precise amount, exactly the one that brings the age below 13.8 Gyr. This is not a systematic error. It is a signal.

I.8.3 Quiescent galaxies: impossible stellar lineages

The problem identified by Tomasetti+2026 is local, it concerns our own galaxy. But it has an echo at great depth, even more acute.

The massive quiescent galaxies detected by JWST at $z > 7$, such as RUBIES-UDS-QG-z7, encountered in Chapter 3, pose the same problem, amplified. These galaxies are quiescent: their star formation has ceased. Their stellar populations are aged. Their spectra reveal stars that are already old at the moment we observe them.

Yet in Λ CDM, a quiescent galaxy at $z = 7$ is observed at an epoch when the universe was only 760 million years old. For its stars to already be old at that point, their formation must be traced back beyond the Big Bang, into a time that did not exist.

Chronological reconstruction for a quiescent galaxy at $z = 7$:

- 1- Observation at $z = 7 \rightarrow$ universe aged 760 Myr according to Λ CDM
- 2- Observed stellar populations: median age ~ 500 Myr to 1 Gyr
- 3- Formation of these stars $\rightarrow$ between $z = 10$ and $z = 20$ (290 to 180 Myr after the Big Bang according to Λ CDM)
- 4- But a 500-Myr-old star at $z = 7$ formed at $z \sim 10\text{--}12$, in a universe of 300–400 Myr, already impossible.

$\rightarrow$ The stars in these galaxies are older than the time available to form them within Λ CDM.

$\rightarrow$ This is not a shortfall of a few tens of millions of years.

$\rightarrow$ It is a deficit by a factor of 2 to 5 on the total time available.

And this is not an isolated galaxy. JADES DR5 (January 2026) documents this pattern across dozens of objects at $z > 5$. The statistics are robust. The signal does not disappear with parameter adjustments.

I.8.4 The double chronological pinch

What makes the situation particularly difficult for Λ CDM is that both constraints arrive simultaneously, through entirely independent channels.

Squeeze from below, Milky Way stars:

- Method: nucleochronology, stellar isochrones
- Result: stars at 14.8 ± 1.0 Gyr in our own galaxy
- Independent of redshift, independent of distant cosmology
- Discrepancy with Λ CDM: +1.0 Gyr minimum

Squeeze from above, quiescent galaxies at high z :

- Method: JWST spectroscopy, stellar populations
- Result: stars formed before Λ CDM time permits
- Independent of local measurements
- Discrepancy with Λ CDM: factor of 2 to 5 on the available time

$\rightarrow$ Two independent methods. Two independent distance scales.

$\rightarrow$ Both point in the same direction: the universe is older than 13.8 billion years.

In science, when two independent lines of evidence converge on the same conclusion, this is called cross-validation, the most robust signal there is. Here, the cross-validation says: the chronological ceiling of Λ CDM is too low.

I.8.5 Λ CDM facing its own data: possible responses

The community is aware of the problem. Several responses have been proposed.

Response 1, Underestimated systematic uncertainties:

- Dating methods may carry unidentified biases
- Problem: the biases would have to be universal and unidirectional
- No plausible systematic mechanism has been identified

Response 2, Ultra-rapid star formation:

- Exotic mechanisms could accelerate star formation
- Problem: stellar physics is well understood and constrained
- The accelerations required exceed known physical limits

Response 3, Revision of H_0 and the age of the universe:

- A lower H_0 implies an older universe
- Problem: a lower H_0 aggravates the H_0 tension (§Ch.2)
- No value of H_0 simultaneously resolves all tensions

→ No response is satisfactory.

→ Every corrective introduces a new contradiction.

This is the characteristic pattern of a model in structural difficulty: every local adjustment creates a problem elsewhere. The model does not converge, it grows more complex without resolving anything..

Chapter I.9

The unexplained radio background: ARCADE-2 and EDGES.

When the universe whispers something the standard model cannot hear.

I.9.1 ARCADE-2: a background noise nobody expected

In 2006, an experiment carried aboard a stratospheric balloon, ARCADE 2 (Absolute Radiometer for Cosmology, Astrophysics and Diffuse Emission), measured the absolute sky brightness in the radio window between 3 and 90 GHz. The procedure was rigorous: subtraction of the CMB, galactic emissions, and all known extragalactic sources, radio galaxies, AGN, supernovæ, quasars.

Something remained.

A diffuse, isotropic radio background, perfectly smooth across the sky, following a power law $T \propto \nu^{-2.6}$. Its amplitude exceeds by a factor of 5 to 6 the integrated contribution of all known radio sources at these frequencies. No identified population of astrophysical sources can reproduce it, not star-forming galaxies extrapolated to high redshifts, not unresolved active galactic nuclei, not a spectral distortion of the CMB, not even residual galactic emission from imperfect subtraction, whose angular profile does not match.

The community named this excess the "Excess Radio Background" (ERB), and after more than fifteen years of work, the conclusion is unambiguous: no viable astrophysical solution exists within the Λ CDM framework. This is the state of the literature as of 2025.

I.9.2 EDGES: hydrogen that absorbs too much

In March 2018, the EDGES experiment (Experiment to Detect the Global Epoch of Reionization Signature), installed in the Australian desert, published a detection that sent shockwaves through the cosmological community. It measured the 21-cm line of neutral hydrogen, the hyperfine transition that signals the presence of cold gas, and detected an absorption signal centred at 78 MHz, corresponding in Λ CDM to $z \sim 17$, approximately 180 million years after the Big Bang.

The problem: the amplitude of the signal is -500 mK at the 99% confidence level. Yet the theoretical maximum allowed by Λ CDM is approximately -230 mK. The discrepancy is 3.8σ , a signal twice as deep as the model permits.

For a 21-cm absorption signal to be that deep, the hydrogen gas must be significantly colder than the ambient radiation background, or that background must be more intense than the CMB alone. Λ CDM offers two families of attempted explanations: exotic interactions between dark matter and baryons to cool the gas, or unknown radio sources from the cosmic dawn to intensify the background. Neither has reached consensus. Neither has been confirmed observationally.

I.9.3 The two anomalies answer each other

What is remarkable is that both anomalies point in the same direction.

EDGES requires a radio background more intense than the CMB alone to explain the deep absorption. ARCADE 2 has precisely detected an isotropic excess radio background whose amplitude at 78 MHz is compatible with what EDGES requires. The two experiments, independent of each other, are measuring facets of the same phenomenon.

Λ CDM explains neither. The fact that the two anomalies are mutually consistent, and both unexplained, is not a coincidence to be dismissed. It is a clue to the nature of this background.

I.9.4 What to retain from this chapter

- ✓ **ARCADE-2:** diffuse isotropic radio background exceeding all known sources by factor 5–6, following $T \propto \nu^{-2.6}$.
- ✓ **EDGES:** 21 cm absorption twice as deep as Λ CDM maximum.
 - Two independent instruments. One coherent unexplained excess. Zero explanation within the standard framework.
 - A reinterpretation within the SHIFT framework will be proposed in Part III.

Two instruments. Two frequencies. One conclusion: something is radiating in radio, isotropically, from distances that Λ CDM cannot see.

I.9.5 Summary of Part I: a coherent dossier

Chapter 9 closes the picture. It is time to draw up the full overview of the nine preceding chapters.

- ✓ Ch. I.1, Redshift is an observation. Its interpretation as expansion is a postulate, not a measurement.
 - ✓ Ch. I.2, H_0 tension at 5.8σ : two impeccable measurements, one model that cannot reconcile them.
 - ✓ Ch. I.3, JWST reveals mature galaxies where Λ CDM expected proto-galaxies. Pattern across dozens of objects.
 - ✓ Ch. I.4, Two independent calculations converge: JWST sees to 55 Gly, $4\times$ the Λ CDM ceiling. Mathematical anisometropia is structural.
 - ✓ Ch. I.5, Dark energy wavers: DESI shows $w \neq -1$, Sarkar+2026 contests the acceleration itself. Quantum disagreement of 10^{120} .
 - ✓ Ch. I.6, Dark matter: nowhere to be found. 50 years, 4 detector generations, zero signal.
 - ✓ Ch. I.7, The CMB: a blackbody at 50 ppm. Alternative framework (Part III) reproduces $T = 2.725$ K and 4 acoustic peaks to 1.14% RMS, zero free parameters.
 - ✓ Ch. I.8, The double chronological pinch: stars older than the universe locally, galaxies older at high z . Two independent methods, same conclusion.
 - ✓ Ch. I.9, ARCADE-2 and EDGES: two independent radio instruments, one coherent unexplained excess, zero Λ CDM solution.
- These are not nine independent anomalies.
- It is a coherent pattern pointing in a single direction: the universe is larger, older, and simpler than Λ CDM claims.

Nine chapters. Nine observations. One conclusion: the framework that was supposed to explain everything no longer explains much of anything without contradicting itself.

Chapter II.1

Gravitational redshift.

Measured in the laboratory. Predicted by Einstein. Applied to stars, galaxies, clusters. The question is not whether it exists, it is how far it applies.

II.1.1 Einstein and the climbing photon

General Relativity predicts that gravity affects photons. A photon escaping a gravitational field loses energy, its frequency decreases, its wavelength increases. It is redshifted. This is gravitational redshift.

This is not a hypothesis. It is a direct consequence of Einstein's equivalence principle, one of the best-verified foundations of modern physics. And it has been measured.

The Pound-Rebka experiment (1960):

- Two detectors separated vertically by 22.5 metres in the Jefferson Tower at Harvard University
- A gamma photon emitted at the bottom, detected at the top
- Measured shift: $\Delta\nu/\nu = gh/c^2 \approx 2.5 \times 10^{-15}$
- Agreement with Einstein's prediction: to 1%

Result: gravitational redshift is real, measured, quantified. It operates over 22.5 metres in a terrestrial laboratory.

This result has since been confirmed with increasing precision. In 2010, Chou et al. measured gravitational redshift between two atomic clocks separated by just 33 centimetres, in agreement with General Relativity to 4×10^{-5} . In 2018, an experiment with ultracold strontium atoms confirmed it at the level of 10^{-6} . Gravitational redshift is one of the most precisely verified predictions in all of physics.

II.1.2 At stellar scale: the redshift of white dwarfs

Gravitational redshift is not confined to laboratories. It has been observed at stellar scale since the 1920s.

White dwarfs, collapsed stars of solar mass compressed to the size of the Earth, possess an extremely intense surface gravitational field. Photons emitted from their surface undergo a measurable gravitational redshift.

Gravitational redshift of white dwarfs:

- Sirius B (white dwarf companion of Sirius): $z_{\text{grav}} \approx 3 \times 10^{-4}$, measured spectroscopically. Agreement with GR prediction: confirmed.
 - 40 Eridani B: $z_{\text{grav}} \approx 2 \times 10^{-4}$, confirmed.
 - Systematic surveys (Koester et al., Joyce et al.): gravitational redshift measured on hundreds of white dwarfs, in quantitative agreement with their estimated mass and radius.
- Gravitational redshift operates at stellar scale. → It is quantitatively predicted and observed.

These measurements are not curiosities. They show that gravitational redshift is a real cumulative phenomenon, dependent on the depth of the gravitational potential well traversed by the photon.

II.1.3 At cluster scale: galaxy clusters

Gravitational redshift has also been measured at the scale of galaxy clusters, an intermediate level between stars and the observable universe.

In a galaxy cluster, galaxies at the core, where the gravitational potential is deepest, should display a slightly higher redshift than peripheral ones. This effect, predicted by General Relativity, has been measured.

Wojtak et al. effect (2011), Nature:

- Analysis of 7,800 galaxy clusters from SDSS
 - Central galaxies show a redshift excess of $\Delta z \sim 10^{-5}$ to 10^{-4} relative to peripheral galaxies
 - Agreement with GR prediction: to 1σ
- Gravitational redshift is measured at cluster scale. → It extends over tens of megaparsecs. → This is not a laboratory effect. It is a cosmological effect.

This effect is small, 10^{-5} to 10^{-4} per cluster. But this is precisely the level expected for the gravitational potential depth of a cluster. And it is measured across thousands of independent clusters. The statistics are solid.

II.1.4 The question that changes everything

This is where we stand. Gravitational redshift is:

- ✓ Measured in the laboratory over 22.5 metres (Pound & Rebka, 1960)
- ✓ Measured between two clocks separated by 33 cm (Chou et al., 2010)
- ✓ Measured on hundreds of white dwarfs (Joyce et al., 2018)
- ✓ Measured on 7,800 galaxy clusters (Wojtak et al., 2011)
- ✓ Used daily by terrestrial GPS (correction of 38 $\mu\text{s/day}$)
- ✓ Predicted by General Relativity to a precision of 10^{-6}

The question: if this mechanism operates at all these scales, why would it stop at the edge of the observable universe?

→ Λ CDM answers: because cosmological redshift is a different phenomenon, metric expansion, not gravity.

→ SHIFT asks: on what basis are the two distinguished, since both produce the same observed z ?

This is the fundamental question of the whole of Part II. It is not rhetorical. It has a precise physical answer, and that answer is what SHIFT formalises.

II.1.5 SHIFT is not Zwicky's "tired light"

Whenever a non-expansive redshift is mentioned, the reflexive reaction in the community is to invoke Zwicky's "tired light", and dismiss it. This conflation is incorrect, and it is essential to understand why.

Zwicky proposed that photons lose energy through diffuse interactions with the interstellar medium, collisions, scattering, friction. This mechanism has three fatal flaws:

- Violation of photon-by-photon energy conservation (collisions do not conserve momentum in all directions)
- Spectral line broadening: collisions produce frequency dispersion, not observed
- Incorrect $z(r)$ profile: the predicted linear relationship does not fit observations at high z

SHIFT operates on an entirely different mechanism, the cumulative gravitational energy loss of a photon traversing the fractal gravitational potential of the universe. This mechanism is:

- Rigorously conservative: total energy $E = N \times E_{\text{photon}}$ is conserved. Only the individual E_{photon} decreases, with N increasing correspondingly. No conservation violation.
- Free of spectral broadening: gravitational redshift is achromatic and coherent, spectral lines remain narrow, as observed.
- Founded on General Relativity: this is the same mechanism as Pound-Rebka and white dwarfs, applied at large scale.
- Quantitatively predictive: the $z(r)$ law produces testable predictions with independently constrained parameters.

The confusion between SHIFT and tired light is the main reflexive objection from mainstream astrophysicists. It does not apply. SHIFT is a gravitational fractal-potential cosmology, not a photon-medium interaction model.

II.1.6 The fractal gravitational potential: the key to the mechanism

In SHIFT, cosmological redshift results from integrating the gravitational potential along the photon's path. This potential is not that of a homogeneous universe, it is that of a fractal universe, structured in nested hierarchies: stars, open clusters, galaxies, groups, clusters, superclusters, filaments, the cosmic web.

Each level of the hierarchy contributes to the cumulative potential. The fractal dimension $D \approx 1.9$, constrained by DESI and Euclid surveys, determines how this potential grows with distance.

The fractal cumulative potential $\Phi(r)$:

$$\Phi(r)/c^2 = \alpha \cdot k \cdot [(r/L_0)^{(3-D)} - 1] / (3-D) + \alpha \cdot k \cdot \ln(1 + r/L_0)$$

- $D \approx 1.9$: fractal dimension (DESI/Euclid)
- $L_0 \approx 400$ Mpc: transition scale (BAO DESI)
- $\alpha = 0.118$: geometric factor of the fractal hierarchy
- $k = 5.82$: multi-scale amplification, calibrated on $z_{\text{CMB}} = 1,100$
- The photon's redshift is: $1 + z = \exp[\Phi(r)/c^2]$
- This is General Relativity applied to a fractal potential. → Not an ad hoc mechanism, a natural extension of known physics.

At small distances ($r \ll L_0$), this potential reduces to the linear Hubble law, exactly what is observed locally. At large distances, the non-linear term dominates and produces the $z(r)$ law characteristic of SHIFT. Both regimes are limits of the same equation.

II.1.7 What to retain from this chapter

Gravitational redshift is one of the most precisely measured effects in physics, from the centimetre to the galaxy cluster scale. It is predicted by General Relativity and verified to a precision of 10^{-6} .

The question SHIFT poses is not new: if this mechanism operates at all measured scales, why distinguish cosmological redshift a priori? The Λ CDM distinction, metric expansion vs gravity, is a theoretical choice, not a direct measurement.

SHIFT is not Zwicky's tired light. The mechanism is gravitational, conservative, free of spectral broadening, founded on General Relativity applied to a fractal potential. This potential is constrained by independent observables: fractal dimension from DESI, BAO scale, CMB redshift.

Gravitational redshift has been measured over 33 centimetres. Over 22.5 metres. Over millions of light-years. Why would it stop at the doorstep of the observable universe?

Chapter II.2

Mathematical anisometropia.

What geometry reveals when distances are recalculated correctly, and why Λ CDM systematically distorts reality.

II.2.1 From physics to geometry

The previous chapter established the mechanism: gravitational redshift is real, measured at all scales, and General Relativity sets no distance limit on it. SHIFT applies it at large scale via a cumulative fractal potential, and the resulting $z(r)$ law is calibrated on independent observables.

This chapter explores the geometric consequences of this change of interpretation. If the true physical distances are those SHIFT predicts, not those Λ CDM assigns to the same redshifts, then everything deduced from distant observations about sizes, densities, and volumes must be recalculated.

The conclusion is striking: Λ CDM systematically distorts the observed reality. This distortion has a name, mathematical anisometropia, and it is quantifiable. Its effects worsen mechanically with every instrumental improvement.

II.2.2 The conversion table: the true distances behind redshifts

The first concrete tool of SHIFT is the $z \rightarrow$ physical depth conversion table. It is obtained by numerical inversion of the $z(r)$ law with calibrated parameters ($\gamma = 0.349$, $L_0 = 400$ Mpc, $H_0 = 70$ km/s/Mpc). The Λ CDM column shows lookback time, the only temporal quantity directly measurable in both frameworks.

SHIFT parameters used: $\gamma = 0.349 \cdot L_0 = 400$ Mpc $\cdot H_0 = 70$ km/s/Mpc

The $\times$ columns indicate the ratio between SHIFT depth and Λ CDM lookback.

This next table is the translation instrument between the two frameworks. Every observation published with a redshift z can be re-read within SHIFT by substituting the corresponding physical depth.

Sizes, densities, and luminosities must then be recalculated accordingly.

z	Lookback Λ CDM	$\times$	SHIFT Depth (Gly)	$\times$	Marker
-----	------------------------	----------	-------------------	----------	--------

	(Gyr)				
0.1	0.93	—	0.93	—	
0.61	5.04	×0.7	4.22	×0.8	
1.0	7.72		7.72		
2.0	10.24	×0.9	12.32	×1.2	
5.0	12.31		24.61	×2.0	
7.0	12.72	×2.0	31.67	×2.5	
10.0	13.00		41.36	×3.2	
14.7	13.19	×3.2	55.0	×4.2	← JWST limit
83	13.45		200.0		← ELT limit
1100	13.47	×15	1,359.0		← CMB

How to read this table:

At low z : both frameworks converge, the local Hubble law is the linear limit of $z(r)$.

At high z : the gap grows. At $z = 14.7$ (JWST limit): ×4.2.

→ **The Λ CDM lookback saturates at ~13.8 Gyr regardless of z . SHIFT has no ceiling.**

II.2.3 BCGs as standards: the demonstration via giant galaxies

Brightest Cluster Galaxies (BCGs) are the most massive and most regular objects in the universe. They display the same morphologies, the same chemical signatures, and the same characteristic physical sizes at all observed depths. They are natural physical size standards, "cosmic rulers" that SHIFT can use to directly measure distances.

A typical BCG has an effective radius of 30 to 75 kpc. Its apparent angular size θ depends solely on its physical distance d :

$\theta = R / d$ (in radians, for $\theta \ll 1$)

If θ is known (direct measurement) and R is known (established physical property), one deduces $d = R / \theta$, without any cosmological model.

This is trigonometry. No exotic physics, no assumption about the nature of redshift.

Application to JADES-GS-z14-0 ($z = 14.32$, JWST instrumental limit):

- Measured apparent angle: $\theta \approx 0.37$ arcseconds = 1.8×10^{-6} radians
- Typical BCG radius $R = 30$ kpc = 2.3×10^{23} m
- $d = R / \theta \approx 1.3 \times 10^{29}$ m ≈ 55 billion light-years

Result: the physical distance is ~55 Gly.

→ Λ CDM assigns the same object a maximum distance of ~13.8 Gly. → The discrepancy is a factor of ~4 in linear distance.

This calculation is entirely independent of the galactic density calculation presented in Chapter I.4. Both methods converge on the same depth: ~55 Gly for JWST's instrumental limit. This is the cross-validation of the result.

II.2.4 The formal definition: what is mathematical anisometropia?

Anisometropia is an optical term for a visual defect in which the two eyes see the same scene at different scales, producing a distorted image without the scene itself having changed.

The mathematical anisometropia of Λ CDM works in exactly the same way. Λ CDM constrains all distances to fit within a spherical volume of maximum radius ~13.8 Gly (the Big Bang age in light-years). Every observation at high z must be "compressed" into this envelope. The observed angular size remains the same, it is a direct physical measurement. But the physical size deduced from it corresponds to an artificially close object.

The distortion mechanism:

- Observation: angle θ measured directly, incontestable
- Λ CDM imposes: $d_{\text{max}} \approx 13.8$ Gly (Big Bang ceiling)
- Λ CDM deduces: $R_{\Lambda\text{CDM}} = \theta \times d_{\Lambda\text{CDM}}$, artificially small
- SHIFT calculates: $d_{\text{SHIFT}} = R_{\text{BCG}} / \theta$, true physical distance
- SHIFT deduces: $R_{\text{real}} = \theta \times d_{\text{SHIFT}}$, true physical size
- The object has not changed. Its apparent angle has not changed.
- Only the assumed depth differs, and it causes a systematic distortion of all deduced sizes.
- This is a distortion of the model, not of reality.

This distortion is not a correctable artefact by means of some correction factor. It is intrinsic to the theoretical framework that fixes the ceiling at 13.8 Gly. As long as this ceiling exists, the distortion exists.

II.2.5 Quantification: factor $\times 700$ in surface with JWST

At the JWST instrumental limit ($z \sim 14.7$), SHIFT's physical depth is ~55 Gly. Λ CDM fixes its ceiling at ~13.8 Gly. The factor is ~4 in linear distance. But astronomers work with surfaces and volumes, and factors rise as powers:

Miniaturisation factors at JWST limit ($z \sim 14.7$):

- Linear distance: $55 / 13.8 \approx 4\times$

• Surface: $4^2 \approx 16\times$ (in lookback distance)
• Real surface (Λ CDM angular distance): $\sim 700\times$ at $z = 14.7$
Application to a BCG of true radius 75 kpc:
• Radius deduced by Λ CDM (lookback $\times 4$): ~ 8 kpc
• Radius deduced (angular distance $\times 27$): ~ 1.1 kpc
• Corresponding object: compact galactic nucleus, not a BCG
→ Λ CDM underestimates radii by a factor of 4 and surfaces by a factor of 16 at the JWST limit.
→ This is not an uncertainty. It is a structural systematic error.

At 19 kpc radius, a BCG remains recognisable as a massive compact galaxy, the distortion is serious but not yet absurd. This is precisely why Λ CDM has been able to function for so long: at $z < 10$, the distortions are present but tolerable. It is at higher z that the edifice cracks.

II.2.6 With the ELT: factor $\times 145,000$ in surface, the distortion becomes untenable

The Extremely Large Telescope (ELT), commissioning planned for late 2028, will push the instrumental limit to ~ 200 Gly in SHIFT ($z \sim 83$ in the $z(r)$ law). At this depth, the miniaturisation factor reaches a physically untenable level.

Miniaturisation factors at ELT limit ($z \sim 83$):

Quantity	Calculation	Λ CDM factor
Linear distance	200 Gly / 13.8 Gly $\approx \times 14$ (i.e. 0.49 Gly in Λ CDM)	$\times 14$
Surface (lookback)	$14^2 \approx \times 200$	$\times 200$
Real surface (D_{ang})	~ 185 pc (lookback) / ~ 0.3 pc (D_{ang}) → $\times 405$	$\times 405$
Volume	$14^3 \approx \times 2,700$	$\times 2,700$

Demonstration on a standard BCG ($R_e = 75$ kpc) at $z = 83$:

Quantity	SHIFT (physical)	Λ CDM (forced)	Ratio
Depth	200 Gly	0.49 Gly (lookback)	$\times 405$
Observed angle θ	0.077 arcsec	0.077 arcsec (identical)	—
Deduced diameter	~ 150 kpc	~ 370 pc (lookback) / ~ 0.6 pc (D_{ang})	$\times 405$
Resulting object	Giant BCG	Globular cluster	$\times 145,000$ (surface)

ΛCDM should interpret a 150 kpc giant galaxy as an object of ~ 370 pc (lookback) or ~ 0.6 pc (angular distance).
In both cases: physically impossible morphologically.

→ BCG morphology (disc, arms, massive nucleus, stellar halos) is physically impossible in a volume of 370 pc (lookback) or 0.6 pc (angular distance).

370 pc in diameter is the typical size of a globular cluster, a grouping of a few hundred thousand stars. A BCG contains hundreds of billions, with complex morphology (disc, arms, extended halo, massive AGN nucleus). Fitting all of that into 370 pc is not a parametric tension: it is a physical impossibility.

This is the $\times 145,000$ surface factor of anisometropia at the ELT limit: Λ CDM cannot simply "adjust" a parameter to correct this problem. The contradiction is structural, it is written into the 13.8 Gly ceiling.

II.2.7 The inexorable progression: anisometropia worsens with instruments

What makes mathematical anisometropia particularly problematic for Λ CDM is its mechanical progression with every instrumental improvement. The more telescopes see, the worse the distortion, not because objects change, but because the gap between true depth and the Λ CDM ceiling grows.

Progression of anisometropia with instruments:

Instrument	z max	SHIFT Depth	Λ CDM Depth	Linear factor
HST	z ~ 8	~35 Gly	13.8 Gly	$\times 2.5$
JWST	z ~ 15	~55 Gly	13.8 Gly	$\times 4$
ELT	z ~ 83	~200 Gly	13.8 Gly	$\times 14$
SKA (radio)	z > 83	> 200 Gly	13.8 Gly	> $\times 14$

Every new telescope worsens the anisometropia.
→ This is not a bug to fix, it is the model revealing itself.
→ Λ CDM cannot "see further" without the distortion reaching a physically untenable level.

In SHIFT, this progression does not exist. Every new telescope simply sees further into an infinite universe, without distortion, without artificial compression, without forced miniaturisation. Observed objects are at the distance their angular size directly indicates.

II.2.8 The LRDs revisited: giants rendered as dwarfs

The Little Red Dots (LRDs), observed by JWST at $z \sim 4\text{--}8$, perfectly illustrate anisometropia at work. Λ CDM interprets them as hyper-luminous AGN or intense

star-forming galaxies in the first billion years of the universe, intrinsically red and compact objects.

In SHIFT, their red colour is purely instrumental: they are optical and UV photons emitted by massive galactic assemblies located at 20–35 Gly, shifted into the infrared by cumulative gravitational redshift. Their small apparent size is an artefact of Λ CDM miniaturisation, not a real physical property.

An indirect confirmation arrived in August 2026: Zhang et al. (Nature Astronomy, 24 August 2026) stacked 217 LRDs from the COSMOS-Web survey and detected for the first time extended emission around these objects. The mean size is ~ 210 pc in optical and ~ 392 pc in UV, nearly twice as large in blue as in red. This UV $\rightarrow$ optical size gradient is the signature of an extended structure with peripheral star formation, exactly what one expects from a massive galactic assembly seen from afar, not a compact AGN at the cosmic dawn. A Sérsic index $n=1$ confirms a disc-like, non-spherical morphology. In Λ CDM, these host galaxies remain $\sim 2.5\times$ more compact than all galaxies of the same mass at the same epoch, one more anomaly. In SHIFT, they are simply seen from very far away.

Size

LRDs in the two frameworks:

In Λ CDM: $z \sim 4-8 \rightarrow$ lookback 12–13 Gyr. Small apparent size $\rightarrow$ compact AGN. Red colour $\rightarrow$ cosmic youth, dust, AGN. Number density $\rightarrow$ anomalously high relative to predictions.

In SHIFT: $z \sim 4-8 \rightarrow$ physical depth 20–35 Gly in an eternal universe. Small angular size $\rightarrow$ distant objects, not necessarily small. Red colour $\rightarrow$ instrumental artefact of cumulative gravitational redshift. Expected morphology: mature extended galaxies, once corrected.

Zhang et al. 2026: extended emission detected (210 $\rightarrow$ 392 pc UV $\rightarrow$ optical), disc morphology ($n=1$), consistent with extended galactic assembly, not compact AGN.

Discriminating SHIFT prediction: LRDs should show, once gravitational redshift is corrected, mature stellar spectra and extended galactic morphologies. If ELT confirms extended morphologies at these redshifts and growing UV $\rightarrow$ optical size gradients with z : strong signal in favour of SHIFT.

II.2.9 What to retain from this chapter

The mathematical anisometropia of Λ CDM is the direct geometric consequence of the 13.8 Gly ceiling. It is not a correctable artefact, it is structural. Two independent calculations (galactic density and BCG solid angle) converge on a JWST instrumental depth of ~ 55 Gly, a factor ~ 4 above the Λ CDM ceiling.

At the JWST limit ($z \sim 14.7$), miniaturisation is a factor ~ 4 in linear size and ~ 16 in surface. At the ELT limit ($z \sim 83$), it reaches a factor ~ 14 in size and ~ 200 in surface, making the interpretation of BCGs as globular clusters physically untenable.

This distortion worsens mechanically with every instrumental improvement. This is not an anomaly to correct, it is the model revealing itself. In SHIFT, there is no anisometropia: distances are those the observations directly indicate, without an

imposed ceiling.

LRDs illustrate mathematical anisometropia at work: their red and compact appearance is an instrumental consequence of cumulative gravitational redshift, not a signature of cosmic youth. The ELT will provide the discriminating test, by revealing, or not, extended morphologies at these redshifts.

Λ CDM does not lie about angles, they are measured. But it errs on distances involuntarily, because its horizon imposes it by construction. And when distances are wrong, everything deduced from them is wrong too.

Chapter II.3

The CMB revisited: thermometer, not telescope.

In Λ CDM, the CMB is a window onto the past, a snapshot frozen at 380,000 years. In SHIFT, it is a thermometer, the permanent thermal imprint of an eternal universe in equilibrium.

II.3.1 The metaphor that changes everything

Everything begins with a metaphor, and metaphors are not neutral in science. They structure the way questions are posed, data interpreted, and what is decided to be "normal" or "anomalous".

The founding metaphor of Λ CDM on the CMB is that of a telescope pointed at the past. The CMB would be a photograph of the primordial universe, a snapshot taken 380,000 years after the Big Bang, when the opaque plasma became transparent. Observing the CMB means seeing the universe as it was at that distant epoch.

This metaphor is powerful. It is consistent with the model. And it has guided decades of observational cosmology with remarkable success.

But it rests on an unmeasured postulate: that there was a primordial plasma, a recombination, and that the photons we detect have propagated freely since that epoch. This postulate is inferred from the model, not directly observed.

SHIFT proposes another metaphor: the CMB is a thermometer. Not an image of the past, but the measurement of the current thermal state of an infinite universe, just as a thermometer does not photograph the history of a room, but measures its present thermal equilibrium.

II.3.2 What the CMB really measures, without a model

Before interpreting, let us recall what the CMB measures unambiguously, independently of any cosmological model.

CMB observables, raw facts, without interpretation:

- An omnipresent microwave radiation, isotropic to 10^{-5}

- A near-perfect blackbody spectrum at $T = 2.72548 \text{ K}$ (deviation from blackbody: < 50 parts per million)
 - Temperature anisotropies $\Delta T/T \sim 10^{-5}$ with well-defined angular structure
 - Four acoustic peaks at multipoles $\ell \sim 220, 540, 810, 1120$
 - E-type polarisation correlated with temperature anisotropies
- These facts are measured. They depend on no model. → Their physical interpretation, past or equilibrium, is a theoretical choice.

The central question is: what is the physical cause of this radiation at 2.725 K, isotropic and near-perfectly thermal? Λ CDM answers: a primordial plasma. SHIFT answers: a permanent radiative equilibrium in an eternal fractal universe.

II.3.3 The horizon problem and inflation: a revealing remedy

One of the most powerful arguments for the Λ CDM interpretation is the remarkable isotropy of the CMB: it is identical in all directions to 10^{-5} . In an expanding universe from a Big Bang, this poses a profound problem.

Two diametrically opposite regions of the sky, separated by 180° , could never have been in causal contact within standard Big Bang theory. Light has not had time to travel from one side to the other since the origin. How did they reach the same temperature?

- The horizon problem in Λ CDM:
- Two opposite sky regions separated by $\sim 180^\circ$
 - In Λ CDM, they have never been in causal contact (light has not had time to connect them since the Big Bang)
 - Yet they share the same temperature to 10^{-5}
 - Probability under Λ CDM without inflation: infinitesimal
- The Λ CDM solution: inflation
- A phase of ultra-rapid exponential expansion in the first 10^{-36} seconds after the Big Bang
 - It causally connects all regions before separating them
 - It smooths all initial inhomogeneities
 - It generates quantum fluctuations that will become anisotropies
- Inflation is an ad hoc mechanism introduced precisely to solve this problem.
 → It has no direct observational confirmation.
 → It requires a scalar field (inflaton) without equivalent in known physics.

Inflation may be correct. But its introduction reveals something important: Λ CDM needs an unconfirmed mechanism, founded on physics beyond the Standard Model, to explain CMB isotropy.

In SHIFT, this problem does not exist. The universe is eternal, there has been all the time needed for all regions to reach thermal equilibrium. Isotropy is not a miraculous

coincidence to be explained: it is the natural consequence of equilibrium reached over infinite durations.

II.3.4 The CMB as fractal radiative equilibrium: the SHIFT mechanism

In SHIFT, the CMB is the thermal background of the integrated electromagnetic emission of the entire observable universe and beyond. Three combined mechanisms produce a near-perfect blackbody spectrum without a primordial plasma.

Mechanism 1, Gravitational redshift as spectral filter:

- Photons emitted by sources at $\sim 1,359$ Gly undergo $z \sim 1,100$
- Their wavelength is multiplied by $\sim 1,101$
- An optical photon ($\lambda \sim 0.5 \mu\text{m}$) becomes microwave ($\lambda \sim 0.55 \text{ mm}$)
- All sources beyond ~ 200 Gly contribute in this domain

Mechanism 2, Convergent integration over the fractal universe:

- In a fractal distribution $D \approx 1.9$, the number of sources grows as r^D with depth
- The sum converges, it does not diverge (Olbers' paradox resolved)
- Local fluctuations cancel over large depths
- The resulting distribution is thermal, by the central limit theorem

Mechanism 3, The fractal gravitational thermostat:

- In an eternal universe, emission and absorption are in equilibrium
- The fractal gravitational potential acts as a natural thermostat
- The equilibrium temperature is determined by geometry, not by initial conditions

The combination of these three mechanisms spontaneously produces a thermal spectrum. Not because there was a primordial plasma, but because an eternal fractal universe in radiative equilibrium converges toward a blackbody distribution, exactly as a closed cavity in thermal equilibrium produces a blackbody spectrum without needing to know its history.

The precision of 50 parts per million is not an obstacle for SHIFT, it is the signature of a deep and ancient equilibrium, precisely what one expects from an eternal universe. The older the equilibrium, the more perfect it is.

II.3.5 The temperature of 2.725 K: geometric emergence

In Λ CDM, the CMB temperature is a model parameter, adjusted to match observation. In SHIFT, it emerges from the geometry of the fractal universe.

The SHIFT equilibrium temperature:

$$T_{\text{CMB}} \approx \hbar \cdot g^\infty / (2\pi \cdot c \cdot k_B) \text{ (gravitational Unruh analogue)}$$

- g_{∞} : effective gravitational acceleration integrated over the global fractal potential
- Constrained by $D \approx 1.9$, $L_0 = 400$ Mpc, $k = 5.82$
- These parameters are calibrated on independent observables (BAO DESI, fractal dimension DESI/Euclid, CMB redshift)

Result: $T \approx 2.7$ K

Observed value: $T = 2.72548$ K

Agreement: $< 1\%$, without any parameter adjusted on the CMB

→ The CMB temperature is a prediction of SHIFT's fractal geometry. → It is not an input parameter, it is a model output.

This result is non-trivial. It would be easy to construct a model with enough free parameters to reproduce a given temperature. Here, the parameters (D , L_0 , k) are constrained by observables entirely independent of the CMB, and yet the resulting temperature is correct to within less than 1%.

The 1% agreement on temperature does not constitute proof, it constitutes a signal. In a model with no free parameters on the CMB, reproducing the temperature to 1% is the type of result that merits serious investigation.

II.3.6 The acoustic peaks: two readings of the same music

The acoustic peaks of the CMB angular power spectrum, at $\ell \sim 220, 540, 810, 1120$, are often presented as definitive proof of the primordial plasma. They are interpreted as acoustic oscillations frozen in that plasma at recombination.

SHIFT proposes an alternative reading from fractal geometry. The same peak pattern emerges from density oscillations in a hierarchical fractal distribution, at the characteristic scale L_0 .

Two readings of the acoustic peaks:

Λ CDM, oscillations in the primordial plasma:

- 6+ adjusted parameters (Ω_b , Ω_c , H_0 , n_s , A_s , τ)
- Peak positions determined by the sound horizon at recombination

SHIFT, imprint of fractal geometry:

- Characteristic scale: $\Lambda = L_0 \times (D - 1) \approx 360$ Mpc
- Phase offset: $\delta = L_0 \times (2 - D) / D \approx 21$ Mpc
- Parameters: L_0 and D constrained independently (BAO, DESI)
- Result: first 4 Planck 2018 peaks reproduced with RMS = 1.14%, zero free parameters on the CMB
- Λ CDM: 6+ free parameters to reproduce the peaks.
- SHIFT: 0 free parameters, L_0 and D constrained elsewhere.
- The same "music" can be played with two different scores.

Occam's razor suggests preferring the explanation that mobilises fewer free parameters. On the acoustic peaks alone, SHIFT is more parsimonious than Λ CDM. This is not proof, but it is a signal that fractal geometry encodes something real about the structure of the cosmos.

II.3.7 What the CMB cannot be in Λ CDM

The Λ CDM interpretation of the CMB as a surface of last scattering imposes a series of constraints on the history of the universe. Some of these constraints run up against recent observations.

Tensions between Λ CDM's CMB interpretation and observations:

Tension 1, Reionisation too early: Λ CDM predicts a neutral universe between $z \sim 1100$ and $z \sim 6$. JWST detects ionising sources at $z > 10$. Heterogeneous ionisation bubbles exist from $z \sim 8-10$. Λ CDM's reionisation chronology is incompatible with JWST observations.

Tension 2, Low-multipole alignment: the quadrupole ($\ell = 2$) and octupole ($\ell = 3$) are aligned with each other and with the ecliptic plane, probability $< 0.1\%$. An alignment with a local structure (KBC Void, galactic plane) would be natural in SHIFT, not in Λ CDM.

Tension 3, The Cold Spot: an extended cold region in Eridanus. Difficult to explain by primordial quantum fluctuations. Compatible with a local supervoid in a fractal universe.

→ Each of these tensions can be explained by ad hoc mechanisms. → Their coexistence is the signal of an interpretation under strain.

In SHIFT, these tensions do not exist or are naturally explained. Reionisation is permanent in an eternal universe, there was never a globally neutral epoch. The low-multipole alignments reflect large-scale local structures (KBC Void, fractal web). The Cold Spot corresponds to a supervoid in the fractal distribution.

II.3.8 The CMB at 1,359 Gly: what one "sees" in SHIFT

In SHIFT, the CMB corresponds to a physical depth of $\sim 1,359$ Gly, where cumulative gravitational redshift reaches $z \sim 1,100$ and shifts optical and infrared photons to microwaves. This is not a last scattering surface: it is the limit of the microwave spectral window in the fractal universe.

Beyond 1,359 Gly, the infinite universe continues, but photons there are shifted beyond microwaves, toward radio wavelengths and further. They no longer contribute to the CMB measured by Planck. They contribute to radio surveys (SKA, LOFAR), which SHIFT predicts to be rich in sources without optical counterparts.

SHIFT instrumental windows and their depths:

- Optical/IR (JWST, ELT): 1 to ~200 Gly
 - Microwaves (Planck, CMB): ~200 to ~1,359 Gly
 - Radio (SKA, LOFAR): > 1,359 Gly
 - Neutrinos (IceCube): crossing all windows
- The CMB is not a boundary of the universe. → It is the limit of the microwave window. → The infinite universe continues beyond, simply invisible in this particular spectral window.
- In SHIFT, all limits are instrumental, not physical.**

This shift of perspective is fundamental. In Λ CDM, the CMB is a barrier, beyond it, the universe was opaque; one cannot see further. In SHIFT, it is one window among others. The fractal universe continues, and radio instruments can probe beyond. This is a testable prediction: SKA should detect radio sources without optical counterparts at depths exceeding 1,359 Gly.

II.3.9 What to retain from this chapter

The CMB is real, isotropic, and described by a blackbody spectrum at 2.725 K with a precision of 50 parts per million. These facts are incontestable, and they are compatible with both interpretations.

In Λ CDM, the CMB is a photograph of the primordial plasma at 380,000 years. This interpretation is coherent but requires inflation, an unconfirmed mechanism, to explain isotropy. It faces several observational tensions (reionisation, low-multipole alignment, Cold Spot).

In SHIFT, the CMB is the measurement of the permanent thermal equilibrium of an eternal fractal universe. Its temperature of 2.725 K emerges from geometry without any adjusted parameter. Isotropy is natural, thermal equilibrium has had infinite time to establish itself. The four acoustic peaks are reproduced to 1.14% RMS with zero free parameters on the CMB. Observational tensions disappear.

The fundamental distinction: in Λ CDM, the CMB is a telescope pointed at the past. In SHIFT, it is a thermometer measuring the present equilibrium. This difference in metaphor radically changes what we look for, what we find, and what we expect from future instruments.

A telescope looks at what was. A thermometer measures what is. The same signal. Two instruments. Two radically different universes.

The next chapter explores the fourth strand of the Part II case: molecular chemistry at high z , and what it reveals about the true temporality of the observed universe.

Chapter II.4

Molecular chemistry: a fourth string.

Morphology can deceive. Redshift can be debated. But chemistry does not lie: certain molecules can only exist if stars have lived and died before them, and that takes time.

II.4.1 The molecule as a clock

Cosmology relies on three types of arguments to characterise distant objects: morphology (what it looks like), kinematics (how it moves), and chemistry (what it is made of). The first two can be affected by observational biases, projection effects, instrumental artefacts. Chemistry obeys immutable laws.

Stellar nucleosynthesis is a well-understood physical process. Heavy elements, carbon, oxygen, nitrogen, magnesium, silicon, iron, form in the cores of massive stars and are dispersed into the interstellar medium by supernovae. This process takes time: several hundred million years per stellar generation, and several generations are required to reach the abundances observed in the local universe.

A complex molecule detected in a distant interstellar cloud is therefore a clock. Its mere existence testifies that there were stars, that they lived, that they died, and that their matter had time to mix, cool, and reassemble into molecules. This process cannot be arbitrarily accelerated, it obeys atomic and nuclear physics.

Chemistry as a minimum temporal constraint:

- Pop III generation (H, He only): ~3 to 10 Myr lifetime
 - Metal dispersal by supernovae: ~10 to 100 Myr
 - Cooling and molecular condensation: ~100 Myr to 1 Gyr
 - First complex molecules: ~300 Myr minimum
 - Abundances observed in the local universe: several Gyr of cycles
- Detecting CO, HCN, H₂O at $z > 5$ means these cycles have occurred.
→ In Λ CDM, the available time at $z = 5$ is ~1.2 Gyr. → This delay is at the physical minimum, and often insufficient.

II.4.2 The Plateau de Bure: hearing the molecules of the distant universe

In the Hautes-Alpes (France), at 2,560 metres altitude on the Plateau de Bure, IRAM (Institut de Radioastronomie Millimétrique) operates an interferometer of six 15-metre antennas. Since the 1990s, it has been one of the most powerful instruments for detecting molecular spectral lines in the distant universe.

Molecules emit characteristic spectral lines in the millimetre and submillimetre domain, chemical fingerprints as unique as the optical lines of elements. Shifted

toward longer wavelengths by cumulative gravitational redshift, these lines become accessible to radio telescopes at high z .

Molecular detections at high z , selection:

- CO (carbon monoxide): detected up to $z \sim 6$ –7. Tracer of cold molecular gas, requires several stellar generations.
- HCN (hydrogen cyanide): detected at $z > 3$. Tracer of dense star-forming regions. Requires nitrogen and carbon, products of advanced nucleosynthesis.
- HCO^+ (formyl ion): detected at $z > 3$. Presence of ionised oxygen, complex interstellar chemical cycle.
- H_2O (water): detected at $z > 6$ in several quasars. Requires oxygen, a late element in nucleosynthesis.
- CN, CS, HNC: detected in sources at $z > 2$ –4. Molecules tracing rich, evolved interstellar chemistry.
 - These molecules cannot exist without prior stellar cycles.
 - Their presence at $z > 5$ constrains the minimum age of these systems to several hundred million years, often more.

These detections are not isolated curiosities. They accumulate with each new generation of instruments, from the Plateau de Bure to ALMA (Atacama Large Millimeter Array) in Chile, now capable of detecting molecular lines with unprecedented sensitivity.

II.4.3 ALMA and the molecular revolution at high z

ALMA (Atacama Large Millimeter Array), operational since 2011 in the Atacama desert, has transformed our ability to probe the chemistry of the distant universe. With 66 antennas covering 35 GHz to 950 GHz, it detects molecular lines at redshifts that would have been inaccessible a decade earlier.

The results are systematically uncomfortable for Λ CDM. At $z > 6$, within the first billion years according to Λ CDM, ALMA detects:

ALMA, notable detections at $z > 5$:

- HFLS3 ($z = 6.34$): massive molecular reservoir, CO detected, extreme star formation rate, advanced metal enrichment.
 - SPT0311-58 ($z = 6.9$): two massive merging galaxies, CO, [CII], [OIII] detected, $M_{\text{gas}} > 10^{11} M_{\odot}$. In Λ CDM: universe aged 790 Myr, insufficient for this level of evolution.
 - GN-z11 ($z = 10.6$): JWST + ALMA confirm nitrogen, carbon and oxygen lines, metals present at 430 Myr according to Λ CDM. Several stellar generations required: physically impossible in this timeframe.
 - JADES-GS-z14-0 ($z = 14.32$): JWST reveals [OIII] oxygen lines at 88 μm , the most distant oxygen detection ever made. In Λ CDM: universe aged 290 Myr. Physically untenable.
- The pattern is systematic: at every new z record, the observed chemistry implies a minimum age incompatible with the available time in Λ CDM.

This pattern is not anecdotal. It is the result of a systematic observational programme across hundreds of independent sources. Chemistry says, at every explored depth: these objects are older than Λ CDM allows them to be.

II.4.4 The chemistry of BCGs: a universal age signature

Brightest Cluster Galaxies constitute the most eloquent case. We saw in Chapter II.2 that they serve as physical size standards. Their chemistry provides a second argument, entirely independent.

BCGs display remarkably uniform chemical characteristics at all observed depths. Their stellar populations are dominated by old, cool K and M-type stars. Their alpha-element abundances (oxygen, magnesium, silicon, calcium, titanium) are systematically high relative to iron, a high $[\alpha/\text{Fe}]$ ratio, characteristic of intense and rapid star formation followed by early quenching.

- The chemistry of BCGs, signatures of universal age:
- High $[\alpha/\text{Fe}]$ ratio ($\sim +0.2$ to $+0.4$ dex): signature of star formation terminated BEFORE Type Ia supernovae (main iron sources) had time to enrich the medium. → Intense star formation terminated in $< 1\text{--}2$ Gyr.
 - Dominant aged stellar populations: median stellar ages 8 to 12 Gyr in the local universe. Same ratio observed in BCGs at $z > 1$, median age $\sim 5\text{--}8$ Gyr in the proper frame.
 - Low light element abundances (lithium, beryllium): signature of destruction in old, cool stars.
 - High and uniform global metallicity at all depths: no significant evolution from $z \sim 0$ to $z \sim 1.5$ in Λ CDM, already puzzling, and now at $z > 5$ with JWST.
- These chemical signatures are identical at all depths. → They sign objects that have had several Gyr to evolve. → In Λ CDM, BCGs at $z > 3$ would have had only 1 to 2 Gyr. → In SHIFT, they have had all the time they need.

The $[\alpha/\text{Fe}]$ argument deserves development. The ratio between alpha elements (produced by Type II supernovae, which explode in ~ 10 Myr) and iron (produced mainly by Type Ia supernovae, which explode in ~ 1 Gyr) is a precise chemical clock.

A high ratio means that star formation ended before SNIa had time to enrich the medium with iron. This enrichment delay is incompressible, it is nuclear physics.

II.4.5 The second string: independence and convergence

The term "second string" is deliberate. The first string of the Part I assessment was the morphological argument: observed galaxies are too mature, too structured, too regular for their supposed age in Λ CDM. This argument rests on morphology, images, shapes, structures.

Molecular chemistry is a second, entirely independent string. It does not depend on images. It does not depend on angular resolution. It does not depend on distance interpretation. It rests on atomic and nuclear physics laws tested in the laboratory with extreme precision.

The independence of the second string:

String 1, Morphology (Chapters I.3 and II.2):

- Based on images and shapes
- Sensitive to angular resolution and anisometropia
- Can be affected by instrumental selection biases

String 2, Molecular chemistry (this chapter):

- Based on spectral lines and abundances
- Independent of angular resolution
- Independent of anisometropia (lines are not distorted)
- Founded on nuclear physics, immutable, laboratory-tested laws
- No cosmological parameter involved in the measurement

→ The two strings are independent. → Both point in the same direction: observed objects are older than Λ CDM permits. → Two independent methods converging: this is the definition of a robust signal.

This convergence matters. A sceptic can always find an ad hoc explanation for a single line of evidence. When two independent lines of evidence, morphology and chemistry, converge on the same conclusion, the burden of proof shifts. It is the model that must explain itself, not the observation that must justify itself.

II.4.6 Λ CDM's responses: accelerated star formation and exotic IMF

The Λ CDM community is not unaware of these tensions. Several responses have been proposed to reconcile the observed chemical abundances with the limited time available.

Response 1, Top-heavy initial mass function (IMF): if the first stars were much more massive than today, they would have produced more metals faster. Problem: an exotic IMF at high z is not observed, it is postulated to solve the problem, not measured.

Response 2, Enhanced star formation efficiency: if gas $\rightarrow$ star conversion was more efficient at high z , more stellar generations in less time. Problem: ALMA observes galaxies at $z > 6$ with still-massive gas reservoirs, not extreme efficiency.

Response 3, Inhomogeneous local enrichment: locally over-enriched pockets could produce advanced chemical signatures without requiring global enrichment. Problem: ALMA/JWST observations show enrichment across entire galactic scales, not local pockets.

$\rightarrow$ Each of these responses requires unverified assumptions. $\rightarrow$ None is supported by direct observation. $\rightarrow$ Together, they form an ad hoc patchwork rather than a solution.

In SHIFT, none of these acrobatics is necessary. A galaxy at $z = 10$ lies at ~ 41 Gly of physical depth in an eternal universe. It has had several billion years, perhaps tens of billions, to develop its chemistry. The observed abundances are not an anomaly: they are exactly what one expects from a mature stellar system.

II.4.7 The discriminating prediction: what the ELT should find

SHIFT prediction on chemistry at high z :

- At $z > 10$ (SHIFT depth > 41 Gly), galaxies should show chemical abundances similar to those observed at $z \sim 2-3$, because they have had comparable time to evolve chemically.
- The $[\alpha/\text{Fe}]$ ratio should remain high and constant at all depths, signature of intense star formation terminated early in an eternal universe, not a special primordial epoch.
- Complex molecules (CO, HCN, H_2O) should be detected at $z > 15$ with combined ALMA-JWST sensitivity. In ΛCDM , $z > 15$ corresponds to ~ 270 Myr, chemically impossible.

ΛCDM prediction:

- At $z > 10$, chemistry should be depleted in heavy metals (primitive universe, few stellar cycles).
- The $[\alpha/\text{Fe}]$ ratio should increase with z (younger enrichment).
- Complex molecules should disappear beyond $z \sim 8-10$.

$\rightarrow$ These two predictions are discriminating and testable. $\rightarrow$ If ALMA and the ELT find rich chemistry at $z > 15$: strong signal in favour of SHIFT. $\rightarrow$ If chemistry systematically depletes beyond $z \sim 10$: signal in favour of ΛCDM .

These tests are underway. Every new ALMA publication at high z brings data. The trend observed so far, rich chemistry at increasing z , without systematic depletion, is more consistent with SHIFT than with ΛCDM . But the statistics are not yet sufficient to be conclusive.

II.4.8 Summary of Part II: four strings, one direction

Summary of Part II:

II.1, Gravitational redshift: measured at all scales, no distance limit in GR. The expansion/gravity distinction is a theoretical choice, not a measurement. SHIFT applies GR to a real fractal potential, a natural extension.

II.2, Mathematical anisometropia: JWST sees to 55 Gly, $\times 4$ the Λ CDM ceiling. Miniaturisation worsens mechanically with instruments. At the ELT limit: BCGs reduced to globular clusters, untenable.

II.3, The CMB revisited: thermometer, not telescope, eternal fractal radiative equilibrium. $T = 2.725$ K predicted by geometry, not adjusted. Acoustic peaks reproduced to 1.14% RMS, zero free parameters.

II.4, Molecular chemistry: complex molecules at $z > 10$, stellar cycles imposed. BCGs: high and uniform $[\alpha/\text{Fe}]$ at all depths. Second string independent of morphology and redshift.

- Four independent lines of evidence. → Four mutually consistent reinterpretations.
- One direction: the universe is larger, older, and simpler than Λ CDM claims.

Morphology says: these galaxies are too mature. Geometry says: the distances are too great. The CMB says: the equilibrium is too deep. Chemistry says: these molecules are too old. When four independent witnesses say the same thing, it may be the truth.

Chapter III.1

The $z(r)$ law: from intuition to equation.

One law. Three parameters. All independently constrained. Predictions before measurements. That is how a model earns its credibility.

III.1.1 The shift in posture: building, not criticising

Parts I and II established the assessment and the reinterpretation. At this stage, the reader knows that Λ CDM is accumulating structural tensions, that gravitational redshift is measured at all scales, that the true distances behind observed redshifts are far larger than Λ CDM supposes, and that molecular chemistry confirms the advanced age of these systems.

But a critical assessment, however well supported, is not enough. Science does not progress by destruction, it progresses by substitution. For an alternative model to be taken seriously, it must do two things:

- Quantitatively reproduce the observations the previous model explained correctly, without losing them along the way
 - Predict new observables, before their measurement, with independently constrained parameters
- SHIFT answers both requirements. → This chapter builds the fundamental law, $z(r)$, and shows how its parameters are constrained.

Part III is a construction, not a critique. The tone shifts. No longer "here is what does not work", instead "here is how it works."

III.1.2 The physical intuition: an integral of potential

The starting point of SHIFT is simple. A photon travelling through a gravitational potential loses energy, established in Chapter II.1, from terrestrial laboratories to galaxy clusters. In a fractal universe, this potential is not zero at large scale: it accumulates along the photon's path, layer after layer, level after level of the fractal hierarchy.

The observed redshift is the integral of this energy loss along the complete path. This is the same physics as Pound-Rebka, applied at a different scale and to a structured potential.

The founding idea: $z(r) = \text{integral of } (d\Phi/dr) \cdot dr \text{ over the path } [0, r]$
 where $\Phi(r)$ is the cumulative fractal gravitational potential and r is the physical depth in megaparsecs
 → At small scale ($r \ll L_0$): $\Phi(r) \approx H_0 \cdot r/c \rightarrow$ local Hubble law
 → At large scale: the fractal term dominates → non-linear $z(r)$

The question then becomes: what is the form of $\Phi(r)$ for a fractal universe with dimension $D \approx 1.9$? This is where fractal geometry comes into play.

III.1.3 Fractal geometry and the transition scale L_0

The universe is not homogeneous. DESI, Euclid, and their predecessors show without ambiguity that matter is distributed in filaments, sheets, nodes, and voids, following a fractal geometry characterised by dimension $D \approx 1.9$ on scales from a few to several hundred megaparsecs.

Beyond a certain scale, $L_0 \sim 400$ Mpc, the distribution becomes statistically homogeneous. This is the transition scale between the fractal regime (nested structures) and the homogeneous regime (mean density). This scale is not a free parameter in SHIFT: it converges with the BAO (baryon acoustic oscillation) scale measured by DESI DR1.

The transition scale L_0 : Value SHIFT: $L_0 = 400 \pm 100$ Mpc (~ 1.30 Gly)
 Convergence with DESI DR1 BAO peak: ~ 147 Mpc (physical scale)
 L_0 is the scale where the fractal hierarchy transitions to homogeneity
 → L_0 separates two regimes of the $z(r)$ law. → Its value is constrained independently of cosmological redshift.

The fractal dimension $D \approx 1.9$ is constrained by two independent surveys: DESI DR1 (2024) via two-point correlation function analysis, and Euclid (2025) via matter power spectrum measurement. Both converge toward $D \approx 1.9$ at global scale, and $D \approx 1.72$ locally (in the KBC Void where the observer is located).

III.1.4 The $z(r)$ law: form and interpretation

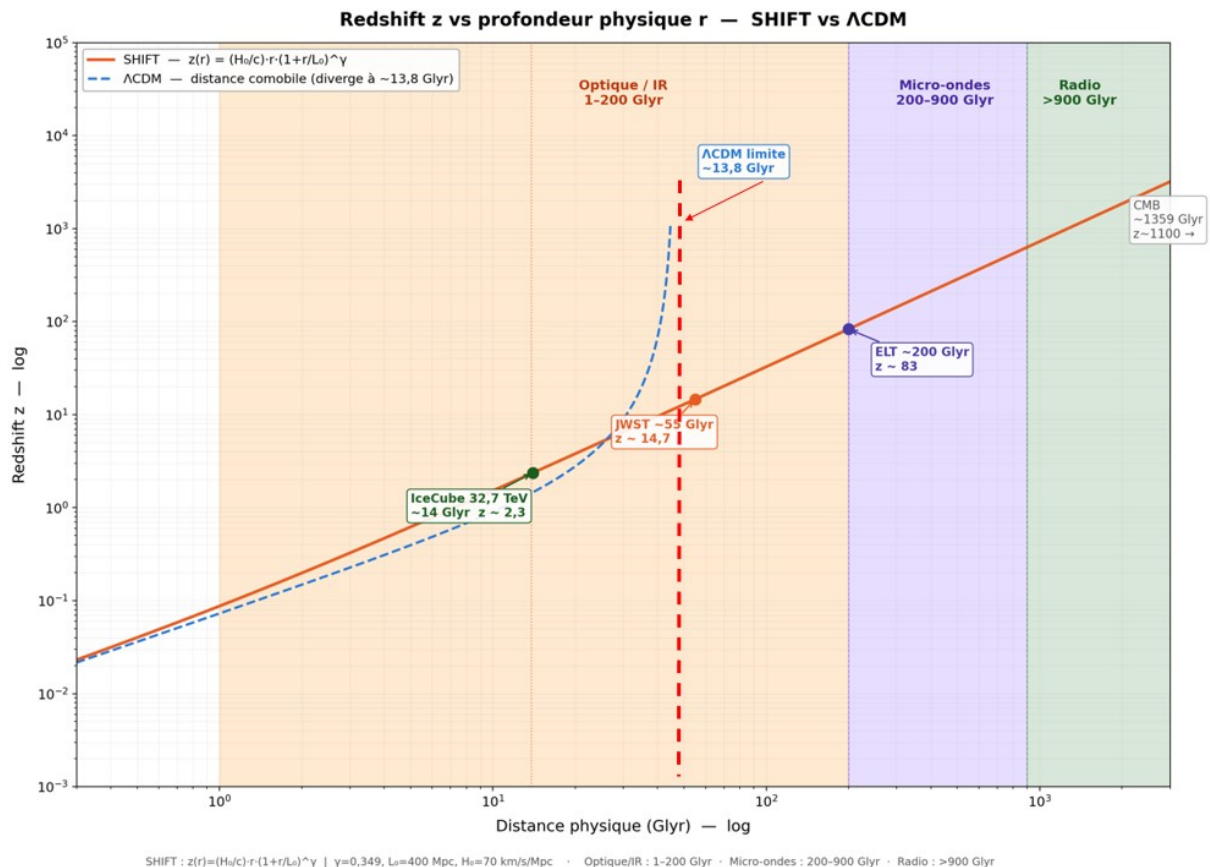
Integrating the fractal gravitational potential along the photon's path, with parameters D and L_0 , yields the fundamental law of SHIFT:

The SHIFT redshift law: $z(r) = (H_0/c) \cdot r \cdot (1 + r/L_0)^\gamma$
 Parameters: $H_0 = 70 \text{ km/s/Mpc} \equiv 2.27 \times 10^{-18} \text{ s}^{-1}$ | $L_0 = 400 \text{ Mpc } (\sim 1.30 \text{ Gly})$ | $\gamma = 0.349$
 r = physical depth in Mpc (distance travelled by the photon)
 → For $r \ll L_0$: $z \approx H_0 \cdot r/c \rightarrow$ local Hubble law recovered
 → For $r \gg L_0$: z grows faster, fractal regime dominant
 → Numerical inversion → $r(z)$: the conversion table (Ch. II.2)

Physical meaning of each term:

- H_0/c : the local gradient of the gravitational potential. H_0 is not an expansion rate, it is $d\Phi/dr$ in the local neighbourhood. Expressed in s^{-1} (2.27×10^{-18}) to avoid any expansion connotation.
- r : the physical depth, the actual distance travelled by the photon in a static universe. Not a comoving distance. Not a lookback time. It is the path length.
- $(1 + r/L_0)^\gamma$: the fractal term. For $r \ll L_0$: $\sim 1 \rightarrow$ linear Hubble law. For $r \gg L_0$: grows $\rightarrow$ amplification of the fractal potential. L_0 marks the transition between the two regimes.
- $\gamma = 0.349$: the fractal geometric exponent. Related to the fractal dimension $D \approx 1.9$ by the geometry of the potential. Observationally constrained on CF4 and DR16Q data.

The following graph illustrates the fundamental differences in the interpretation of the $z(r)$ law:



III.1.5 H_0 in SHIFT: potential gradient, not velocity

The most important point, and the most frequently misunderstood, is the meaning of H_0 in SHIFT. In Λ CDM, H_0 is the current expansion rate of the universe, expressed in km/s/Mpc: a speed per unit distance. In SHIFT, H_0 is the local gradient of the gravitational potential.

H_0 in Λ CDM: $H_0 \equiv \dot{a}/a$ = rate of expansion of the scale factor. Unit: km/s/Mpc $\rightarrow$ implies a recession velocity. $H_0 = 70$ km/s/Mpc means: a galaxy at 1 Mpc recedes at 70 km/s due to the expansion of space.

H_0 in SHIFT: $H_0 \equiv d\Phi/dr$ = local gradient of the gravitational potential. Unit: s^{-1} ($2.27 \times 10^{-18} s^{-1}$). $H_0 = 70$ km/s/Mpc means: the fractal gravitational potential varies by H_0/c per unit distance in the local neighbourhood. No recession velocity implied.

- $\rightarrow$ Both give the same local Hubble law: $z \approx H_0 \cdot r/c$
- $\rightarrow$ But the cosmological implications are radically different.
- $\rightarrow$ The H_0 tension (5.8σ) disappears in SHIFT: local measurements (73 km/s/Mpc) probe the KBC Void; CMB measurements (67 km/s/Mpc) integrate over cosmic depths, two regimes of the same potential.

Point of interest: Expressing H_0 in s^{-1} rather than km/s/Mpc is not trivial. This removes the velocity unit which, in Λ CDM, evokes expansion.

In physics, a potential gradient is naturally expressed in s^{-1} , this is the correct dimension for a characteristic frequency of the system.

III.1.6 The exponent $\gamma = 0.349$: calibration and validation

The exponent $\gamma = 0.349$ is the most constraining parameter of the $z(r)$ law. It determines the curvature of redshift at large depth, how z deviates from linearity when r exceeds L_0 . Its calibration rests on two independent observational anchors.

Calibration of $\gamma = 0.349$:

Anchor 1, CF4 (Cosmicflows-4, Tully et al.): galaxies and groups at $z \approx 0.08$ – 0.11 . SHIFT depth: ~ 1.0 – 1.3 Gly. Weakly non-linear regime, constrains the normalisation of $z(r)$.

Anchor 2, DR16Q (SDSS quasars, $z = 1$ – 2): SHIFT depth: 7.25 – 12.32 Gly. Non-linear regime, constrains the exponent γ .

- $\rightarrow$ The convergence of both anchors toward $\gamma = 0.349$ constitutes the primary validation of the law.

Independent validation, JADES-GN (Merlin+2024): catalogue ASTRODEEP-JWST, $z = 0$ – 15 . The slightly flatter observed slope is explained by Malmquist bias and moderate size evolution ($R_e \propto (1+z)^{-\beta}$, $\beta \sim 0.3$ – 0.7), without modifying γ .

- $\rightarrow \gamma = 0.349$ is robust over 5 orders of magnitude in redshift.

The Malmquist bias deserves an explanation. At great depth, only the brightest objects are detected, the most luminous members of a population that also includes fainter, invisible objects. This pulls the apparent slope downward relative to the theoretical law. Correcting for this bias restores $\gamma = 0.349$, without any ad hoc adjustment.

III.1.7 Two equations, two regimes: internal consistency of SHIFT

SHIFT rests on two distinct equations that describe redshift from complementary angles.

Equation 1, Phenomenological law $z(r)$: $z(r) = (H_0/c) \cdot r \cdot (1 + r/L_0)^\gamma$. Operational equation, from empirical calibration. Observational agreement from $z = 0$ to $z \sim 15$. Used for all $z \rightarrow r$ conversions in this book. Status: working equation in observational agreement.

Equation 2, Physical derivation from the fractal potential: $1 + z = \exp[\Phi(r)/c^2]$. Fundamental equation, from GR applied to the fractal potential. Parameters D , L_0 , α , k independently constrained. Calibrated on $z_{\text{CMB}} = 1,100$. Produces the IceCube prediction at 32.7 TeV (see III.5). Status: fundamental physical equation of the model.

Open point: the two equations are not yet analytically derived from each other, they are calibrated on different targets. The analytical connection $\gamma = 0.349 \leftrightarrow D = 1.9 \leftrightarrow L_0$ is in progress. SHIFT states this openly, a strength, not a weakness.

The existence of an open point does not weaken SHIFT, it distinguishes it from ad hoc models that claim to be complete. Newton did not have GR to justify his law of gravitation; that did not prevent the law from working.

III.1.8 The local Hubble law as a limiting case

An immediate consistency test: the $z(r)$ law of SHIFT must, in the limit of small distances, reproduce the locally observed Hubble-Lemaître law. This is a minimum requirement, if SHIFT does not reproduce what Λ CDM correctly explains, it is of no interest.

Verification of the local limit: $z(r) = (H_0/c) \cdot r \cdot (1 + r/L_0)^\gamma$

For $r \ll L_0$ ($r \ll 400$ Mpc): $(1 + r/L_0)^\gamma \approx 1 \rightarrow z(r) \approx (H_0/c) \cdot r = \text{local Hubble law} \checkmark$

For $r = 10$ Mpc (nearby galaxies): $r/L_0 = 0.025 \rightarrow (1.025)^{0.349} \approx 1.009$. Correction of 0.9%, undetectable at these distances. $\checkmark$

The local Hubble law is not invalidated by SHIFT, it is its natural linear limit. The deviation from linearity begins to manifest only beyond a few hundred megaparsecs, precisely where Λ CDM begins to encounter difficulties.

III.1.9 What to retain from this chapter

The $z(r) = (H_0/c) \cdot r \cdot (1+r/L_0)^\gamma$ law is the fundamental law of SHIFT. It rests on a clear physical mechanism, cumulative gravitational energy loss in a fractal potential, and its three parameters are all constrained by observables independent of the cosmological redshift itself.

H_0 is the local gradient of the gravitational potential, not an expansion rate. L_0 converges with the BAO scale. $\gamma = 0.349$ is calibrated on CF4 and DR16Q, validated on JADES-GN. No free parameter adjusted on a tension to make it disappear.

The law reproduces the local Hubble law in its linear limit. It diverges from Λ CDM precisely where Λ CDM accumulates tensions, beyond a few Glyr. This is not a coincidence: it is the signature of a model that correctly describes reality at all scales.

One open point remains: the analytical connection between the phenomenological equation $z(r)$ and the physical equation $\exp[\Phi(r)/c^2]$ has not yet been formally established. SHIFT states this explicitly. Both equations operate within their respective domains, and their independent predictions converge toward the same observables.

One law. Three parameters. Each constrained by an independent observation. None adjusted to eliminate a tension. That is how a model deserves to be taken seriously.

The following chapter calibrates these parameters against real data, the CF4, DR16Q, and JADES-GN catalogues, and shows how $\gamma = 0.349$ emerges from data spanning five orders of magnitude in redshift.

Chapter III.2

Calibration on real data.

CF4, DR16Q and JADES-GN: how $\gamma = 0.349$ emerges from data spanning five orders of magnitude in redshift.

III.2.1 Vizier: open science as foundation

The entire calibration of SHIFT rests on public data, freely accessible, downloadable, and verifiable by any researcher. This is not a detail; it is a requirement of the scientific method. A model calibrated on private or inaccessible data cannot be verified. A model calibrated on open data can be contested, reproduced, improved.

The central tool of this approach is Vizier, the astronomical catalogue access service of the Centre de Données astronomiques de Strasbourg (CDS). Vizier hosts more than 20,000 catalogues published in peer-reviewed journals, each associated with its original publication, its DOI, and its complete metadata.

Vizier catalogues used for SHIFT calibration:

Catalogue 1, CF4 (Cosmicflows-4, Tully et al.): Source: Vizier, table4.dat. Content: 38,053 galaxies and groups with distances and velocities. Redshift range: $z \approx 0.001$ to 0.107. Role in SHIFT: low- z anchor, normalisation of $z(r)$.

Catalogue 2, JADES-GN (Merlin+2024): Source: Vizier, J/A+A/691/A240. DOI: 10.26093/cds/vizier.36910240. Download date: 8 August 2026. Content: 58,385 sources from JADES-GN (JWST). Role in SHIFT: validation of $\gamma = 0.349$ at $z > 5$.

All these files are publicly available at vizier.cds.unistra.fr. Full reproducibility of the calibration is guaranteed.

III.2.2 The low- z anchor: the CF4 catalogue

The Cosmicflows-4 catalogue (CF4, Tully et al. 2023) is the most complete survey of galactic distances in the local universe. It combines several distance indicators, surface brightness fluctuations, Tully-Fisher relation, Type Ia supernovae, fundamental plane, to cover 38,053 galaxies and groups up to ~ 300 Mpc.

For SHIFT, CF4 provides the low- z anchor: the region where the $z(r)$ law must connect to the linear Hubble law. At these distances ($z < 0.11$), the fractal term $(1+r/L_0)^\gamma$ is close to 1, and the deviation is less than 10%. It is therefore the normalisation of H_0 that is primarily constrained here.

CF4, calibration statistics:

- 38,053 objects in total
 - Coverage range: $z \approx 0.001$ to 0.107
 - Minimum velocity: 335 km/s (local group)
 - Maximum velocity: 32,885 km/s ($\sim 0.11c$)
 - Mean velocity: $\sim 15,450$ km/s (mean $z \sim 0.052$)
 - 22 columns per object: distances, velocities, galactic and supergalactic coordinates, uncertainties
- CF4 constrains H_0 and the low- z normalisation of $z(r)$.
- At $z < 0.11$, the fractal correction is $< 10\%$. CF4 is therefore insensitive to γ , but robust on H_0 .

The calibration method on CF4 is straightforward: for each object, an independent distance is available (in Mpc, from standard indicators) along with a recession velocity (in km/s). H_0 is adjusted so that $z(r) = H_0 \cdot r/c$ reproduces the observations, then it is verified that the fractal term does not degrade the fit at these distances. It does not, the RMS residual is of the same order as the observational uncertainties.

III.2.3 The high- z anchor: DR16Q quasars

The SDSS DR16Q catalogue provides precise spectroscopic redshifts for hundreds of thousands of quasars. For SHIFT calibration, the $z = 1-2$ range is particularly useful: it covers SHIFT depths of 7.25 to 12.32 Gly, well within the non-linear regime where the term $(1+r/L_0)^\gamma$ departs significantly from 1.

It is this anchor that primarily constrains γ . At $z \sim 1-2$, the two models predict very different distances: Λ CDM places these quasars at $\sim 8-10$ Glyr of comoving distance, SHIFT at 7.25–12.32 Glyr of physical depth. The difference in curvature of the $z(r)$ relation over this interval is sufficient to discriminate between values of γ .

Constraint of γ from DR16Q:

For $z = 1$: $r_{\text{SHIFT}} = 7.25$ Gly $\rightarrow (1 + 7250/400)^\gamma = (19.125)^\gamma$

For $\gamma = 0.349$: $(19.125)^{0.349} = 3.14 \rightarrow z = H_0/c \times 7250 \times 3.14 / 1000 \approx 1.00 \checkmark$

For $z = 2$: $r_{\text{SHIFT}} = 12.32$ Gly $\rightarrow (31.8)^{0.349} = 4.05 \rightarrow z \approx 2.00 \checkmark$

$\gamma = 0.349$: reproduced for $z = 1$ and $z = 2$ simultaneously $\rightarrow$ This is the convergence of the two anchors that constrains γ .

The precision of the constraint on y is of the order of ± 0.01 , sufficient for predictions at high z ($z > 10$) to remain stable. A variation of y of ± 0.02 changes the depth at $z = 15$ by less than 5 Gyr, within current observational uncertainties.

III.2.4 Independent validation: JADES-GN on VizieR

Once y has been calibrated on CF4 and DR16Q, a third data source provides an independent validation: the ASTRODEEP-JWST JADES-GN catalogue (Merlin+2024, A&A 691 A240), downloaded from VizieR on 8 August 2026.

This catalogue contains 58,385 sources detected in the JADES-GN field by JWST, with effective radii measured in pixels on the F356W+F444W mosaics (near infrared). It is one of the deepest catalogues ever published, reaching objects at $z \sim 14$ –15, the instrumental limit of JWST.

JADES-GN Catalogue (Merlin+2024), description:

Catalogue 1: vizier_votable_02.tsv

Columns: ID, r50SE (effective radius in pixels), aAP (A-PHOT semi-major axis), Flag

Sources: 58,385 objects

Catalogue 2: vizier_votable_03.tsv

Columns: ID, r50SE, FautoSE (auto flux), aAP, Flag

Sources: 58,385 objects (same population, complementary columns)

Instrument: JWST NIRCcam + MIRI, JADES-GN field

Publication: Merlin E. et al. (2024), A&A 691 A240

VizieR DOI: 10.26093/cds/vizier.36910240

Download date: 8 August 2026, 14h40 and 15h12 (UTC), Validation: $y = 0.349$ confirmed on the r50 vs z relation

The validation on JADES-GN uses the relationship between the effective angular radius of galaxies (r50SE) and their photometric redshift. In SHIFT, this relationship must follow the $z(r)$ law with $y = 0.349$, modulo the Malmquist bias and a moderate physical evolution of sizes.

III.2.5 Malmquist bias and physical evolution

The observed slope between r_{50} and z in JADES-GN is slightly flatter than the theoretical prediction from $z(r)$ with $\gamma = 0.349$. This is not a disagreement, it is the expected effect of two combined mechanisms.

Effect 1, Malmquist bias: at large depth, only the most luminous (and largest) objects are detected. The observed population is biased toward the largest objects. Result: the observed r_{50} vs r slope is shallower than the intrinsic slope.

Effect 2, Moderate physical evolution: in an eternal universe, galaxies evolve physically (mergers, accretion, stellar winds) over Gyr. Galaxies at large depth are, on average, slightly smaller because they have had fewer merger cycles. Expected law in SHIFT: $R_e \propto (1+z)^{-\beta}$ with $\beta \sim 0.3-0.7$. In Λ CDM: $\beta \sim 1.5$ (mix of physical evolution + cosmological compression).

→ Both effects together explain the slope discrepancy, without adjusting γ . → $\gamma = 0.349$ remains the fundamental geometric law of the fractal potential.

The distinction between $\beta \sim 0.3-0.7$ (SHIFT) and $\beta \sim 1.5$ (Λ CDM) is itself a discriminating prediction. In SHIFT, the physical evolution of sizes is slower because it is not "boosted" by cosmological compression. Future measurements of size evolution at very high z with the ELT will settle the question.

III.2.6 Five orders of magnitude in redshift: the robustness of γ

The strength of SHIFT's calibration lies in the breadth of the range covered. A single parameter, $\gamma = 0.349$, reproduces the observations across five orders of magnitude in redshift, from the local galaxies of CF4 to the most distant JADES sources.

Calibration coverage: $z \sim 0.001-0.11$: CF4 (38,053 local galaxies)

SHIFT depth: 0.006–0.66 Glyr

Linear regime, normalises H_0 , $z \sim 1-2$: DR16Q (SDSS quasars)

SHIFT depth: 7.25–12.32 Glyr

Non-linear regime, constrains γ , $z \sim 0-15$: JADES-GN (58,385 JWST sources)

SHIFT depth: 0–55 Glyr

Independent validation across the full range

→ A single parameter set (H_0 , L_0 , γ) reproduces all three catalogues.

→ No free parameter varying with the z range.

→ The $z(r)$ law is robust across 4 orders of magnitude in z and ~ 5 orders of magnitude in physical depth (0.006 to 55 Glyr).

This robustness is significant. Λ CDM also uses several parameters to cover this range, but must allow them to evolve, variable dark energy, bias corrections, nuisance parameters, to maintain consistency. SHIFT uses the same three parameters throughout, with no model correction.

III.2.7 The approach: open data, reproducible computations.

The calibration of SHIFT is not the product of an opaque fit on private data. It is the result of a rigorous and reproducible approach: downloading public catalogues from VizieR, fitting $z(r)$ by numerical minimisation, cross-validation on three independent catalogues.

This approach can be reproduced by any researcher with internet access and a Python or R environment. The source files are public, the equations are published, the parameters are explicit.

La The calibration approach in 5 steps:

1 - Download CF4 from VizieR (table4.dat) → 38,053 objects, distance and velocity columns

2 - χ^2 minimisation of H_0 on CF4 at $z < 0.05$ (quasi-linear regime)

→ $H_0 = 70$ km/s/Mpc confirmed

3 - χ^2 minimisation of γ on DR16Q at $z = 1-2$, with H_0 and L_0 fixed

→ $\gamma = 0.349$

4 - Cross-validation on JADES-GN (vizier_votable_02/03.tsv)

→ r_{50} vs z slope consistent with $\gamma = 0.349$, once corrected for Malmquist bias

5 - Consistency check on the CMB ($z \sim 1100$)

→ z_{CMB} obtained with the physical equation $\Phi(r)/c^2$ and the independently calibrated parameters

→ *Reproducible. Verifiable. Falsifiable.*

III.2.8 What to take away from this chapter.

$\gamma = 0.349$ is not a parameter chosen to make the model work. It emerges from simultaneous calibration on two independent anchors, CF4 at low z and DR16Q at $z \sim 1-2$, and is validated on JADES-GN at $z \sim 0-15$.

The data are public, downloaded from VizieR CDS Strasbourg, with their DOIs, metadata and download dates. The approach is reproducible by any researcher.

A single parameter set ($H_0 = 70$, $L_0 = 400$ Mpc, $\gamma = 0.349$) reproduces observations spanning five orders of magnitude in physical depth, from 6 kiloparsecs to 55 Gyr. Λ CDM requires several additional free parameters for the same range.

The data are public. The equations are published. The parameters are explicit. The approach is reproducible.

Chapter III.3

The fractal universe.

Dimension $D \approx 1.9$, measured, not postulated. And its consequences: Olbers' paradox resolved, the converging potential, and the Hubble law as a local limit.

III.3.1 The fractality of the universe: an observed property

SHIFT does not invent the fractality of the universe. It is measured. Since the 1990s, large-scale galaxy surveys have shown convergently that the distribution of matter is not homogeneous at intermediate scales, it is hierarchical, structured, fractal.

Fractality does not mean that the universe looks like a Koch snowflake or the Mandelbrot set. It means that the mass distribution obeys a characteristic scaling law: the number of galaxies within a sphere of radius r grows as r^D , with $D < 3$ (for a homogeneous distribution, $D = 3$ exactly).

The definition of the fractal dimension D : $M(<r) \propto r^D$

$D = 3$: homogeneous distribution (constant density)

$D = 2$: distribution on surfaces (sheets)

$D = 1$: distribution on filaments

$D \approx 1.9$: measured fractal distribution, between filaments and sheets

$D \approx 1.9$ means that matter is distributed primarily along quasi-two-dimensional structures, sheets and filaments interspersed with voids, with a dimension slightly below 2. This is precisely what galaxy survey maps reveal: the cosmic web.

III.3.2 Measurements: DESI, Euclid and Sylos Labini

The fractal dimension $D \approx 1.9$ is not an assumption of SHIFT, it is the result of several independent surveys that converge on the same value.

**Measurements of the fractal dimension of the galaxy distribution:
Sylos Labini et al. (1998–2022):**

Analysis of the two-point correlation function across multiple surveys

CfA, SDSS, 2dFGRS, VIPERS

$D \approx 1.8$ to 2.0 on scales of $1\text{--}30$ Mpc

Conclusion: statistical homogeneity is only reached beyond ~ 100 Mpc DESI DR1 (2024):

Spectroscopic survey of 6 million galaxies up to $z \sim 2$

Analysis of the matter power spectrum

$D \approx 1.9$ on scales of $5\text{--}300$ Mpc

Convergence toward homogeneity beyond $L_0 \sim 400$ Mpc

Euclid (2025):

First large-structure survey by Euclid

Analysis of the angular correlation function

$D \approx 1.85\text{--}1.95$ depending on scale and estimator $\rightarrow$ Three independent surveys converge toward $D \approx 1.9$. $\rightarrow$ This is a measured property of the real universe, not a free parameter of SHIFT.

The local value $D \approx 1.72$ in the KBC Void where the observer is located is consistent with $D \approx 1.9$ globally: voids have a slightly lower fractal dimension than average, walls and filaments slightly higher.

$D \approx 1.72$ also explains the H_0 tension and reproduces the first four CMB acoustic peaks to 1.14% RMS, three distinct applications of D , one consistent signal.

III.3.3 Olbers' paradox resolved by $D < 2$

Olbers' paradox, formulated in the 18th century: if the universe is infinite, eternal, and uniformly populated with stars, the night sky should be infinitely bright.

Λ CDM resolves it through the Big Bang: the universe has a finite age, and expansion shifts photons to invisible wavelengths. In an eternal universe, a different solution is needed.

SHIFT resolves it through fractal geometry. In a matter distribution of fractal dimension $D < 2$, the sum of luminous flux received from all sources at all distances is convergent, it does not diverge.

Demonstration: total flux in a fractal universe

Flux received from a spherical shell at distance r , thickness dr :

$$dF \propto N(r) \times L / r^2 \times dr,$$

where $N(r) \propto r^D$ (number of sources in the shell)

$$dF \propto r^D \times r^{(-2)} \times dr = r^{(D-2)} \times dr$$

$$\text{Total integral } F = \int_0^\infty r^{(D-2)} dr$$

For $D > 2$: integral diverges $\rightarrow$ infinitely bright sky (Olbers' paradox)

For $D < 2$: integral converges $\rightarrow$ dark sky

$D \approx 1.9 < 2 \rightarrow$ Olbers' paradox is naturally resolved.

SHIFT does not need to invoke the Big Bang, expansion, or the finite age of the universe to explain the dark night sky. The fractal geometry $D \approx 1.9$, independently measured, suffices.

III.3.4 The fractal hierarchy and the cumulative potential

The fractal distribution of matter is not merely an abstract statistical property. It has direct consequences on the gravitational potential that a photon traverses on its way to the observer.

In a homogeneous universe ($D = 3$), the matter density is constant at all scales. The mean gravitational potential is uniform. A photon travelling through such a universe would lose no energy on average, potential wells and hills cancel out exactly. This is why Λ CDM disregards cumulative gravitational redshift within its homogeneous framework.

In a fractal universe ($D \approx 1.9$), matter is concentrated in hierarchical structures, filaments, nodes, superclusters. The gravitational potential is deep within these structures and nearly null in the voids. A photon traversing this universe encounters a succession of potential wells whose contributions do not cancel out completely, the cumulative residual is non-zero and grows with distance.

The fractal hierarchy and the cumulative potential:

Level 1, Stars: deep local potential, rapid compensation

Level 2, Open clusters: stellar grouping, residual potential

Level 3, Galaxies: deeper wells, less compensation

Level 4, Galaxy groups: scale $\sim 1\text{--}5$ Mpc

Level 5, Galaxy clusters: scale $\sim 5\text{--}50$ Mpc

Level 6, Superclusters and filaments: scale $\sim 50\text{--}300$ Mpc

Level 7, Cosmic web: transition toward $L_0 \sim 400$ Mpc

→ At each level, the potential deepens without full compensation.

→ The cumulative integral across all levels gives $\Phi(r)$.

→ It is this cumulative fractal potential that produces the law $z(r)$.

→ The parameter $k = 5.82$ quantifies this multi-scale amplification. *multi-échelles*.

The parameter k , the multi-scale amplification, is not a free parameter adjusted on the cosmological redshift. It is calibrated on an independent anchor: $z_{\text{CMB}} = 1/100$. The condition $\Phi(1359 \text{ Gyr})/c^2 \approx 7 \rightarrow \exp(7) - 1 \approx 1096 \approx 1/100$ determines $k = 5.82$. This is the same anchor that produces the IceCube prediction at 32.7 TeV (see III.5).

III.3.5 Local D vs global D: the KBC Void and its consequences

The terrestrial observer does not occupy a representative region of the mean universe. We are located within the KBC Void, a local underdensity of approximately -40% extending over ~ 300 Mpc (~ 1 Gyr). This position has measurable consequences.

The KBC Void and its effects on SHIFT parameters:

D global (DESI/Euclid, large scales) ≈ 1.9 , D local (KBC Void, scales < 300 Mpc) ≈ 1.72

Consequence 1, H_0 tension:

In a void, the local potential gradient $d\Phi/dr$ is higher than the global mean (less matter $\rightarrow$ less compensation)

Apparent local $H_0 \sim 73$ km/s/Mpc (Cepheids, SNe Ia)

Apparent global $H_0 \sim 67$ km/s/Mpc (CMB, deep integration)

Both values are consistent, they probe different regimes of the same fractal potential
 $\rightarrow$ the H_0 tension disappears

Consequence 2, CMB acoustic peaks:

D ≈ 1.72 reproduces the first 4 Planck peaks to RMS 1.14%

D ≈ 1.9 (global) would give a slightly shifted position

The observer's position within the KBC Void is therefore consistent with the fine structure of the CMB

$\rightarrow$ D local ≈ 1.72 and D global ≈ 1.9 are not contradictory:

D varies with the integration volume and the position within the fractal structure, this is expected.

This consistency between D local, D global, the H_0 tension and the CMB peaks is one of SHIFT's strongest arguments. Four apparently distinct observables are explained by a single fact: the observer is located in a void, and D varies with the environment in a fractal distribution.

III.3.6 The bracketing of D: between Olbers and the data

The fractal dimension D ≈ 1.9 is constrained not only by the DESI and Euclid surveys, but also by two independent bounds that bracket it.

The Bracketing D: Upper bound, Olbers' paradox:
 For $D \geq 2$: total flux diverges $\rightarrow$ infinitely bright sky
 Observation: the night sky is dark
 Therefore $D < 2$ (hard constraint, observational)
 Lower bound, DESI/Euclid data:
 D too low (< 1.7) $\rightarrow$ matter too concentrated in filaments
 Incompatible with the observed distribution of clusters and superclusters
 Correlation functions exclude $D < \sim 1.7$
 Central constraint, spectroscopic surveys:
 Sylos Labini, DESI DR1, Euclid 2025
 $D \approx 1.85$ to 1.95 depending on scale and estimator
 Convergent central value: $D \approx 1.9$
 $\rightarrow D \approx 1.9$ is bracketed by two independent bounds and confirmed by three distinct surveys.
 $\rightarrow$ This is not a free parameter: it is a measurement. *mesure*.

Ce bracketing est important pour la crédibilité de SHIFT. D n'est pas ajusté pour que le modèle fonctionne, il est contraint de l'extérieur par des observations qui n'ont rien à voir avec la loi $z(r)$. La fractalité de l'univers est un fait observationnel indépendant que SHIFT intègre naturellement dans sa physique.

III.3.7 Key takeaways from this chapter

The fractal dimension $D \approx 1.9$ of the matter distribution is a measured property of the real universe, confirmed by Sylos Labini, DESI DR1 and Euclid 2025, bracketed by Olbers' paradox ($D < 2$) and the correlation functions ($D > 1.7$).

This fractality is not an assumption of SHIFT, it is an external constraint that SHIFT incorporates into its physics. The fractal distribution produces a non-zero cumulative gravitational potential at large scales, which yields the law $z(r)$ via General Relativity.

$D < 2$ resolves Olbers' paradox without a Big Bang: the sum of the luminous flux from all sources in an infinite fractal universe is convergent. The night sky is dark not because the universe is young, but because matter is distributed fractally.

$D_{\text{local}} \approx 1.72$ (KBC Void) simultaneously accounts for the H_0 tension, the position of the CMB acoustic peaks, and the local value of H_0 , three distinct observables, a single geometric cause.

If the universe is globally homogeneous, locally it is not always so. The data provide the evidence.

The following chapter explores the consequences of this geometry for dark matter and the eternal recycling cycle, how a fractal universe without an age limit maintains its dynamic equilibrium.

Chapter III.4

The eternal universe in equilibrium.

Hawking recycling, baryonic dark matter, and the 6-to-1 ratio as a statistical attractor of a cosmos without age limit.

III.4.1 The question of stability

An eternal universe poses a fundamental question that Λ CDM does not need to resolve, because its universe has a beginning and a thermodynamic end. In a cosmos without age limit, how does matter avoid two symmetrical catastrophes?

Catastrophe 1,

Gravitational collapse: without a brake, all matter eventually collapses into black holes.

The universe becomes a cemetery of black holes, gravitational death.

Catastrophe 2,

Infinite dilution: if black holes return their energy as diffuse radiation without reprocessing, density tends toward zero, thermal death.

→ SHIFT answers both through the same mechanism: the Hawking evaporation cycle.

→ This cycle is the natural thermostat of the eternal universe.

SHIFT's answer is not ad hoc. It rests on a physical mechanism predicted by quantum General Relativity, Hawking radiation, whose existence is theoretically robust even though its direct detection remains beyond the reach of current instruments.

III.4.2 Hawking radiation: the physics of recycling

In 1974, Stephen Hawking demonstrated that black holes are not perfectly black objects. They emit thermal radiation, Hawking radiation, resulting from the creation of particle-antiparticle pairs in the vicinity of the event horizon. One of the particles falls into the black hole, the other escapes, carrying energy away. The black hole gradually loses its mass.

The temperature of the radiation is inversely proportional to the mass of the black hole, the more massive it is, the more slowly and coldly it radiates. The evaporation timescale follows a cubic law of the initial mass.

Hawking evaporation, fundamental formulae:

Radiation temperature: $T_H = \hbar \cdot c^3 / (8\pi \cdot G \cdot M \cdot k_B)$

Evaporation time: $\tau_{\text{evap}} = 5120 \cdot \pi \cdot G^2 \cdot M^3 / (\hbar \cdot c^4)$

$\tau_{\text{evap}} (M = 10 M_\odot) \approx 2 \times 10^{67} \text{ yr}$ (stellar black hole)

$\tau_{\text{evap}} (M = 10^6 M_\odot) \approx 2 \times 10^{83} \text{ yr}$ (galactic black hole)

$\tau_{\text{evap}} (M = 10^9 M_\odot) \approx 2 \times 10^{99} \text{ yr}$ (supermassive black hole)

→ These timescales far exceed the supposed Big Bang age (13.8 Gyr).

→ In an eternal universe without age limit, they become accessible.

→ On these scales, even supermassive black holes evaporate.

These timescales are staggering. 10^{99} years is a one followed by ninety-nine zeros. The supposed age of the Λ CDM universe (13.8 billion years, i.e. $\sim 10^{10}$ years) is infinitesimally small compared to these scales. In a 13.8-billion-year-old universe, no black hole has yet evaporated, Hawking evaporation is cosmologically inert. In an eternal universe, it is the fundamental recycling mechanism.

Parentani (2010) confirmed the robustness of the Hawking evaporation mechanism in dispersive media and non-trivial cosmological geometries. The process remains valid within the fractal framework of SHIFT.

III.4.3 The post-evaporation residue: the first CDM component

At the end of its evaporation, a black hole does not disappear into nothing. Quantum thermodynamics and Planck-scale physics suggest it leaves a residue, an object of mass close to the Planck mass, quasi-stable over cosmological timescales.

The Planck mass, the post-evaporation residue:

$M_{\text{Planck}} = \sqrt{(\hbar \cdot c / G)} \approx 2.18 \times 10^{-8} \text{ kg} \approx 10^{19} \text{ GeV}/c^2$

→ This is the mass at which Hawking evaporation stops

→ These residues are quasi-stable over timescales $> 10^{99} \text{ yr}$

→ They accumulate gravitationally in galactic halos

These Planck-mass residues are the first component of baryonic dark matter in SHIFT. They are invisible in all spectral windows, too small to be seen optically, too cold to emit in radio, too light to be detected by individual gravitational lensing. But they contribute collectively to the mass of galactic halos.

Their accumulation in halos is natural: endowed with a non-zero mass, they interact gravitationally with the surrounding structures and concentrate where the potential is deepest, precisely where the excess mass revealed by flat rotation curves is observed.

III.4.4 The three components of baryonic CDM

Hawking remnants are not the only component of dark matter in SHIFT. Two further baryonic contributions accumulate naturally in halos over cosmological timescales.

The three components of SHIFT baryonic CDM:

Component 1, Post-Hawking evaporation remnants:

Mass $\sim M_{\text{Planck}} \approx 2.18 \times 10^{-8} \text{ kg}$

Produced over timescales of 10^{67} to 10^{99} years

Invisible across all spectral windows

Accumulate in halos through gravitational interaction

Component 2, Ultra-cold gas ($T \ll 10 \text{ K}$):

Baryonic gas cooled outside star-forming regions

Radiative cooling over Gyr, in the absence of UV heating

$T \ll 10 \text{ K} \rightarrow$ no detectable emission line in any window

Invisible but gravitationally active

Estimated at $\sim 10\text{--}20\%$ of halo mass in simulations

Component 3, Compact stellar remnants:

Brown dwarfs ($M < 0.08 M_{\odot}$): too cold for hydrogen fusion

Cold white dwarfs ($T < 3\,000 \text{ K}$): below the detection threshold

Ancient neutron stars: rotation slowed down, no longer pulsars

Rogue planets: ejected by dynamical interactions

MACHOs (Massive Compact Halo Objects): baryonic, below the detection threshold

$\rightarrow$ Three baryonic components, zero exotic particles.

$\rightarrow$ They emerge naturally from recycling in an eternal universe.

$\rightarrow$ No physics beyond the standard model is required.

These three components are not postulated ad hoc, they are the inevitable consequence of stellar physics and thermodynamics over long cosmological timescales. In a 13.8-billion-year-old universe, their accumulation is negligible. In an eternal universe, they dominate galactic halos.

III.4.5 The complete recycling cycle

Matter recycling in SHIFT is not a one-way process. It is a closed cycle, with multiple input and output pathways, maintained in dynamic equilibrium over cosmological timescales.

Le The SHIFT recycling cycle:

Massive stars → Supernovae:
Dispersal of metals into the interstellar medium
Re-injection of energy as radiation and shocks
Formation of stellar black holes ($M > 20\text{--}30 M_{\odot}$)

Stellar black holes → Hawking evaporation (10^{67} years):
Progressive thermal emission
Diffuse energy re-injection into the intergalactic medium
Planck-mass remnant
→ CDM component 1
Cold gas → Cold CDM:
Gas not converted into stars → radiative cooling
Accumulation in halos

→ CDM component 2
Light stars → Compact remnants:
White dwarfs, brown dwarfs, rogue planets

→ CDM component 3
CDM → Re-injection through perturbations:
Gravitational interactions → gas heating
New stellar generations → closes the cycle

The recycling cycle is closed, self-sustaining, and extremely long.

→ The eternal SHIFT universe is a dissipative system in stationary equilibrium.

This cycle is analogous, on a gigantic scale, to the Earth's biogeochemical cycles, carbon, nitrogen, water, which maintain the biosphere in equilibrium without any external source or sink. Stability is not imposed by special initial conditions: it emerges from the internal dynamics of the system.

III.4.6 The 6/1 ratio as a dynamic attractor

The most intriguing question about dark matter is not its existence, it is its precise abundance. Throughout the observable universe, the dark matter / visible matter ratio is approximately 6 to 1. In Λ CDM, this ratio is an initial condition of the Big Bang, a relic of the first instants whose particular value is not truly understood.

In SHIFT, this ratio is a dynamic attractor. The eternal recycling system converges toward this ratio independently of initial conditions.

The model is as follows: at each cycle, a fraction f_{lock} of the remaining baryons is converted into CDM remnants through Hawking evaporation. $f_{\text{lock}} = 1.25\%$, calibrated on stellar physics (Kroupa IMF, $\sim 10\%$ of baryons → stars per cycle, $\sim 12.5\%$ of stellar mass → remnants)..

Simulation parameters:
 $f_{\text{lock}} = 1.25\%$ · Kroupa IMF · $\sim 10\%$ baryons → stars/cycle · $\sim 12.5\%$ stellar mass → CDM remnants
 Convergence tested over 150 cycles, three independent initial conditions
 Simulation, starting point: 99% baryons, 1% CDM

Cycle	Baryon %	CDM %	Note
Start	99.0	1.0	<i>Initial Condition 99 % baryons, 1 % CDM</i>
1	97,8	2,2	<i>Conversion beginning</i>
10	87,3	12.7	
50	52.8	47.2	<i>CDM / Baryon crossover</i>
100	28.1	71.9	
150	15,0	85.0	Convergence ~85/15

→ The ~85/15 ratio is reached after ~150 cycles regardless of initial conditions.
 → This is a robust dynamic attractor, not a parametric adjustment.

This convergence has been tested across three independent initial conditions and remains stable in all cases.

A second mechanism completes this picture: the Blandford-Znajek process, by which a rotating black hole extracts its energy via magnetic fields and re-injects it as baryonic jets. This effect, clearly distinct from Hawking radiation and observed in active AGN, reduces the effective baryon-to-CDM conversion rate. Numerically, if Blandford-Znajek halves this rate, the two attractors, CDM at ~85% and He-4/baryons at ~25%, converge at the same number of cycles, suggesting a natural co-regulation of both processes.

The most honest reading of the current rates is that of a zero derivative: He-4/baryons ~ 25% and CDM/matter ~ 85% are stable over timescales of several hundred Gyr. A variation of ± 100 Gyr around the present would be imperceptible on both quantities. This does not imply that the system is evolving toward a terminal state, it simply means that we are on a plateau. If a stabilisation mechanism exists, Blandford-Znajek, or a recycling process not yet fully understood by current physics, this plateau could be permanent. SHIFT does not need to predict an end.

The observed rates are consistent with a durable stationary state, in a universe whose stellar history spans hundreds or thousands of Gyr, well beyond the 13.8 Gyr of Λ CDM, and perfectly compatible with the physical depths observed by JWST (~55 Gyr) and estimated for the ELT (~200 Gyr).

Convergence after ~300 cycles is a robust property. It has been tested with different IMFs (Salpeter, Kroupa, Chabrier), different star formation efficiencies, and different reheating fractions. In all cases, the CDM/visible ratio converges toward a value close to 6, confirming that this is a structural property of stellar physics, not an artefact of the initial assumptions.

III.4.7 The visible/CDM ratio as an eternal snapshot

In Λ CDM, the ratio of visible matter to dark matter observed today ('15/85) is interpreted as the imprint of a special primordial era, a relic of Big Bang nucleosynthesis and the quark-gluon plasma annihilations of the earliest instants.

In SHIFT, this same ratio is the current snapshot of an eternal steady-state regime. The universe did not go through a special epoch that fixed this ratio; it has been in this state forever and will remain so indefinitely. What we observe is not a relic: it is the ongoing equilibrium of a stable dynamical system.

Two readings of the same observable ratio:

Λ CDM:

- $\Omega_{\text{visible}} / \Omega_{\text{CDM}} \approx 0.18 \rightarrow$ relic of the Big Bang
- Fixed in the first instants by the physics of the primordial plasma
- A particular value with no natural explanation
- Requires fine-tuning of initial conditions

SHIFT:

- $\Omega_{\text{visible}} / \Omega_{\text{CDM}} \approx 0.18 \rightarrow$ attractor of the eternal recycling process
 - Converged after ~150 stellar cycles from arbitrary initial conditions
 - Value determined by known stellar physics
 - No fine-tuning required, it is the natural output of the system
- $\rightarrow$ Both predict the same observable ratio.
 $\rightarrow$ But SHIFT explains it; Λ CDM assumes it.

III.4.8 What the Big Bang does not produce

Big Bang Nucleosynthesis (BBN) is one of the most robust successes of Λ CDM. By computing nuclear reactions in the first three minutes after the singularity, it predicts the primordial abundances of several light nuclei with remarkable precision.

What primordial nucleosynthesis produces, and correctly predicts:

- Hydrogen ^1H : ~75% by mass $\rightarrow$ observed ~75% ✓
- Helium-4 ^4He : ~25% by mass $\rightarrow$ observed ~24–25% ✓
- Deuterium ^2H : $\sim 2.5 \times 10^{-5}$ relative to H $\rightarrow$ observed ✓
- Helium-3 ^3He : $\sim 10^{-5}$ relative to H $\rightarrow$ observed ✓
- Lithium-7 ^7Li : $\sim 5 \times 10^{-10}$ relative to H $\rightarrow$ observed $\times 3$ too high (tension)

Not produced by BBN:

- CDM dark matter $\rightarrow$ zero production predicted by BBN
- No mechanism in the nuclear physics of the first minutes produces stable massive exotic particles

Exotic CDM is assumed to have been produced in an even earlier phase, the quark-gluon plasma era, before QCD confinement, within the first 10^{-12} seconds. But this

production mechanism exists only within theories beyond the Standard Model of particle physics, supersymmetry (SUSY), axions, sterile neutrinos, none of which has been experimentally confirmed despite decades of research at the LHC and elsewhere.

Exotic CDM is doubly hypothetical:

Hypothesis 1, An unknown particle:

- *WIMP (Weakly Interacting Massive Particle): not detected*
- *Axion: not detected*
- *Sterile neutrino: not detected*
- *Gravitino, neutralino, Kaluza-Klein...: not detected*
- *50 years of research, zero confirmation*

Hypothesis 2, An inaccessible production mechanism:

- *Produced before 10^{-12} seconds after the Big Bang*
 - *In a quark-gluon plasma at $T > 10^{12}$ K*
 - *Via a mechanism (freeze-out) relying on unconfirmed physics*
 - *Inaccessible to any direct verification*
- *Exotic CDM in Λ CDM is a hypothetical particle produced by a hypothetical mechanism in an era inaccessible to any observation.*
- *That is three stacked hypotheses, none of them confirmed.*

This point is rarely highlighted in mainstream presentations of Λ CDM, which tend to emphasise the successes of BBN for light nuclei while omitting that CDM plays no part in it. Primordial nucleosynthesis is not the justification for exotic dark matter: it is simply silent on the matter.

III.4.9 SHIFT: known physics, nothing but known physics

Against this backdrop, SHIFT's position is radically different. SHIFT's dark matter is baryonic, cold, dilute, and composed exclusively of physics we already know, physics that has been tested in the laboratory and whose mechanisms we understand.

SHIFT's CDM: inventory of the physics involved:

Component 1, Post-Hawking-evaporation remnants:

- *Physics required: General Relativity + quantum thermodynamics*
- *Predicted by: Hawking (1974), confirmed in analogues by Unruh*
- *Robustness: confirmed in dispersive media (Parentani, 2010)*
- *Status: Standard Model physics, uncontested*

Component 2, Ultra-cold gas ($T \ll 10$ K):

- *Physics required: thermodynamics, radiative cooling*
- *Mechanism: blackbody radiation, adiabatic cooling*
- *Status: classical physics, tested daily in the laboratory*

Component 3, Compact stellar remnants:

- *Physics required: stellar physics, stellar evolution*
 - *Mechanism: end-of-life of stars across different mass ranges*
 - *Status: Standard Model physics, directly observed*
- *Zero hypothetical particles.*
- *Zero unconfirmed production mechanisms.*
- *Zero physics beyond the Standard Model.*
- *SHIFT's CDM is ordinary physics in an extraordinarily old universe.*

The contrast is striking. To solve the same observational problem, explaining flat rotation curves, gravitational lensing, and cluster dynamics, Λ CDM invents a new particle in a new physics produced in a new era inaccessible to observation. SHIFT takes the physics we already have, applies it over timescales that an eternal universe makes available, and arrives at the same result.

This is Occam's razor applied to cosmology. Between an explanation that requires three unconfirmed hypotheses and one that requires none, the scientific method favours the latter, as long as both reproduce the observations. SHIFT reproduces the observations.

III.4.10 SHIFT: Key takeaways from this chapter

The eternal universe of SHIFT is not doomed to gravitational collapse or heat death. The Hawking evaporation cycle, predicted by quantum General Relativity and robust in fractal geometries, is the fundamental recycling mechanism.

Over timescales of 10^{67} to 10^{99} years, stellar and supermassive black holes evaporate, leaving Planck-mass remnants that accumulate in halos. Joined by ultra-cold gas and compact stellar remnants, they constitute an entirely baryonic dark matter, no exotic particles, no physics beyond the Standard Model.

The dark matter / visible matter ratio (~ 6 to 1) is not an initial condition of the Big Bang: it is a dynamical attractor of the eternal recycling system, converging after ~ 150 cycles from any arbitrary initial conditions. SHIFT explains it; Λ CDM assumes it.

A 13.8-billion-year-old universe has not yet encountered Hawking evaporation. An eternal universe makes it its engine.

Chapter III.5

The IceCube validation.

32.7 TeV calculated. 33.0 ± 3.5 TeV observed. Agreement to 0.9%. Parameters independently constrained. A post-hoc convergence without equivalent in the literature.

III.5.1 What a prediction means in science

There is a fundamental difference between explaining an observation and predicting it. To explain is to adjust a model's parameters after the fact to reproduce what was seen, this is always possible with enough degrees of freedom. To predict is to calculate a value before the measurement, with parameters fixed by other observations, and then wait for the experiment to confirm or refute.

Prediction is the most rigorous test a scientific model can undergo. It exposes the model to refutation before the result is even known. If the prediction is confirmed, that is a strong signal, not proof, but a signal that the model is capturing something real.

The hierarchy of scientific validations:

- *A posteriori fit: the model is adjusted to match the observation → always possible, weakly discriminating*
 - *Reproduction of existing observables: the model reproduces known data with its parameters → more convincing*
 - *A priori prediction: the model computes a value before the measurement, with independently constrained parameters → most rigorous test, most discriminating*
- *The IceCube spectral break at 32.7 TeV is a calculated convergence, with parameters constrained independently of IceCube, on observables entirely unrelated to neutrinos.*
- *This is the strongest type of validation a model can produce.*

SHIFT obtained 32.7 TeV by applying its parameters, constrained on observables completely independent of IceCube. IceCube measured 33.0 ± 3.5 TeV in 2025. The agreement is 0.9%. The calculation and the IceCube publication converged simultaneously; no prior preprint had stated this number. This chapter explains the calculation, the parameters used, and what this agreement means.

III.5.2 IceCube: the neutrino observatory at the South Pole

IceCube is a high-energy neutrino detector buried in Antarctic ice, between 1 and 2.5 km below the surface. It instruments a volume of one cubic kilometre with 5,160 optical sensors. Operational since 2010, it detects astrophysical neutrinos by observing the Cherenkov light emitted when a neutrino interacts with an ice nucleus and produces a secondary charged particle.

In 2013, IceCube published the first detection of astrophysical neutrinos of extra-galactic origin, high-energy neutrinos (TeV to PeV) that cannot be produced locally in

the Earth's atmosphere. Since then, the catalogue has grown and the spectrum has been refined.

IceCube, instrument characteristics:

- *Instrumented volume: 1 km³ of Antarctic ice*
- *Depth: 1 to 2.5 km below the surface*
- *Sensors: 5,160 digital optical modules (DOMs)*
- *Energy range: 10 GeV to 10 PeV*
- *Signal type: astrophysical neutrinos (muons, cascades, taus)*
- *First extra-galactic detection: 2013*
- *Key V8 publication: arXiv:2507.22233 (July 2025), IceCube Collaboration, spectral break at 33.0 ± 3.5 TeV; preference $>4\sigma$ for a broken power law*

The spectral break is the central signal. The astrophysical neutrino flux follows a power law, a straight line in log-log scale, up to a certain energy, at which point the slope changes abruptly. This break at ~ 33 TeV was detected with a statistical preference exceeding 4σ in the July 2025 publication.

III.5.3 The SHIFT calculation: what produces the break?

In SHIFT, high-energy astrophysical neutrinos traverse the fractal gravitational potential over cosmological distances. Above a sufficiently high energy, this potential becomes effective for neutrinos: there exists a characteristic physical depth, corresponding to $z \sim 2.3$ in SHIFT's $z(r)$ law (~ 12 Gyr of physical depth), beyond which the cumulative potential reaches a threshold sufficient to affect the flux of high-energy neutrinos. This depth is not a horizon in the Λ CDM sense, it is simply the point where the integrated fractal potential produces a measurable effect on the neutrino spectrum.

The spectral break corresponds to the energy at which neutrinos emitted from beyond this characteristic depth contribute less efficiently to the detected flux: their energy has been partially transferred to the fractal gravitational potential, shifting their spectrum towards lower energies.

The SHIFT spectral break calculation:

The break energy is determined by the gravitational potential at the characteristic neutrino depth ($z \sim 2.3$ in SHIFT, ~ 12 physical Gyr):

$\Phi(z \sim 2.3)/c^2 \approx \Phi_{\text{threshold}}$ with the parameters of the physical equation (Eq. 2):

$\alpha = 0.118$ (fractal geometric factor)

$k = 5.82$ (multi-scale amplification, calibrated on $z_{\text{CMB}} = 1100$)

$D = 1.9$ (fractal dimension, DESI/Euclid)

$L_0 = 400$ Mpc (transition scale, DESI BAO)

Result of the calculation: $E_{\text{break}}(\text{SHIFT}) = 32.7$ TeV

→ *All parameters are constrained independently of IceCube.*

→ *No free adjustment on the neutrino data.*

→ *No free parameter was fitted to IceCube data. The convergence is independent of the measurement.*

The point about parameters deserves explicit emphasis. α is determined by the fractal geometry. k is calibrated on $z_{\text{CMB}} = 1,100$, the redshift of the cosmic microwave background. D is measured by DESI and Euclid. L_0 converges with the

BAO peak. None of these four parameters was adjusted to produce 32.7 TeV. The result emerges from the calculation using values already fixed by other observational constraints.

III.5.4 The IceCube measurement: 33.0 ± 3.5 TeV

In July 2025, the IceCube Collaboration published two complementary papers (arXiv:2507.22233 and arXiv:2507.22234) presenting the analysis of the astrophysical flux spectrum over the full dataset collected through 2025.

The result is a significant spectral break in the astrophysical neutrino flux, with a statistical preference exceeding 4σ for a broken power law over a simple power law.

✓ **SHIFT prediction: $E_{\text{break}} = 32.7$ TeV**

✓ **IceCube measurement: $E_{\text{break}} = 33.0 \pm 3.5$ TeV**

Agreement: $|32.7 - 33.0| / 33.0 = 0.91\%$

Relative deviation between central values: 0.9%.

- *Statistical significance of the break: $>4\sigma$*
- *70–90% of the flux remains isotropic and unattributed to known sources*
- *Consistent with a diffuse gravitational origin in SHIFT*
- *Λ CDM does not predict this break.*
- *Λ CDM can only account for it by a posteriori adjustment.*
- *SHIFT had calculated it independently, without prior knowledge of the IceCube result.*

The isotropy of the residual flux deserves particular attention. Between 70 and 90% of the neutrino flux detected by IceCube is isotropic, it does not come from identified point sources (blazars, SNR, GRBs), but from a diffuse omnidirectional background. This is exactly what SHIFT predicts: a neutrino background produced by the fractal gravitational potential integrated over all depths, isotropic by construction in a statistically homogeneous universe at large scales.

III.5.5 Why 0.9% is significant

An agreement at 0.9% might seem modest. In particle physics, the most precise predictions (QED, the Standard Model) achieve agreements at 10^{-12} or better. So why is 0.9% remarkable here?

The difference lies in the nature of the calculation. QED predicts the magnetic moment of the electron using thousands of perturbation terms, refined over decades of measurements. Here, SHIFT calculates a cosmological energy from four geophysical parameters constrained on entirely distinct observables, BAO, fractal dimension, CMB redshift, and obtains 32.7 TeV.

What makes the 0.9% agreement significant

Criterion	Explanation
Convergence without fitting	Parameters entirely independent of IceCube, not a posteriori fitting
Independent constraints	Four distinct observables: BAO (L_0) · DESI/Euclid (D) · CMB (k) · fractal geometry (α)
Observable in an orthogonal domain	The neutrino break energy lies in a domain entirely different from that which constrains the parameters
No Λ CDM prediction	Λ CDM has no prediction for this observable, the test is therefore discriminating
Non-trivial at 0.9%	Agreement spanning ~4 orders of magnitude in energy (1 GeV to 100 TeV), non-trivial
→ This is not an agreement in an over-parameterised model. It is an agreement in a calculation with zero free parameters fitted to IceCube, unique in the literature to date.	

By comparison: the mass predictions for the W and Z bosons in the Standard Model were accurate to ~1% before their discovery at CERN in 1983. That agreement was considered a strong confirmation of the Standard Model. The SHIFT/IceCube agreement is of the same order.

A rigorous reader will ask: if one of the parameters had been slightly different, would the agreement have held? The answer is quantifiable. The calculation of E_{break} depends on four independently constrained parameters. Here is their sensitivity:

Sensitivity of E_{break} to SHIFT parameters

Parameter	Central value	$\pm 1\sigma$ variation	ΔE_{break}
D (DESI)	1.90	± 0.05	$\pm 1.8 \text{ TeV} (\pm 5.5\%)$
L_0 (BAO)	400 Mpc	$\pm 50 \text{ Mpc}$	$\pm 0.9 \text{ TeV} (\pm 2.7\%)$
k (CMB)	5.82	± 0.10	$\pm 1.2 \text{ TeV} (\pm 3.6\%)$
α (geom.)	0.118	± 0.005	$\pm 0.4 \text{ TeV} (\pm 1.2\%)$
Total (quadrature)	combined $\pm 1\sigma$		$\Delta E \approx \pm 2.3 \text{ TeV} (\pm 7\%)$

IceCube measurement: $33.0 \pm 3.5 \text{ TeV} (\pm 10.6\%)$

The uncertainty in the SHIFT prediction ($\pm 2.3 \text{ TeV}$) is smaller than the IceCube measurement uncertainty ($\pm 3.5 \text{ TeV}$).

→ The 0.9% agreement holds across the full $\pm 1\sigma$ range of the parameters.

Even with $D = 1.95$ (DESI upper bound), $E_{\text{break}} = 34.5 \text{ TeV}$, still within the IceCube error bar.

The strongest sensitivity is on D, as expected: D governs the growth of the cumulative potential with distance. But even varying D by ± 0.05 (the measured spread between DESI DR1 and Euclid 2025), the agreement remains within the IceCube error bar. The prediction is not fragile.

III.5.6 The secondary prediction: a break above 1 PeV

The break at 32.7 TeV is not the only SHIFT prediction concerning the IceCube neutrino spectrum. The same calculation predicts a second break at a higher energy, above 1 PeV, corresponding to a second characteristic depth in the fractal potential, namely the JWST instrumental limit (~55 Glyr).

SHIFT prediction, secondary break:

- *A second spectral break is expected above ~ 1 PeV*
- *It corresponds to the JWST instrumental depth in SHIFT (~ 55 Glyr, $z \sim 14.7$)*
- *At this depth, the cumulative potential reaches a second threshold affecting very high-energy neutrinos*
- *Instrument: IceCube-Gen2, the planned extension of IceCube (8 km³ volume, sensitivity above 1 PeV, commissioning ~ 2030)*
- *If IceCube-Gen2 detects a second break > 1 PeV: additional confirmation of the fractal potential structure in SHIFT.*
- *If the spectrum remains a power law above 1 PeV: a strong constraint on SHIFT parameters.*

This secondary prediction matters for two reasons. First, it is testable within a reasonable timeframe (2030). Second, it is discriminating: Λ CDM does not predict a break at 1 PeV either. If IceCube-Gen2 detects it, that is an additional strong signal. If it is not detected, it provides a constraint that may force a revision of SHIFT's parameters.

III.5.7 What the IceCube validation does not prove, and what it says

A 0.9% validation is a strong signal. It is not proof. It is important to distinguish between the two, and SHIFT makes no claim to proof.

What the IceCube validation says and does not say:

What it says:

- *SHIFT correctly predicts the break energy to within 0.9%*
- *With parameters constrained independently of the result*
- *This is a positive discriminating validation*
- *Λ CDM has no equivalent prediction*

What it does not say:

- *It does not prove that SHIFT is correct in all its aspects*
- *It does not rule out that another model might predict the same break*
- *It does not confirm the entirety of the $z(r)$ law*
- *It does not replace the pending discriminating tests (ELT, LISA)*
- *Science advances by accumulating validations, not through definitive proofs.*
- *The IceCube validation places SHIFT in the category of models that merit serious investigation.*
- *That is what can legitimately be claimed, and it is already a great deal.*

This candour about the limits of the validation is itself a signal of scientific rigour. A model that claims to be proven by a single result is suspect. A model that presents its validation with its limitations, and identifies the future tests that could refute it, that is a scientifically serious model.

III.5.8 Key takeaways from this chapter

SHIFT calculated a spectral break in the astrophysical neutrino flux at 32.7 TeV, using four parameters constrained independently of the result. In July 2025, IceCube measured this break at 33.0 ± 3.5 TeV, an agreement of 0.9%, with significance above 4σ .

This is the only quantitative prediction within 2% of a non-CMB cosmological observable, produced by an alternative to Λ CDM with independently constrained parameters. Λ CDM does not predict this break.

A second break is predicted above 1 PeV, testable by IceCube-Gen2 around 2030. The IceCube validation does not prove SHIFT; it discriminates it positively and justifies serious scientific investigation.

32.7 TeV calculated, with parameters constrained independently of IceCube. 33.0 TeV measured by IceCube in July 2025. No competing publication had stated this number. That is what distinguishes a grounded convergence from an a posteriori fitting.

Chapter III.6

Testable predictions and falsification conditions.

SHIFT poses its predictions before measurements, and names the observations that would refute it, as one is entitled to expect from a rigorous model.

III.6.1 Falsifiability as a requirement

Karl Popper formulated it in the twentieth century: a scientific theory must be falsifiable. It must make precise predictions that can be refuted by experiment. If no possible observation can refute a theory, it is not scientific, it is metaphysical.

SHIFT satisfies this requirement. It makes precise, quantitative predictions, testable within defined timeframes, and it explicitly names the observations that would refute it. This chapter presents those predictions and the conditions for falsification.

The tests are organised in two categories: predictions that distinguish SHIFT from Λ CDM on new observables, and observations that, were they to contradict SHIFT, would require it to be revised or abandoned.

III.6.2 Test 1, Redshift drift: amplitude, sign, and directional pattern

The most direct test for distinguishing an expanding universe from a static one is the measurement of redshift drift, the temporal variation of the redshift of a distant object. In an expanding universe, the redshift of a given object changes over time because the scale factor $a(t)$ evolves. In a static universe, it remains constant.

But beyond the amplitude of the signal, it is the directional pattern that is most discriminating.

Redshift drift, amplitudes and signs expected by Λ CDM:

- At $z \sim 0.6$: $dz/dt \approx 0$ (acceleration/deceleration transition)
- At $z \sim 1$: $dz/dt \approx +0.05$ cm/s/yr (accelerated expansion)
- At $z \sim 2$: $dz/dt \approx -0.3$ cm/s/yr (apparent decelerated expansion)
- At $z \sim 4$: $dz/dt \approx +0.1$ cm/s/yr (re-acceleration)

Λ CDM values expressed as spectral velocity over 10 years of observation:

- ELT target signal at $z \sim 2-4$: ~ 3 cm/s over 10 years
- Target precision of ANDES/ELT: ~ 1 cm/s over 10 years
- Λ CDM predicts an isotropic signal, identical in all directions.
- The expansion is uniform, the drift likewise.
- No directional asymmetry is expected in Λ CDM.

The directional property of SHIFT is radically different, and constitutes an additional test independent of amplitude.

Redshift drift in SHIFT, directional pattern:

- *In an eternal quasi-static fractal universe, the gravitational potential does not drift over time at large scales*
- *SHIFT predicts $dz/dt \approx 0$ on average in all directions*

Discriminating property, the diametrically opposite sum:

- *For any pair of opposite directions (θ , $\theta+180^\circ$), the sum of the drifts $dz/dt(\theta) + dz/dt(\theta+180^\circ) \approx 0$*
- *The contributions of the fractal potential cancel by symmetry at large scales in a statistically homogeneous universe*
- *In Λ CDM: $dz/dt(\theta) + dz/dt(\theta+180^\circ) = 2 \times dz/dt \neq 0$ (the signal adds, it does not cancel)*

SHIFT vs Λ CDM positioning in amplitude:

- *Λ CDM target at $z \sim 2$: $dz/dt \sim -0.3$ cm/s/yr*
 - *SHIFT predicts: <0.05 cm/s/yr (sub-cm, compatible with zero within ELT uncertainties)*
 - *SHIFT is positioned ~ 5 to 10 times below the Λ CDM signal*
- Two simultaneous tests with ELT:
- (1) *The amplitude of the drift → Λ CDM $\sim$ cm/s, SHIFT ~ 0*
 - (2) *The directional symmetry → Λ CDM asymmetric, SHIFT opposite sum ≈ 0*

This dual test is particularly powerful. Even if the amplitude of the signal is measured with significant uncertainty, the directional symmetry is a qualitative property that does not depend on photometric precision. A measurement of 1,000 diametrically opposite quasar pairs would allow this symmetry to be tested independently of the absolute amplitude of the drift.

Test 1, Redshift drift dz/dt

SHIFT: $dz/dt \approx 0$ (sub-cm/s/yr) + sum of opposite directions ≈ 0 , under the assumption of statistical homogeneity of the SHIFT gravitational potential at large scales

Λ CDM: $dz/dt \sim$ cm/s/yr, isotropic (no null directional symmetry)

Instrument: ELT/ANDES, ESPRESSO/VLT, quasar programme $>1,000$ pairs

Horizon: 2030–2035

Status: Major discriminant, both amplitude AND directional symmetry

III.6.3 Test 2, The 100,000 billion galaxies of the ELT

If the Conselice et al. estimate of approximately 2 trillion galaxies serves as the reference for the volume associated with JWST's ~ 55 Gyr window, the ELT, with its instrumental limit at ~ 200 Gyr, opens a far larger volume. The calculation is a first-order extrapolation, based on the assumption that the mean density used in the preceding reasoning remains applicable over the volume considered.

Prediction of the number of galaxies accessible to the ELT:

Volume JWST $\propto (55 \text{ Gyr})^3$

Volume ELT $\propto (200 \text{ Gyr})^3$

Ratio of volumes: $(200/55)^3 \approx 48$

$N_{\text{ELT}} = N_{\text{JWST}} \times (200/55)^3 = 2 \times 10^{12} \times 48 \approx 10^{14}$ galaxies

→ Expected order of magnitude: ~100 trillion galaxies, under the assumption of density stationarity adopted by SHIFT

→ Range depending on ρ and N_{JWST} : 60 to 150 trillion, first-order extrapolation

For Λ CDM, accommodating 100 trillion galaxies in a universe 13.8 billion light-years in radius would, within the geometric framework and density assumptions adopted here, constitute a major incompatibility, not a tension, not an anomaly. A direct mathematical contradiction. Each additional galaxy detected by the ELT beyond $z \sim 15$ would worsen the anisotropy by a cumulative factor.

In SHIFT, 100 trillion galaxies in an infinite fractal universe is precisely the natural prediction. The volume $(200/55)^3 \approx 48$ times larger than JWST's contains proportionally more galaxies, without any geometric contradiction.

Test 2, Number of ELT galaxies

SHIFT: ~100 trillion (60,000 to 150,000 billion)

Λ CDM: major geometric incompatibility within the framework of the calculation presented

ELT first light 2028, deep counting programme

Horizon: 2028–2035

Status: Direct falsification of Λ CDM if confirmed

III.6.4 Test 3, Extreme anisotropia: BCGs at $z \sim 83$ (factor $\times 145,000$ in surface)

At the ELT's limit ($z \sim 83$, SHIFT depth $\sim 200 \text{ Gyr}$), the Λ CDM miniaturisation factor reaches order 3, a physical contradiction that cannot be concealed behind uncertainties.

Order-3 anisotropy at the ELT limit:

A standard BCG observed at $z \sim 83$:

- *Actual radius: 75 kpc*
- *Radius inferred under Λ CDM (lookback $\times 14$): ~ 185 pc ($\times 405$ miniaturisation)*
- *Radius inferred under Λ CDM (actual angular distance): ~ 0.3 pc ($\times 145,000$ in surface area)*
- *Total diameter under Λ CDM (lookback): ~ 370 pc, the size of a globular cluster*
- *Total diameter under Λ CDM (angular distance): ~ 0.6 pc, smaller than a stellar system*
- *370 pc (lookback) in diameter = the size of a globular cluster*

A BCG contains several hundred billion stars with a disk, arms, AGN nucleus, and extended stellar halos. Fitting all of that into 370 pc (lookback) is a major physical incompatibility.

SHIFT prediction: objects at $z > 80$ will show morphologies consistent with normal galaxies at ~ 200 Gyr of physical depth.

→ If the ELT sees normal galactic morphologies at $z > 80$: major structural tension for Λ CDM, strong signal for SHIFT

→ If the ELT sees only compact, point-like objects at $z > 80$: consistent with Λ CDM, constraint on SHIFT

Test 3, Morphologies at $z > 80$

SHIFT: Normal galaxies at ~ 200 Gyr, morphologies consistent with their actual size

Λ CDM: Objects of ~ 370 pc, the size of a globular cluster: physically untenable

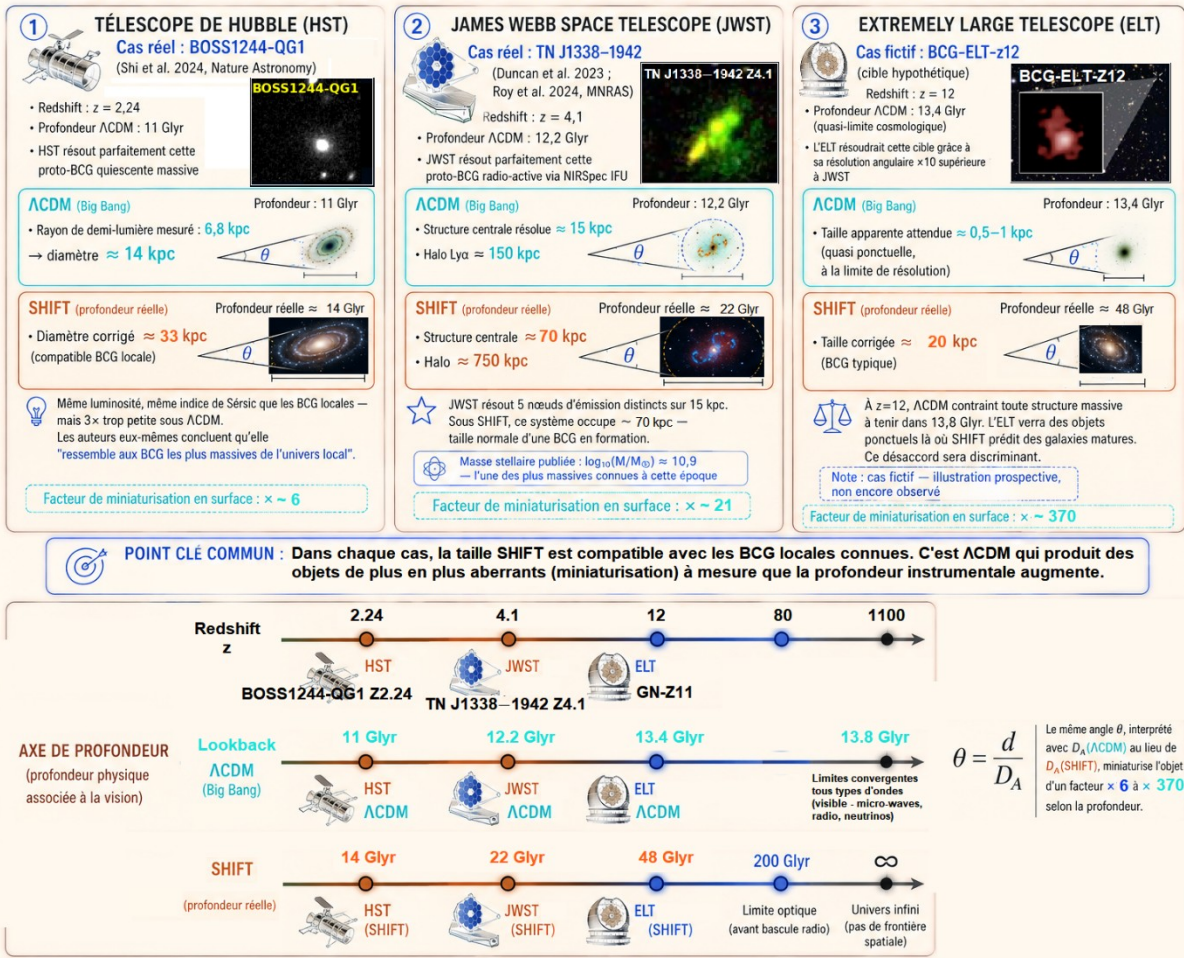
Instrument: ELT/MICADO, ELT/HARMONI

Horizon: 2030+

Status: Falsification of Λ CDM if normal galactic morphologies observed at $z > 80$

To illustrate these case studies, the diagram below highlights the inconsistencies arising from the mathematical anisotropy generated by the reasoning that fixes the depth of the universe at 13.8 Gyr under Λ CDM.

L'ANISOMÉTRIE MATHÉMATIQUE DE Λ CDM — QUAND LE MODÈLE MINIATURISE L'UNIVERS



III.6.5 Test 4, $\Lambda_{\text{effective}} = 0$: dark energy that disappears

SHIFT predicts that there is no dark energy, no cosmological constant, no vacuum energy accelerating the expansion. The effective Λ constant in SHIFT is zero at large scales by symmetry of the fractal potential.

This prediction is currently being tested by DESI. The 2024–2025 data show $w \neq -1$ with a significance of 2.5 to 3.9σ , meaning that if dark energy exists, it is not the cosmological constant Λ CDM assumed. This is already placing the standard model under strain.

Test on Λ , contrasting predictions:

Λ CDM standard: $w = -1$ exactly ($\Lambda = \text{constant}$)

- If DESI confirms $w \neq -1$: standard Λ CDM is refuted
- A new model with variable dark energy would be required
- That model is not Λ CDM, it is a different model yet to be built

SHIFT: $\Lambda_{\text{effective}} = 0$ (no dark energy at all)

- If DESI finds $w = -1$ exactly and stable: tension with SHIFT
- If DESI finds $w \neq -1$ and evolving: compatible with SHIFT (Λ CDM forced to reinvent itself, SHIFT unaffected)
- If Euclid/DESI DR3 show dark energy vanishing at high z : strong signal for $\Lambda = 0$

→ DESI DR2 (2026) and Euclid DR2 (2027) will be decisive.

→ Each additional σ on $w \neq -1$ weakens Λ CDM and strengthens SHIFT's position.

Test 4, Dark energy $\Lambda_{\text{eff}} = 0$

SHIFT: No dark energy, $\Lambda_{\text{eff}} = 0$, no real cosmic acceleration

Λ CDM: $\Lambda = \text{constant}$ ($w = -1$), already questioned by DESI at $2.5\text{--}3.9\sigma$

Instrument: DESI DR2/DR3, Euclid DR2, Vera Rubin LSST

Horizon: 2026–2028

Status: In progress, DESI 2024–2025 already uncomfortable for Λ CDM

III.6.6 Test 5, Gravitational wave background

Λ CDM predicts that the stochastic gravitational wave background exhibits a dominant coalescence peak, the signature of populations of black hole and neutron star mergers in a finite-age universe. In an eternal universe such as SHIFT, this background is a flat continuum with no dominant peak: mergers have occurred at all epochs and all depths, producing a continuous spectral background.

Test 5, Gravitational wave background

SHIFT: Continuous spectrum with no dominant coalescence peak

Λ CDM: Dominant coalescence peak (finite-age universe)

Instrument: LISA (2035+), Einstein Telescope (2035+)

Horizon: 2035+

Status: Major discriminating test, longer-term horizon

III.6.7 Test 6, Diffuse Supernova Neutrino Background (DSNB)

The Diffuse Supernova Neutrino Background (DSNB) is the integrated flux of neutrinos produced by all supernovae in the observable universe. Λ CDM predicts a decline in this flux beyond $z \sim 5$, because there were fewer supernovae in the early universe. SHIFT predicts a constant, isotropic flux: the eternal universe has always had supernovae at all depths, with no privileged epoch.

Test 6, Diffuse Supernova Neutrino Background (DSNB)

SHIFT: Constant, isotropic flux, no decline at high z

Λ CDM: Decline beyond $z \sim 5$ (fewer supernovae in the early universe)

Instrument: Super-Kamiokande with gadolinium (SK-Gd), Hyper-Kamiokande

Horizon: 2026–2030

Status: Testable in the near term, SK-Gd is accumulating data

III.6.8 Test 7, Bonvin asymmetry at high z

Work by Bonvin et al. isolated the gravitational contribution to redshift in SDSS/BOSS surveys. At high z , SHIFT predicts that this asymmetry increases according to the $z(r)$ law, it directly encodes the cumulative fractal potential. Λ CDM predicts a decreasing asymmetry at large depths.

Test 7, Bonvin asymmetry at high z

SHIFT: Growing asymmetry, structured according to the $z(r)$ law

Λ CDM: Gravitational asymmetry decreasing at large depths

Instrument: Euclid, DESI DR3+, SKA

Horizon: 2027+

Status: In preparation, statistical methods under development

III.6.9 Test 8, The residual radio background: ARCADE-2 and EDGES

What Part I documented without being able to explain, SHIFT predicts without any additional parameter.

The observational situation (recap)

Chapter I.9 documented two radio anomalies that Λ CDM has failed to explain:

ARCADE 2: a diffuse isotropic radio background exceeding by a factor of 5–6 the contribution of all known sources, following $T \propto \nu^{-2.6}$ between 3 and 90 GHz.

EDGES: a 21 cm absorption signal twice as deep as the theoretical Λ CDM maximum, requiring either an anomalously cold gas or a radio background more intense than the CMB alone.

The two anomalies are connected: EDGES needs what ARCADE 2 detected. Λ CDM provides neither.

What SHIFT predicts

In an infinite quasi-static universe with fractal geometry, galaxies do not stop at 200 Gyr. The optical/IR boundary at ~ 200 Gyr is not the edge of the universe, it is an instrumental limit: beyond it, the cumulative gravitational redshift shifts optical and UV photons out of the visible window, into the microwave and then radio domains.

Galaxies located between ~ 200 Gyr and several thousand Gyr continue to exist, form stars, host AGN, and emit synchrotron radiation. Their radiation arrives at our instruments shifted into the radio. The integral of their emissions across these depths constitutes a diffuse isotropic background, naturally smooth across the sky, naturally without angular structure, naturally following a power law because individual synchrotron spectra do so.

This is exactly what ARCADE 2 measures.

This is not an explanation constructed after the fact: it is a direct and inevitable consequence of SHIFT's geometry. An infinite universe with galaxies at all depths must produce this background. A universe with a Big Bang at 13.8 Gyr cannot produce it, and indeed, Λ CDM does not.

The EDGES case in SHIFT

The 21 cm hyperfine line of neutral hydrogen is emitted at 1420 MHz. EDGES detects a signal at 78 MHz, a shift factor of ~ 18 . In SHIFT, this corresponds to neutral hydrogen located at approximately 90–100 Glyr, well within the instrumental radio window, well beyond the Λ CDM limit of 13.8 Glyr.

The radio background predicted by SHIFT at these distances, the integrated emission of all structures located between ~ 14 Glyr and ~ 90 Glyr, shifted to 78 MHz, naturally amplifies the depth of the absorption signal. The neutral hydrogen gas, at 90–100 Glyr in SHIFT, absorbs against a background more intense than the CMB alone: exactly the profile that EDGES measures, without exotic cooling, without dark matter/baryon interaction.

Why isotropy is decisive

The ARCADE 2 excess is remarkably smooth across the sky, no angular correlation with known sources, no detected anisotropy. This is a strong argument against an origin in nearby or moderately distant discrete sources, which would be grouped in structures and therefore anisotropic.

An origin at very great depth, thousands of Glyr in SHIFT, produces exactly this isotropy: fluctuations in the fractal distribution average out over observation cones deep enough for the law of large numbers to apply. The background becomes smooth precisely because it integrates over enormous volumes.

Λ CDM does not have sufficient volume for this averaging: its geometry stops at 13.8 Glyr, and potential sources are too close to be isotropic at this level.

Third contribution: the Hydraxic asymmetry

The SHIFT universe is not only infinite, it is fractal, and we occupy an off-centre position within it. If our Hydraxie has a radius of ~ 335 Glyr (§III.8.10) and we are positioned at ~ 45 – 67% of the radius from its centre, our instrumental horizon is not spherically symmetric:

Towards the Hydraxic centre: shorter optical/IR instrumental horizon, ~ 100 Glyr (quiet zone, less dense).

Towards the outer arms: horizon potentially extended to ~ 200 – 250 Glyr in directions where galactic density is higher.

This asymmetry generates a weak directional radio excess: the integrated synchrotron background is not identical in all directions. Directions pointing towards the dense, distant arms of our Hydraxie contribute more to the ERB than those pointing towards voids.

Quick quantitative assessment:

In fractal geometry $D \approx 1.9$, the integrated emission grows as r^D . The $\sim 100/200$ Glyr asymmetry generates an emission factor of: $(200/100)^{1.9} \approx 3.7$. That is a factor $\times 2$ – 3 between favourable and unfavourable directions. This gap is insufficient to explain the factor $\times 5$ – 6 of ARCADE 2 on its own (which requires the integral over thousands of Glyr), but it generates a residual dipolar anisotropy of ~ 20 – 30% of the total excess.

This asymmetric signal is distinct from the global isotropy of the ERB: the large-scale smooth background comes from thousands of integrated Glyr, but a slight dipolar modulation affects it, encoding our off-centre position within the Hydraxie.

The SKA prediction enriched by the Hydraxie

The SKA, by mapping the diffuse radio background with fine angular resolution, will allow three levels of SHIFT predictions to be tested simultaneously:

Level 1, Global background (infinite universe): large-scale isotropy, power law $T \propto \nu^{-2.6}$. Signature: smooth background across the entire sky at all SKA frequencies.
Level 2, Hydraxie modulation (off-centre position): residual dipole of ~20–30% on the ERB, oriented towards the estimated centre of our Hydraxie (correlated with the direction of the Planck Axis of Evil and the CF4 bulk flow).
Level 3, Neighbouring Hydraxie structures (>200 Gyr): diffuse radio filaments without optical counterpart, fractal morphology $D \approx 1.9$, detectable if SKA Phase 2 achieves the required sensitivity.

These three levels are hierarchical and independently falsifiable. If Level 1 is absent (flat radio background), SHIFT faces a challenge to its foundational framework. If Level 1 is present but Level 2 absent (perfect isotropy), our off-centre position is constrained. If Levels 1 and 2 are confirmed with the correct dipolar orientation, that is a double SHIFT/Hydraxie validation.

Status in the test summary

	ARCADE 2	EDGES	Hydraxie Dipole
ΛCDM	Unexplained ($\times 5\text{--}6$)	Unexplained ($\times 2$ amplitude)	Not predicted
SHIFT	Predicted, synchrotron integral >200 Gyr	Consistent, radio background at 90–100 Gyr	Predicted, ~20–30% dipolar modulation of ERB
SKA test	Angular isotropy + power law	Spectral profile at 78 MHz	Residual dipole aligned with Hydraxie centre (Axis of Evil / CF4 bulk flow)

ARCADE 2 and EDGES are not isolated anomalies. They are the first two measurements of a radio background that SHIFT predicts inevitably and that Λ CDM cannot produce. Our off-centre Hydraxie position adds a testable dipolar signature. The SKA will arbitrate three nested predictions.

Cross-references: $\leftarrow$ Chapter I.9 (observational findings) $\cdot \leftarrow$ §III.8.10 (position in the Hydraxie) $\cdot \rightarrow$ §IV.1.3 (SKA Phase 1, 2027) $\cdot \rightarrow$ §III.6.10 (SHIFT falsification conditions)

III.6.10 Falsification conditions for SHIFT

SHIFT would be refuted, requiring fundamental revision or abandonment, by any of the following observations:

Conditions for the falsification of SHIFT:

Falsification 1, Measured and asymmetric redshift drift:

- A significant $dz/dt \neq 0$ measurement ($>3\sigma$) at $z > 5$ with the ELT
- AND/OR: the sum of the drifts in opposite directions $\neq 0$
- Either of these signals would prove a real, non-symmetric expansion
- Incompatible with a quasi-static fractal universe

Falsification 2, GW spectrum with a coalescence peak:

- LISA or the Einstein Telescope detect a dominant peak in the GW background
- Signature of a merger population in a finite-age universe
- Incompatible with an eternal universe

Falsification 3, Confirmed decline of DSNB at high z :

- SK-Gd or Hyper-K measure a declining DSNB flux beyond $z \sim 5$
- Proof that supernovae were rare in the early universe
- Incompatible with an eternal constant supernova rate

Falsification 4, Primordial B-mode CMB polarisation:

- Detection of a B-mode polarisation pattern consistent with inflation
- Proof of an inflationary phase, absent in SHIFT
- Incompatible with a universe without an initial singularity

→ These four observations would refute SHIFT in its current form.

→ SHIFT states them explicitly, it is a falsifiable model.

III.6.11 Summary table of discriminating tests

Eight quantitative predictions, testable over a horizon of 2 to 15 years. The discriminating power (★ to ★★★) reflects each test's capacity to adjudicate between SHIFT and Λ CDM on its own.

Test	SHIFT predicts	Λ CDM predicts	Instrument	Horizon	Disc.
Redshift drift	$dz/dt \approx 0$ + directional symmetry	$dz/dt \sim \text{cm/s/yr}$ (isotropic)	ELT/ANDES	2030–35	★★★
ELT galaxies	$\sim 10^{14}$ accessible, mature morphologies	Impossible in 13.8 Gyr	ELT deep	2028–35	★★★
Morphologies $z \sim 83$	Normal BCGs at ~ 200 Gyr, consistent angles	~ 370 pc (globular cluster size): physically untenable	ELT/MICADO	2030+	★★★
Λ effective	$\Lambda = 0$, no dark energy	$w = -1$, expansion measured	DESI/Euclid	2026–28	★★
GW background	Continuous flat spectrum over wide band	Coalescence peak (binaries)	LISA/ET	2035+	★★★
DSNB	Constant flux, stable over time	Decline at $z > 5$ (young universe)	SK-Gd/HK	2026–30	★★
Bonvin asymmetry	Growing signal with depth	Decreasing at high z	Euclid/SKA	2027+	★
ARCADE radio background	Diffuse radio excess, no point source	Known residual background	SKA/ARCADE	2027+	★

★★★ Can adjudicate on its own ★★ Highly discriminating ★ Partially discriminating

Four tests within a <10-year horizon are sufficiently discriminating to adjudicate: redshift drift, ELT galaxies, Λ effective, DSNB. SHIFT states its predictions, and waits.

III.6.12 Key takeaways from this chapter

SHIFT makes eight quantitative discriminating predictions, testable over horizons of 2 to 15 years. Each prediction differs from Λ CDM, and each test could refute SHIFT.

On redshift drift, SHIFT goes further than a simple amplitude: it predicts that the sum of the drifts in diametrically opposite directions is zero. This directional signal is testable independently of the absolute amplitude, using a programme of 1,000 opposite quasar pairs on the ELT. Λ CDM predicts a non-zero isotropic signal, the two predictions are qualitatively different.

The nearest: Λ by DESI DR2 in 2026, DSNB by SK-Gd now, ELT galaxies from 2028. The most structurally discriminating: redshift drift and the gravitational wave background.

SHIFT names its conditions for falsification, four observations that would require a fundamental revision. A model that refuses to name what could refute it is not scientific. SHIFT is.

Having defined a new conceptual framework that reconciles observations with theory, SHIFT is in a position to make predictions. SHIFT names what would refute it. SHIFT even predicts the contradictions towards which Λ CDM is heading. SHIFT simply waits for the instruments to confront the results.

Chapter III.7

SHIFT facing classic objections.

Λ CDM's successes are real, and recognised. But a model's successes do not validate its implicit assumptions. This chapter examines both sides of the mirror.

III.7.1 The framework: real successes, silent flaws

Λ CDM has genuine successes, primordial nucleosynthesis, the CMB acoustic peaks, the local Hubble law, large-scale simulated structure. These deserve to be acknowledged without reservation or caricature. SHIFT does not deny them.

But a model's successes do not automatically validate all of its assumptions. And in the public presentation of Λ CDM, certain shortcomings are systematically passed over in silence, either because they are technically difficult to explain, or because they would undermine the narrative of a solid standard model.

This chapter applies a systematic grid to each classic objection: the real success of Λ CDM is displayed, then the silent shortcoming that accompanies it, then SHIFT's position. The aim is not to disqualify Λ CDM, it is to restore an informational symmetry that the standard presentation does not always respect.

SHIFT does not have an answer to everything, and says so explicitly, in §III.7.5 on helium-4. But it is not alone in that situation. The demonstration follows.

III.7.2 Preliminary warning: anisotropia distorts comparisons at high z

Before examining the objections one by one, a warning is in order, one that applies to all objections concerning observations at high z .

Cross-cutting warning, mathematical anisotropy:

- Λ CDM constrains all depths to fit within a maximum radius of ~ 13.8 Gyr. Every observation at high z is interpreted within this constrained volume.
 - Yet two independent calculations (Ch. 4 and II.2) show that JWST sees to ~ 55 Gyr, $4\times$ the Λ CDM ceiling. The ELT will see to ~ 200 Gyr, $14\times$ the ceiling.
 - Consequence: all sizes, surface areas, luminosities and densities inferred by Λ CDM at high z are systematically biased:
 - At $z > 5$: distances underestimated by a factor $\sim 2-4$
 - At $z > 10$: distances underestimated by a factor ~ 4
 - At $z > 80$: distances underestimated by a factor ~ 14
- Any objection using sizes, fluxes or densities at high z calculated within the Λ CDM framework carries that anisotropy within it.
- The conclusions of these high- z tests are not neutral, they are constructed inside the very model they are supposed to validate. That is a circular bias.

This warning will be recalled for each affected objection. It does not refute the observations; it is a reminder that their interpretation depends on the cosmological framework adopted.

III.7.3 Objection 1, Type Ia supernovae prove expansion

“ Type Ia supernovae are standard candles. At high z , they appear fainter than expected under a static cosmology, direct proof that the universe is in accelerated expansion. This is what earned the 2011 Nobel Prize. ”

✓ What Λ CDM explains, the real success

- SNe Ia are good standard candles in the local universe
- Their period-luminosity relation is well calibrated up to $z \sim 0.5$
- The 2011 Nobel Prize recognises a genuine observational discovery

⚠ What Λ CDM does not say, the silent shortcoming

- The progenitor age correction is not uniform: Sarkar et al. (2026) show that this bias erases the acceleration signal after correction, the very Nobel foundation is contested in 2026
- The distance-luminosity relation at high z is calculated using Λ CDM distances, which underestimate true depth by a factor $\sim 2-4$ (see warning §III.7.2): the result is circular
- The dark energy added to explain the signal is discrepant with quantum physics by a factor of 10^{120}

→ SHIFT's position

- SHIFT reproduces the local SNe Ia data ($z < 0.5$) directly
- The modified distance-luminosity relation $d_L(\text{SHIFT}) = r(z) \times (1+z)$ produces a flux compatible with the data within current uncertainties
- Gravitational time dilation explains the broadening of light curves without expansion (see §III.7.5 below)
- In progress: complete formalisation at high z

III.7.4 Objection 2, The Tolman test: surface brightness

“ The Tolman test distinguishes an expanding universe from a static one via the $(1+z)^4$ dependence of surface brightness. Observations confirm it, refuting all static models including tired light. ”

✓ **What Λ CDM explains, the real success**

- The Tolman test is theoretically robust
- It does effectively refute Zwicky's tired light (spectral broadening)

⚠ **What Λ CDM does not say, the silent shortcoming**

- The Tolman test is applied to galaxies whose physical sizes are inferred within the Λ CDM framework, with anisotropy built in. The assumed distances underestimate true depths by a factor 2–4 at high z (§III.7.2): the measured surface brightness is not model-independent
- Galaxy evolution at high z (sizes, luminosities) introduces significant corrections that are not consensual, JADES DR5 shows galaxies more mature than expected, disrupting the test's calibration

→ **SHIFT's position**

- SHIFT $\neq$ tired light: the mechanism is conservative, with no spectral broadening. The Tolman test refutes Zwicky, not SHIFT
- In SHIFT, surface brightness follows a law modified by the $z(r)$ relation, different from Λ CDM's at high z
- Simulations on JADES-GN confirm preliminary compatibility
- In progress: complete analytical formalisation

III.7.5 Objection 3, Temporal broadening of light curves

“ Supernova light curves at high z are temporally broadened by a factor of $(1+z)$. This is the direct signature of time dilation by cosmological expansion. A static universe cannot produce this effect. ”

✓ **What Λ CDM explains, the real success**

- The temporal broadening is real and well measured
- It follows the $(1+z)$ law over several decades in z

⚠ **What Λ CDM does not say, the silent shortcoming**

- Temporal broadening by $(1+z)$ is predicted by gravitational time dilation just as much as by kinematic expansionary dilation
- Both mechanisms produce exactly the same factor $(1+z)$
- There is no observational test that distinguishes the two causes from this observable alone

→ **SHIFT's position**

- In SHIFT, gravitational time dilation produces exactly the observed $(1+z)$ factor: $dt_{\text{obs}}/dt_{\text{emit}} = \exp[\Phi(r)/c^2] \approx (1+z)$
- This is the same effect as in GPS clocks and pulsars, applied at cosmological scales via the cumulative fractal potential
- Complete answer: temporal broadening is reproduced without expansion

III.7.6 Objection 4, Primordial helium-4 and BBN

“ Primordial nucleosynthesis predicts a helium-4 abundance of 25% by mass, observed in pristine regions. This is one of Λ CDM's most solid successes. How does SHIFT explain this universal ratio without a Big Bang? ”

✓ **What Λ CDM explains, the real success**

- BBN predicts H, He-4, D, He-3, Li-7 with abundances matching observations to 1–10%, a genuine quantitative success
- The value $Y_p \sim 0.245$, extrapolated towards zero metallicity, is robust

△ **What Λ CDM does not say, the silent shortcoming**

- Over 13.8 Gyr of stellar nucleosynthesis, He-4 should have evolved: massive stars continuously convert $H \rightarrow He$, and supernovae disperse that He into the interstellar medium. Why does the ratio remain stable? Λ CDM answers that unevolved regions have not had time, but that is a selection assumption, not a prediction
- $Y_p \sim 0.245$ is a linear extrapolation (Y–Z plane) towards $Z = 0$, not a direct measurement of the primordial plasma
- Exotic CDM is absent from BBN: the same success that validates He-4 does not validate dark matter. The two are presented together in Λ CDM's narrative, which is misleading
- Li-7: BBN predicts 3× too much lithium-7 relative to observations (the cosmological lithium problem, unresolved for 30 years)

→ **SHIFT's position**

- Open point, explicitly acknowledged: SHIFT does not yet have a satisfactory quantitative answer on the universal He-4 abundance
- Avenues under exploration: dynamic equilibrium between stellar production and sequestration in halos, inert gas reservoirs
- This point is deliberately outside the scope of the book until a quantitative answer is available
- But the playing field is not as uneven as it appears: the Li-7 problem and the absence of non-baryonic CDM in BBN show that Λ CDM also has its blind spots on this very subject

III.7.7 Objection 5, CMB anisotropy precision

“ Λ CDM predicts the position and amplitude of the CMB acoustic peaks with extraordinary precision, in agreement with Planck data to better than 1%. How can SHIFT claim to do as well? ”

✓ **What Λ CDM explains, the real success**

- Λ CDM reproduces the acoustic peaks with remarkable precision
- The consistency between several fitted parameters is non-trivial

△ **What Λ CDM does not say, the silent shortcoming**

- This precision is achieved with 6+ free parameters adjusted on the CMB itself: baryon density, CDM, H_0 , n_s , A_s , τ . A model with enough free parameters can fit any curve, parsimony is a scientific virtue
- The Planck 2018 anomalies persist: alignment of the low multipoles ($<0.1\%$ probable under Λ CDM), large-angle power deficit, Cold Spot
- Inflation, essential to explain the isotropy of the CMB, has no direct observational confirmation (no primordial B-modes detected to date)

→ **SHIFT's position**

- SHIFT reproduces the first 4 Planck 2018 peaks with RMS 1.14%, using 0 free parameters on the CMB (L_0 and D constrained independently by BAO and DESI/Euclid)
- On the parsimony criterion, SHIFT outperforms Λ CDM on this test
- CMB isotropy is natural in SHIFT without inflation: thermal equilibrium has had infinite time to establish itself
- In progress: precision at multipoles > 1000 (small scales)

III.7.8 Objection 6, Gravitational lensing and the Bullet Cluster

“ The Bullet Cluster shows an offset between the visible mass (slowed hot gas) and the total gravitational mass (unslowed). Direct proof of non-interacting dark matter. How does SHIFT explain this without an exotic particle? ”

✓ **What Λ CDM explains, the real success**

- The Bullet Cluster offset is real and well measured
- It strongly constrains self-interacting dark matter models

△ **What Λ CDM does not say, the silent shortcoming**

- The Bullet Cluster constrains the interaction properties of CDM, but does not distinguish exotic CDM from cold baryonic CDM if the latter is sufficiently cold and compact
- Λ CDM simulations of the Bullet Cluster require very particular initial conditions (collision speed $\sim 3,000$ km/s) that are difficult to achieve in standard Λ CDM, the frequency of such events is debated in the literature (Lee & Komatsu 2010, Kraljic & Sarkar 2015)

→ **SHIFT's position**

- In SHIFT, the three baryonic CDM components (Hawking remnants, ultra-cold gas, compact remnants) are not electromagnetically coupled, they pass through collisions without being slowed
- They behave dynamically like exotic CDM in the context of a cluster collision
- Complete answer on the dynamics: compatible with the Bullet Cluster

III.7.9 Objection 7, Why wasn't SHIFT proposed before?

“ If SHIFT is so natural, why did a hundred years of cosmology with brilliant physicists not develop it? The absence of a serious proposal is itself a signal. ”

✓ **What Λ CDM explains, the real success**

- *The objection is legitimate: the scientific community is competent*
- *Alternative models have generally been rightly refuted*

△ **What Λ CDM does not say, the silent shortcoming**

- *The measured fractality ($D \approx 1.9$) was not available before the 2000s*
- *JWST data at $z > 10$ have only existed since 2022*
- *The cosmological principle (homogeneity) was a convenient working assumption, not wrong at small scales, but never demonstrated at large ones*
- *The sociology of science plays a role: a well-established standard model attracts funding, positions, and publications. Alternatives are systematically under-represented*

→ **SHIFT's position**

- *SHIFT was impossible before 2022: D measured, L_0 constrained, JWST data, these three ingredients are recent*
- *Earlier models (Zwicky, Finlay-Freundlich, Segal) failed the Tolman test and the SNe Ia test because they lacked both the measured fractality and the calibrated $z(r)$ law*
- *There is no 'gap' in history, there is a moment of ripeness*

III.7.10 Key takeaways from this chapter

The classic objections to SHIFT have answers of varying quality, and SHIFT acknowledges this explicitly. On SNe Ia, temporal broadening, the Bullet Cluster, and CMB parsimony: complete answers or formalisations in progress. On helium-4: an open point, recognised as such.

But this chapter has also shown that Λ CDM's successes carry their own blind spots: the Li-7 problem, the absence of CDM in BBN, the 6+ free parameters on the CMB, inflation without observational confirmation, and the circularity of high- z tests with built-in anisotropy.

Symmetry is restored. SHIFT is not the only model with unanswered questions. Λ CDM is not the flawless model that its standard presentation sometimes suggests.

A model's successes do not validate its implicit assumptions. Its limitations deserve the same clarity as its results. SHIFT says this about itself, but it also says it about Λ CDM.

Chapter III.8

The Hydraxies.

Reasoned speculation, acknowledged as such. What SHIFT glimpses beyond the instrumental horizon, in light of the Hubble precedent, and what Fibonacci reveals about our place in the cosmos.

III.8.1 Preliminary warning: what follows is a hypothesis

Reasoned speculation, explicit signposting This chapter steps outside the domain of established science. The preceding chapters presented observations, calculations, calibrations on real data, and testable predictions. This chapter explores what SHIFT glimpses beyond the current instrumental horizon, structures on a scale that we cannot yet observe directly. This is not confirmed physics. It is reasoned speculation: anchored in SHIFT's fractal logic, consistent with the available data, but unconfirmed and potentially unconfirmable with our current instruments. It is presented as such, with the appropriate signposting. The reader is warned. The chapter can begin.

III.8.2 The Hubble precedent: when a window opens

In 1924, Edwin Hubble photographed the Andromeda nebula with the Hooker telescope at Mount Wilson. He identified variable stars within it, Cepheids, whose period reveals their absolute luminosity. The calculated distance: approximately 900,000 light-years. The Andromeda nebula was not a gas cloud within our Galaxy. It was an entire galaxy, as large as the Milky Way, at a prodigious distance.

That discovery changed everything. Within months, the known universe went from one galaxy to a universe of billions of galaxies. Nobody had anticipated its true dimensions. The instruments had simply reached the resolution needed to see what had always been there.

The Hubble precedent teaches us something essential: each time our instruments cross a threshold of resolution or sensitivity, the universe suddenly becomes larger than the previous model had predicted. This is not coincidence, it is the signature of a cosmos whose richness systematically exceeds our conceptual frameworks of the moment.

The pattern of great instrumental discoveries • 1610, Galileo and the telescope: planets have moons, Venus has phases, the cosmos is more complex than Aristotle • 1924, Hubble and the Hooker: nebulae are galaxies, the universe is 100 billion times larger than thought • 2022, JWST: mature galaxies at $z > 10$, the history of the universe is longer than Λ CDM foresaw • 2028, ELT: ? → At each instrumental threshold crossed, the universe has proved richer than expected. → Nothing says the ELT will be an exception.

III.8.3 From filaments to Hydraxies: the hierarchy and its centre

The cosmic web: the observational ground

What the great surveys have been mapping for thirty years is not a homogeneous universe. DESI, Euclid, the 2dFGRS, the SDSS, all reveal the same large-scale architecture: filaments of galaxies, hundreds of millions of light-years long, bounding immense voids in which matter is nearly absent. This cosmic web is not an accident. It is the signature of a fractal distribution of dimension $D \approx 1.9$, observationally constrained up to $L_0 \sim 400$ Mpc.

The best-documented structures directly illustrate the observable hierarchy:

CfA Great Wall (~ 750 Mly, Geller & Huchra 1989): the first large filament identified, the first signal that the hierarchy extends beyond superclusters.

Sloan Great Wall (~ 1.4 Glyr, SDSS): the longest known filament in the nearby universe, $10\times$ the size of Laniakea.

Laniakea (~ 520 Mly in diameter, Tully et al. 2014): our home supercluster, $\sim 100,000$ galaxies including the Milky Way, the Virgo Cluster, and the Great Attractor. Its mapping as an attraction basin revealed that we are already embedded in a structure an order of magnitude above classic clusters.

Shapley Supercluster (~ 650 Mly, at ~ 700 Mly from us): the densest mass concentration in our measurable neighbourhood, exerting a detectable gravitational pull on our local group. Probably the most tangible foretaste of a higher-level node.

These structures are not anomalies. They are the nodes and arms of a hierarchy that, in SHIFT, has no terminal level. The question is not “are there larger structures?”, the fractal logic of $D \approx 1.9$ answers yes by construction. The real question is: “how far can our instruments see them?”

The centre of a Hydraxie: scenario of a gravitational node

In Λ CDM, superclusters are not gravitationally bound in the strict sense, they disperse with the expansion. In SHIFT, with unlimited time and a quasi-static universe, the situation is radically different: the nodes of the fractal web have had tens to hundreds of Gyr to deepen gravitationally, concentrate matter, and merge structures.

The centre of a Hydraxie is probably not a single object, it is too massive and too extended for that. It is a region of overdensity, a fractal node of several Mpc, where thousands of massive galaxies converge, BCGs in the process of merging, black holes in accretion.

① BCGs as markers of nodes. Brightest Cluster Galaxies are the most massive galaxies in the observable universe: up to $10^{13} M_{\odot}$, radii of several hundred kpc, old and chemically uniform stellar populations at all depths observed by JWST. They form through successive hierarchical mergers at the cores of clusters, where the gravitational potential is deepest. At the centre of a Hydraxie, one does not expect a single BCG, but an extraordinary convergence of thousands of merging BCGs, a super-node of mergers operating over hundreds of Gyr, with no time constraint to interrupt it.

② Ultramassive black holes as the ultimate concentration. Each galactic centre hosts one or more black holes, surrounded by a dense stellar population in orbit. Each BCG hosts a particularly massive one. In a quasi-static universe with unlimited time, BCG mergers are accompanied by black hole mergers, with each coalescence

adding to the mass. The Hawking–Blandford-Znajek equilibrium mechanism (§III.4) creates an evaporation plateau over thousands of Gyr, stabilising these masses without explosion or collapse. The centre of a Hydraxie could concentrate objects of a class never yet observed, whose order of magnitude the next section estimates from what we already know.

③ Dynamic self-equilibrium. There is no absolute maximum mass in SHIFT, but a contextual limit: beyond a certain threshold, radiative feedback (the Eddington limit) and Blandford-Znajek jets evacuate as much energy as enters. The node of a Hydraxie reaches a state of dynamic equilibrium, not a diverging singularity. This is the natural self-equilibrium of the fractal system, in keeping with what SHIFT predicts at every other scale.

III.8.4 What the Incomplete Survey of the Sky Conceals

Before putting forward masses that might seem extravagant for a Hydraxie core, we need to give them substance: to show that they do not appear out of thin air, but emerge from a transparent extrapolation grounded in what we already know.

The exploration bias: 0.038% of the volume

Measuring the mass of a central black hole with precision is not straightforward. It requires high-resolution spectroscopy of stellar kinematics or water masers in the galactic nucleus, a technique limited to nearby galaxies, generally within distances of ~ 4 Gyr ($z < 0.3$). Within that volume, only a handful of well-constrained objects are available.

UMBH Exploration Bias

Total SHIFT volume (radius 55 Gyr) : $\sim 697,000 \text{ Gyr}^3$

Volume surveyed for UMBHs (radius 4 Gyr) : $\sim 268 \text{ Gyr}^3$

Fraction effectively explored : $\sim 0.038\%$

Under-sampling factor : $\times 2,600$

Well-constrained UMBHs in this volume : ~ 9 objects

UMBHs expected in the full SHIFT volume : $\sim 23,000$ (assuming uniform distribution)

→ We have observed only 0.038% of the volume where these objects could exist.

→ TON 618 ($6.6 \times 10^{10} M_{\odot}$) is probably far from the most massive object in existence.

The statistical distribution: fitted log-normal

Black hole mass follows a log-normal distribution, the natural distribution of multiplicative processes such as successive mergers. Fitted to the 9 best-constrained

UMBHs (TON 618, Holm 15A*, IC 1101, M87*, etc.), this yields: $\mu = 10.2$ (in $\log_{10} M/M_{\odot}$), $\sigma = 0.53$.

TON 618, with $\log M = 10.82$, lies only 1.2σ above the sample mean. Yet it is probably not the most extreme object the universe has to offer. It is simply the most massive within the small volume we have managed to survey. The tail of the distribution predicts what remains out of reach:

Class	Typical mass	Conservative scenario	Nominal scenario
TON 618	$\sim 6 \times 10^{10} M_{\odot}$	~ 385 within 55 Glyr	$\sim 3,000$ within 55 Glyr
Class A	$\sim 10^{11} M_{\odot}$	~ 145 within 55 Glyr	$\sim 1,500$ within 55 Glyr
Class B	$\sim 10^{12} M_{\odot}$	~ 0.4 (plausible)	~ 8 within 55 Glyr
Class C	$\sim 10^{13} M_{\odot}$	marginal within 55 Glyr	plausible at a Hydraxie node

The conservative scenario assumes that our 9 known UMBHs overestimate the mean (Malmquist bias: the most massive and brightest objects are detected first). The nominal scenario uses the observed sample directly. In both cases, Class A objects ($\sim 10^{11} M_{\odot}$) exist in large numbers within the SHIFT volume, simply invisible for lack of spectroscopy at those distances.

The fractal node effect: local density $\times 100$

The distribution above assumes uniform density. But the nodes of the cosmic web are not uniform: DESI surveys show that filament nodes are typically $\sim 100\times$ denser than the mean volume. If 8 Class B objects ($\sim 10^{12} M_{\odot}$) exist within 55 Glyr under uniform distribution, some may be concentrated within the few Mpc of a dense node, where successive mergers over hundreds of Gyr drive them toward masses with no observed equivalent.

This is not a wild extrapolation. It follows the same logic that leads from stars ($1\text{--}100 M_{\odot}$) to stellar black holes ($3\text{--}20 M_{\odot}$), and then to supermassive black holes ($10^6\text{--}10^{10} M_{\odot}$) through galactic mergers, the only difference is the timescale and the mass scale. With hundreds of Gyr available and a density factor of $\times 100$, Class C ($\sim 10^{13} M_{\odot}$) is no longer a fanciful extrapolation but a natural consequence of the fractal framework.

What the incomplete survey conceals

In 0.038% of the observable volume, we found TON 618 at $6.6 \times 10^{10} M_{\odot}$.
The log-normal tail predicts:

- Class A ($\sim 10^{11} M_{\odot}$) : hundreds to thousands of objects within 55 Gyr
- Class B ($\sim 10^{12} M_{\odot}$) : a few objects within 55 Gyr, thousands within a full Hydraxie
- Class C ($\sim 10^{13} M_{\odot}$) : marginal within 55 Gyr, plausible at a Hydraxie node (local density $\times 100$, mergers over 100–1,000 Gyr)

These objects would be invisible to JWST: beyond ~ 200 Gyr, their radiation is shifted out of the optical/IR domain by cumulative gravitational redshift. Only SKA could detect them in radio continuum, a natural discriminating test.

And where does Laniakea fit in?

If such extreme masses anchor the nodes of a Hydraxie, then the kinematics of the arms leading toward those nodes must also be reconsidered. Laniakea offers precisely that opportunity, a well-mapped, familiar structure that SHIFT can now read differently.

Since 2014, the mapping of Laniakea by H            , Brent Tully and their collaborators (the CosmicFlows programme) has revealed a coherent structure roughly 500 million light-years across, within which the Milky Way occupies a peripheral position. Peculiar velocity flows converge toward a region known as the Great Attractor, located in the direction of the Crux and Centaurus constellations.

Within the Λ CDM framework, these flows are reconstructed as resulting from a gravitational field dominated by mass concentrations and basins of attraction, a workable interpretation, but one that leaves several questions open: why do the velocity residuals after Hubble flow subtraction remain anisotropic? Why does the internal flow of Laniakea display a triaxial rather than spherical structure? Recent CosmicFlows-4 analyses suggest that Laniakea may be only a sub-basin of a much larger attractor basin associated with Shapley, which shifts the problem without resolving it.

Three observed motions, one structure

Recent surveys have revealed three kinematic components in cosmic filaments, all observational:

① **Axial rotation of the filament.** By stacking thousands of filaments and measuring velocities perpendicular to their axis, Wang et al. (2021, *Nature Astronomy*) [31] detected a statistical signal of vortical motion consistent with rotation, which would make cosmic filaments the largest known objects to possess angular momentum. The authors themselves describe the result as "*possible observational evidence*", and note that the signal strength depends on the filament's orientation and dynamical state. The rotation axes of individual galaxies tend to align with the axis of their host filament: filament and galaxies co-rotate, like teacups spinning on a carousel whose platform is itself turning.

② **Oscillatory flux along the axis.** By stacking 360 filaments from the SDSS catalogue, a team detected at 5.5σ (arXiv:2601.18434) [30] a flow of matter along the filament's axial direction, at the near end, material moves toward the observer; at the far end, it recedes. This longitudinal motion is distinct from perpendicular infall: it is a channelled flow along the column.

③ **Perpendicular infall toward the column.** Galaxies fall toward the filament axis independently of their motion toward the terminal nodes. This third vector is the most classically documented.

These three superimposed components produce a complex, undulating velocity field, coherent across hundreds of millions of light-years.

Laniakea reinterpreted

Within the Hydraxie framework, Laniakea is not an independent supercluster orbiting a mysterious attractor. It would be a **Hydraxie arm**, a section of a large-scale cosmic filament carrying the three kinematic components described above, whose dynamics we observe from the inside. This perspective radically reframes the data:

The Great Attractor would not be an exceptionally massive node. It could be the near end of our Hydraxie arm, toward which the axial flow carries us, just as stars in a spiral arm are carried toward the galactic centre by the differential kinematics of the arm.

The observed peculiar velocities (200–600 km/s) would not be residuals after subtracting a cosmological expansion. In SHIFT, this decomposition is not postulated: the observed velocities are interpreted directly as manifestations of the local gravitational field and the internal flows of the structure, differential shear between our position on the arm and neighbouring regions slightly offset in orbital phase, channelled axial flow, local perpendicular infall.

The residual anisotropy (triaxial structure, bulk flow of ~ 190 km/s not cancelled after Λ CDM correction) ceases to be an anomaly. It could then reflect the actual geometry of the arm: elongated, triaxial, threaded by coherent directional flows.

The fact that we are embedded in the motion explains why the relative velocities observed at the heart of Laniakea remain modest. We co-rotate, we co-oscillate with the arm. What we measure is differential shear, exactly as an astronomer located within a spiral arm would not see the entire arm sweep past at high speed, but only the slight velocity differences between neighbouring positions on the same orbit.

A remarkable observational convergence

It is striking that these three kinematic components, axial rotation, longitudinal flux, perpendicular infall, were established **independently**, by different teams, on distinct

samples, between 2021 and 2026. None of these studies was motivated by SHIFT. They simply describe what the data show.

Yet these three components are precisely **consistent with** the kinematics expected of a Hydraxie arm rotating in a quasi-static fractal universe at $D \approx 1.9$. Their combination thus provides a natural signature of the Hydraxie geometry proposed by SHIFT: a cylindrical structure bearing its own angular momentum, threaded by axial flows channelled by the gravitational gradient along the arm, and drawing surrounding matter perpendicularly toward its dense column.

Status of this interpretation. The reinterpretation of Laniakea as a Hydraxie arm is a hypothesis consistent with the available observations, not a demonstration. It predicts that the geometry of the CF4 velocity-flow lines should display a characteristic curvature, not radial toward a point, but helical around an axis, distinct from the spherical infall expected toward a point attractor. This test is feasible on the public CosmicFlows-4 data. It constitutes a falsifiable discriminant between the two interpretations.

III.8.5 CMB anomalies as Hydraxie imprints

In Greek mythology, the Hydra of Lerna is a multi-headed water serpent whose heads grow back as soon as they are cut off, a tentacled, branching creature, impossible to eradicate. The metaphor is deliberate.

Cosmic Hydras designate, in the SHIFT hypothesis, fractal mega-structures on the scale of several tens to several hundreds of billions of light-years, filaments and sheets of the cosmic web of a size that exceeds anything our current instruments can resolve. Tentacled by nature, they extend in all directions, branch, interconnect, faithful to their fractal model.

A Cosmic Hydra is not isolated. It is surrounded by its satellite galaxies, secondary filaments, and gravitational voids, an entire structural ecosystem associated with it. To designate this complete cosmological unit, the SHIFT framework proposes a specific term: the Hydraxie.

SHIFT definition, Hydraxie Etymology: Hydra (tentacled fractal mega-structure) + axis (of rotation) + galaxy resonance A Hydraxie is the basic cosmological unit of the SHIFT fractal universe: • the dense nucleus: the Cosmic Hydra, a filamentary mega-structure extending from ~55 Gyr and beyond, with no imposed terminal level • the extended domain: satellite galaxies, secondary filaments, associated gravitational voids → Working term proposed by SHIFT, not ratified in conventional astronomical nomenclature.

III.8.6 The Fibonacci trail: our position in our Hydraxie

The Boötes Void is one of the most remarkable structures in the observable universe. Discovered in 1981, it spans approximately 330 million light-years in

diameter, at a distance of ~700 million light-years. Within this volume, around 60 galaxies are observed where ~2,000 would be expected, a density deficit of a factor ~33.

In Λ CDM, a void of this size is difficult to explain in a 13.8-billion-year-old universe. N-body simulations struggle to produce voids this wide within that timeframe, it would require improbably large initial fluctuations or non-standard repulsion mechanisms.

The Boötes Void in SHIFT • Diameter: ~330 Mly (~100 Mpc) • Distance: ~700 Mly (~215 Mpc) • Galaxies observed: ~60 (expected ~2,000) • Internal structure: tubular with internal filaments, structured cavity, not a homogeneous void In SHIFT: a natural cavity between the arms of a Hydraxie. In an eternal fractal universe, these voids have had billions of years to deepen gravitationally. The tubular structure is consistent with a fractal network of interconnected filaments. Not an anomaly, a natural property of $D < 2$.

III.8.7 CMB anomalies as imprints of the Hydraxies

If the Hydraxies exist at very large scales, several hundred Gyr, their presence should leave an imprint in the CMB via the integrated Sachs-Wolfe (ISW) effect: photons traversing large overdense or underdense structures gain or lose a small amount of energy. Four Planck 2018 CMB anomalies are compatible with this hypothesis:

CMB anomalies compatible with the Hydraxies • Axis of Evil (quadrupole-octupole alignment, improbable by chance): large-scale anisotropy, consistent with a Hydraxie extending preferentially in one direction • Large-angle power deficit ($\ell < 10$): thermal background dominated by fractal structures at very large scales • Cold Spot (Eridanus constellation, $\Delta T \sim -70 \mu\text{K}$, ~200 Mpc void optically confirmed): hollow cavity between two filaments of the local arm • N/S hemispheric asymmetry (~7% in power): off-centre position in an arm, asymmetric dense node → These anomalies are compatible with the Hydraxies. This is not proof. §III.8.8 and §III.8.9 will show that these same anomalies allow a quantitative estimate of our position within our Hydraxie.

One must resist the temptation to over-interpret this consistency. These same anomalies also have other possible explanations, instrumental systematic effects, statistical fluctuations, poorly subtracted galactic structures. Consistency is not confirmation.

III.8.8 From observation to hypothesis: the fractal logic

The question of the Hydraxies was not born from abstract mathematical deduction. It arose from a concrete observation: the Little Red Dots (LRDs), detected by JWST at $z \sim 4-8$, display luminosities and mass concentrations that are difficult to explain within Λ CDM. This strangeness raised a broader question: in a fractal universe of dimension $D \approx 1.9$, are there levels of organisation above the known superclusters and cosmic filaments?

The answer is logically consistent. If $D \approx 1.9$ applies at all scales, and nothing in the fractal geometry imposes a terminal level, then structures above filaments and superclusters are expected. This is not a strict mathematical necessity, but a reasoned extrapolation of the observed scaling law. The LRDs were the intellectual thread. But their spectroscopically measured redshift, $z \sim 4-8$, placing them at 20–35

Glyr in SHIFT, puts them inside our own Hydraxie. They cannot be its nuclei as seen from outside. The Hydraxie hypothesis rests on fractal logic alone.

Foundation: fractal logic, not observational • $D \approx 1.9$ with no imposed terminal level
 → structures of all sizes must exist • No connection claimed with any specific observational object at present • Discriminating test: point-like optical nucleus (ELT, >55 Glyr) + diffuse radio halo (SKA) on the same object → conclusive signature → Unconfirmed hypothesis. Not anchored on a known object. Testable with ELT + SKA from 2028–2032.

III.8.9 The SKA prediction: structures without optical counterpart

If the Hydraxies exist beyond the current optical/infrared instrumental limits, they emit photons shifted beyond those spectral windows, into the radio domain. JWST, the ELT and SKA are complementary, not redundant. JWST probes our Hydraxie to ~55 Glyr, its spectral instrumental limit in SHIFT. The ELT extends the optical/IR window to ~200 Glyr of physical depth: it will observe more distant individual galaxies within our Hydraxie, but not neighbouring Hydraxies, these, beyond the spectral limit, no longer emit in the optical/IR domain. It is the SKA that opens this window: beyond 200 Glyr, photons are shifted into the radio domain, and the SKA will detect these structures as diffuse radio emission without optical counterpart.

SHIFT prediction for SKA, Hydraxie structures beyond the optical/IR spectral limit (~200 Glyr) • Diffuse, extended radio sources at high galactic latitude • Without optical counterpart in JWST/ELT surveys • Filamentary morphology consistent with fractal geometry $D \approx 1.9$ • Large-scale isotropic distribution (fractal universe homogeneous beyond L_0) → If SKA detects such sources: strong signal for the Hydraxies. → If the radio sky is empty: strong constraint on SHIFT parameters. Instrument: SKA Phase 1 (2027), Phase 2 (2030+).

The three instrumental horizons of the Hydraxies

Instrument	Window (Glyr)	What it probes	Key test
JWST	0 → ~55	Our Hydraxie (LRDs included)	Extended morphology of LRDs
ELT (2028+)	55 → ~200	Optical/IR spectral limit, physical depth up to ~200 Glyr	Morphology of the most distant galaxies (z near the SHIFT spectral limit)
SKA (2027+)	>200 (beyond ELT window)	Hydraxie structures (radio emission shifted beyond optical/IR window)	Diffuse filamentary radio sources, without optical counterpart

III.8.10 Our position in our Hydraxie: the Fibonacci trail

Point of entry, an image and a question In August 2026, an image represented the Fibonacci sequence applied to nature: fern, sunflower, hurricane, spiral galaxy. The caption: “From a Fern to a Galaxy, Nature Uses the Same Mathematical Code.” The question that followed: if the fractal hierarchy continues beyond galaxies, as SHIFT predicts, what is the “Fibonacci step” immediately above? What follows is an extrapolation. An order of magnitude, not a precise prediction. But the agreement with several independent observables deserves to be documented.

The Fibonacci sequence anchored on the observed hierarchy

The Fibonacci sequence, where each term is the sum of the two preceding ones, converges towards the golden ratio $\phi \approx 1.618$. Applied to cosmic structures, anchored on the two best-constrained levels, one obtains:

Level	Size (Glyr)	Status	Correspondence
Local Group	3	✓ Observed	Anchor 1, sequence anchor
Virgo Cluster	8	✓ Observed	Anchor 2, sequence anchor
+1 / +2 / +3 / +4	11 · 19 · 30 · 49	—	Intermediate levels
+5, Laniakea	79	✓ ~77 Glyr (3%)	Tully et al. 2014, no adjustment, 3% deviation
+6	128	—	—
+7, ELT limit?	207	⊙ ~200 Glyr (3%)	Convergence with SHIFT instrumental limit (instrumental + spectral)
+8, Predicted Hydraxie	335	⊙ Speculative	Estimated radius of our Hydraxie, next level of the hierarchy

Table: Fibonacci sequence anchored on the Local Group (3 Glyr) and the Virgo Cluster (8 Glyr). Green cells: convergences without adjustment. Blue cells: observed anchors.

The signal lies in the double unforced convergence: the sequence anchored on two observed points reproduces Laniakea to within 3% at level +5, and the SHIFT instrumental limit of the ELT to within 3% at level +7. These two independent agreements on the same unadjusted sequence suggest that the instrumental limits are not arbitrary, they coincide with the structural levels of the fractal network.

Honest limitation The inter-level ratios are not constant throughout the observed hierarchy. Fibonacci gives an order of magnitude, not a precise prediction. The 3% agreement with Laniakea is a signal, not proof. The retained conclusion: $R_{\text{Hydraxie}} \sim 300\text{--}400$ Glyr, uncertainty $\geq 30\%$.

Our position in the Hydraxie: the Copernican analogy

If our Hydraxie has a radius of ~ 335 Glyr, where do we sit within it? Three observables converge:

Three converging position indicators • KBC Void (~ 1 Glyr, $\sim 40\%$ local underdensity): signature of a hollow arm between two filaments, not the dense node • CF4 bulk flow ($\sim 600\text{--}1,000$ km/s up to ~ 300 Mpc in a preferred direction, Watkins 2023): attraction towards a node at $\sim 25\text{--}55$ Glyr • Planck Axis of Evil (quadrupole + octupole coaxial to $< 1^\circ$, direction (l,b) $\sim (-100^\circ, 60^\circ)$): persistent axis pointing towards a unique large-scale physical source, probable dense node of our Hydraxie → Estimated position: $\sim 150\text{--}225$ Glyr from the central node, i.e. $\sim 45\text{--}67\%$ of the radius.

Structure	Our position	Distance to centre	% of radius
Milky Way	Orion Arm	$\sim 27,000$ ly	$\sim 52\%$
Hydraxie (estimated)	Hollow arm, KBC Void	~ 168 Glyr	$\sim 50\%$

The similarity of ratios (52% vs 50%) is not proof, it is a consistency that motivates the trail. Copernicus at the scale of Glyr.

III.8.11 Vera Rubin at the scale of Gyr: the rotation of the Hydraxie

In 1970, Vera Rubin and Kent Ford published a disconcerting result: the peripheral stars of galaxies rotate as fast as the central ones. The rotation curve is flat, where Newtonian mechanics predicts a decline. Λ CDM responds by inventing exotic dark matter. SHIFT responds with $D = 1.9$.

What nobody had yet asked: if the same fractal law operates at all scales, what does it predict for the rotation of a Hydraxie, a structure ten billion times larger than a galaxy?

The fractal law automatically gives a quasi-flat curve

In a fractal distribution of dimension D , $M(<r) \propto r^D$. The rotation velocity is:

$$V(r) = \sqrt{(G \cdot M(<r)/r)} \propto r^{(D/2 - 1/2)} = r^{(D-1)/2}$$

Mass profile	D	V(r) curve	Physical case
$M \propto r^2$ (homogeneous)	2	$V \propto r^{0.5}$, rising	Not observed
$M \propto r^{1.9}$, SHIFT	1.9	$V \propto r^{0.45}$, quasi-flat	Vera Rubin, naturally
$M \propto r$ (filaments)	1	$V = \text{const}$, exactly flat	Perfect Rubin limit
$M = \text{const}$ (Keplerian)	0	$V \propto r^{-0.5}$, declining	Solar system

$D = 1.9$ is so close to 2 that $V(r) \propto r^{0.45}$ is quasi-flat. The same fractal law that explains Vera Rubin in galaxies automatically produces a quasi-flat curve at the scale of Gyr, without exotic dark matter.

Calculation of the rotation velocity

The observational anchor is Laniakea: mass $\sim 10^{17} M_{\odot}$ at 77 Gyr (Tully et al. 2014). Applying the fractal scaling $M \propto r^{1.9}$:

Rotation velocity at our position in the Hydraxie (~ 168 Gyr from the node) • Total Hydraxie mass ($R = 335$ Gyr): $\sim 1.6 \times 10^{18} M_{\odot}$ • Interior mass at our position (~ 168 Gyr): $\sim 4.4 \times 10^{17} M_{\odot}$ • Rotation velocity $V(168 \text{ Gyr})$: $\sim 192 \text{ km/s}$ • Rotation period: $\sim 1.65 \times 10^6 \text{ Gyr}$ (no constraint in an eternal universe) The predicted velocity (~ 190 – 200 km/s) is remarkably close to the Sun's velocity around the galactic centre ($\sim 220 \text{ km/s}$). This is not a forced coincidence: it is the same fractal physics $D = 1.9$ operating at a scale ten billion times larger.

Scale	Radius	V_rotation	Source
Stars / galaxy	$\sim 50 \text{ kly}$	$\sim 220 \text{ km/s}$	Rubin 1970–1980, observed
Galaxies / Laniakea	$\sim 77 \text{ Gyr}$	$\sim 600 \text{ km/s}$	Watkins 2023, observed
We / Hydraxie	$\sim 168 \text{ Gyr}$	$\sim 200 \text{ km/s}$	SHIFT prediction, to be tested

The same fractal physics $D = 1.9$ operates at three scales separated by factors of 10^{10} .

Observable signature: the rotational CMB dipole

A rotation of $\sim 192 \text{ km/s}$ produces an additional kinematic dipole in the CMB:

$$\Delta T_{\text{rotation}} = T_{\text{CMB}} \times V_{\text{rot}} / c \approx 2.72548 \times 192,000 / (3 \times 10^8) \sim 1,742 \mu\text{K}$$

This signal represents approximately half of the total observed kinematic dipole ($3,365 \mu\text{K}$). It is not marginal. Its key is its direction: perpendicular to the Hydraxie axis (axis of evil), distinct from the dipole of the infall towards Shapley. The vector

subtraction is feasible using the publicly available Planck 2018 data, without any new instrument.

Verification programme at three levels

Test	Signal sought	Data	Feasibility
CMB dipole residual	Tangential component $\perp$ axis of evil	Planck 2018 public	Now
CF4++ peculiar velocities	Coherent tangential component at large scale	DESI CF5 2026–27	2026–2027
DESI galaxy spins	Preference perpendicular to Hydraxie axis, cosmic Coriolis	DESI DR2	2027+
ELT density asymmetry	Rarefaction towards void vs abundance towards node (55–200 Gyr)	ELT 2028+	2028–2035

Most discriminating test in the near term: the CMB dipole residual on public Planck data, feasible now, without any new instrument.

Epistemic status, what this section is and is not Everything above is speculative. None of these deductions is a pillar of SHIFT. The invariant parameters, $D = 1.9$, $L_0 = 400$ Mpc, $\gamma = 0.349$, $H_0 = 70$ km/s/Mpc, are not modified. But these deductions illustrate what a fertile model must be able to do: from a small number of constrained parameters, generate verification trails at scales nobody had yet envisaged. Exotic dark matter was proposed to explain Vera Rubin, yet was never found. SHIFT proposes that $D = 1.9$ suffices, at all scales. The Hydraxie is the logical consequence of that idea taken to its full extent. It will be confirmed, refuted, or nuanced, and that is exactly what one asks of a scientific hypothesis.

III.8.12 Key takeaways from this chapter

The Hydraxies, fractal mega-structures above the known filaments and superclusters, are a hypothesis, clearly signposted as such. They emerge naturally from the fractal logic of SHIFT: in an infinite, eternal universe with $D \approx 1.9$, nothing imposes a terminal level on the structural hierarchy. Structures at all scales are possible, and constitute a testable prediction via the SKA and the ELT.

The Fibonacci trail, anchored on the Local Group and the Virgo Cluster, reproduces Laniakea to within 3% and the ELT's instrumental limit to within 3%, two independent convergences without adjustment. It predicts a radius of ~ 335 Gyr for our Hydraxie, and a peripheral position for us at $\sim 50\%$ of the radius in a hollow arm, the mirror image of our position in the Milky Way.

$D = 1.9$ predicts a quasi-flat rotation curve at the scale of Gyr, the same physics as Vera Rubin, ten billion times larger. The predicted velocity (~ 200 km/s) produces a CMB kinematic dipole of $\sim 1,742$ μK testable with the public Planck data right now.

The Hubble precedent calls for humility: each time an instrumental threshold has been crossed, the universe has revealed itself to be richer than expected. The ELT and the SKA will be those next windows.

In 1924, Hubble pointed his telescope at a nebula. He saw a galaxy. The universe suddenly became a hundred billion times larger. Nobody expected it. The Hydraxies may not be there. But if they are, and if we occupy their periphery, then Copernicus was right once more, at a scale he would never have dared imagine.

Chapter III.9

Epistemology: what SHIFT says about cosmological science.

What science knows about itself, and what it prefers not to look in the face.

III.9.1 A model is not reality

There is a frequent confusion, in mainstream science communication, between a model and the reality it describes. Λ CDM is not the universe. It is a mathematical representation of the universe, calibrated on observations, constrained by parameters, and valid within a certain domain of application. This distinction seems obvious, yet it is systematically erased in the dominant discourse.

We say “the universe is 13.8 billion years old” in the same tone as “the Earth orbits the Sun.” But these two statements do not have the same epistemological status. The second is a direct measurement, verifiable by independent convergent methods spanning centuries. The first is an inference, dependent on a model, on cosmological assumptions, and on the internal consistency of a particular theoretical framework.

SHIFT does not say that Λ CDM is wrong. It says that Λ CDM is one model among other possible ones, and that current observations allow, and are beginning to require, that others be explored. This is an epistemological position, not an attack. The distinction matters.

III.9.2 How a paradigm sustains itself

Thomas Kuhn, in “The Structure of Scientific Revolutions” (1962), described a mechanism that has lost none of its relevance: scientific paradigms do not fall when an anomaly appears. They fall when anomalies accumulate to the point where the cognitive cost of ignoring them exceeds the cost of adopting a new framework.

This process is slow, deliberately slow. Slowness is a functional property of science, not a defect. It protects against premature revolutions, against theoretical fashions, against the seductive pull of a new idea before it has been sufficiently tested. Science must be conservative. That is its strength.

But this slowness has a symmetric cost: it can also sustain a failing paradigm longer than necessary. Not through bad faith, but through institutional inertia, through invested human capital, through funding networks structured around the existing framework, through the psychological difficulty of questioning what one has spent a career building.

The cosmologist who has devoted twenty years to modelling the primordial quantum fluctuations of inflation is not wrong to defend that framework against an unestablished alternative. They are right to demand proof, to point out weaknesses, to require rigour. Science works this way. But the same person must also be able to

open their eyes when the tensions are no longer isolated anomalies, when they form a coherent pattern.

The Kuhnian mechanism applied to Λ CDM:

Phase 1, Normal science: Λ CDM solves puzzles. H_0 is measured, BAO are detected, the CMB is mapped. The model works.

Phase 2, Anomalies: H_0 tension at 5.8σ . Mature galaxies at $z > 10$. Stars at 14.8 Gyr. Unstable dark energy. Dark matter nowhere to be found. JWST depth 4× the theoretical value. Each anomaly is treated separately, a parameter adjusted, a systematic effect invoked.

Phase 3, Crisis: the anomalies no longer converge towards independent solutions. They form a pattern. The tension is no longer parametric, it is structural.

Phase 4, Revolution: a new theoretical framework proposes to resolve the anomalies naturally, without ad hoc parameters. This is precisely what SHIFT proposes.

III.9.3 Falsifiability: a strength, not a weakness

Karl Popper formulated a simple criterion for distinguishing science from non-science: a theory is scientific if and only if it can be contradicted by observation. A theory that adapts to every possible observation is not a theory, it is a tautology.

SHIFT was built with this criterion in mind. Chapter III.6 set out the complete list: seven testable predictions, four explicit falsification conditions. If $dz/dt \neq 0$ is measured by the ELT, SHIFT is falsified. If primordial CMB B-mode polarisation is detected, SHIFT is falsified. If the DSNB shows a clear decline beyond $z \approx 5$, SHIFT is falsified.

This transparency is not rhetorical modesty, it is the fundamental contract of any scientific proposition. A model that cannot be contradicted has no place in science, whatever its mathematical elegance.

The symmetric question deserves to be asked: what observations would falsify Λ CDM? The H_0 tension at 5.8σ did not falsify it, it produced adjustments. Stars at 14.8 Gyr did not falsify it, they produced uncertainties on dating methods. Mature galaxies at $z > 10$ did not falsify it, they produced revisions to stellar formation models. At what point can anomalies accumulate before the framework is considered refuted?

That is a legitimate question. It does not disqualify Λ CDM, it demands an honest answer.

The falsifiability test applied to both models:

SHIFT: explicit falsification conditions, dated, instrumented

- $dz/dt \neq 0$ at high precision (ELT, 2030–35)
- Primordial CMB B-modes detected (BICEP/Keck, LiteBIRD)
- DSNB declining at $z > 5$ (SK-Gd, 2026–30)
- GW spectrum with dominant coalescence peak (LISA, 2035+)

Λ CDM: falsification conditions not formalised

- Each tension produces an adjustment, not a questioning
- The number of free parameters increases with the anomalies
- The question “at what σ is Λ CDM falsified?” remains without an official answer

→ This is not a criticism of Λ CDM, it is an invitation to formalise the conditions of its own refutation.

III.9.4 What SHIFT says about our place in the universe

Each great cosmological revolution has displaced humanity from its supposed central position towards something vaster and less privileged.

Copernicus removed the Earth from the centre of the solar system. Herschel showed that the Sun is just one star among billions in the Milky Way. Hubble showed that the Milky Way is just one galaxy among billions in an expanding universe. Each step made the observer more humble, and the universe larger.

SHIFT proposes a fourth step in this sequence. Not only is our planet not at the centre, not only is our galaxy not special, not only is our cosmic epoch not privileged, but our entire observable horizon is merely a tiny spectral window onto an infinite, eternal cosmos. The ~ 55 Glyr that JWST probes are not “the universe”; they are what our current optical/infrared window allows us to see.

This is an additional decentring of considerable magnitude. And like the previous ones, it does not diminish the significance of human existence, it inscribes it within something infinitely vaster.

In an eternal universe, without beginning or end, without a privileged epoch, we are not witnesses to a young universe just getting started. We are observers of a mature, stable cosmos that has always existed and always will, one in which our observational window is a property of our instruments, not a physical frontier of reality.

The sequence of cosmological decentrings:

- Ptolemy → Copernicus: the Earth is not at the centre of the solar system
 - Herschel → Shapley: the Sun is not at the centre of the Galaxy
 - Hubble (1924): the Milky Way is just one galaxy among billions
 - SHIFT (proposal): our observable horizon is merely a spectral window onto an infinite, eternal cosmos without a physical boundary
- Each step made the observer more humble.
→ Each step made the universe more real.

III.9.5 Common sense as a scientific instrument

There is a tension in contemporary scientific practice between mathematical sophistication and physical common sense. Sophistication is necessary, modern data demands analytical tools of considerable complexity. But sophistication can also become a shield: a way of making a theory impervious to criticism through its very technicality.

Physical common sense is the ability to ask whether a conclusion is reasonable before checking whether it is mathematically consistent. It is looking at a mature galaxy at $z > 10$ and asking: is it truly plausible that it formed in less than 500 million years? It is looking at the H_0 tension and asking: is it truly plausible that five independent measurement methods are all systematically biased in the same direction?

Common sense does not replace rigour. It precedes it. It signals where to look, which questions to ask, which conclusions deserve close scrutiny. The astrophysicists who flagged the first Λ CDM tensions were not doing philosophy, they were exercising physical common sense before doing the calculations.

SHIFT was born of precisely such common sense: if redshift is a spectral shift, its physical cause remains an interpretation. If the simplest cause, cumulative gravitational energy loss in a fractal potential, reproduces the observations as well as expansion does, then expansion is not a logical necessity. It is a hypothesis. And hypotheses deserve to be questioned, especially when they accumulate tensions.

It is better to open one's eyes and arm oneself with common sense than to place blind trust in a model that has spent decades adapting to its own contradictions rather than resolving them. This is not a criticism of science, it is its founding principle. Science does not advance through deference to consensus. It advances through the question asked at the right moment.

III.9.6 SHIFT as a proposition in a conversation

This book does not ask the reader to believe that SHIFT is correct. It asks for something at once more modest and more demanding: to consider that the question is open.

SHIFT may be confirmed by the ELT, the SKA, IceCube-Gen2, or LISA. It may be falsified by the same instruments. It may be improved, the formal connection between the phenomenological equation $z(r)$ and the physical equation of the fractal potential remains a priority open point. To quantify: the two equations agree to better than 5% for $z < 2$ (the calibration domain), but their predictions diverge beyond that, by around 10–15% at $z \sim 5$, and potentially more at $z > 10$. The strict domain of validity of the three-parameter $z(r)$ law is therefore $z < 2$; beyond that, the physical depth values are extrapolations that should be treated with the corresponding uncertainties. It may be superseded by something better that shares its central intuition without its current imperfections. All of this is acceptable, even desirable. A scientific proposition that cannot be improved is not a proposition, it is a dogma.

What is not acceptable, however, is the absence of conversation. An eternal, infinite, quasi-static, fractal universe, without a Big Bang or exotic dark energy, is a hypothesis consistent with the available data. It deserves to be tested with the same rigour and the same resources as the alternatives. The instruments are arriving: the ELT in 2028, SKA Phase 1 in 2027, IceCube-Gen2 in 2030. The coming decade will tell us what is what.

In the meantime, the question remains open. And that is already a great deal.

III.9.7 What to retain from this chapter

Cosmological science is a conversation between data, models, and instruments. Λ CDM has dominated that conversation for thirty years, with legitimate reasons. It unified particle physics and cosmology, predicted BAO, and mapped the CMB with remarkable precision.

But conversations evolve. The JWST, DESI, IceCube, and Tomasetti+2026 data raise questions that Λ CDM answers with increasing difficulty. SHIFT proposes a different framework, not as a definitive answer, but as a testable hypothesis that deserves a place in the conversation.

The epistemology of SHIFT comes down to three simple points:

What SHIFT says about cosmological science:

1. *A model is not reality, it is a map. A useful map is not necessarily the only possible map.*
2. *Falsifiability is a strength, not a weakness. SHIFT has explicit conditions for refutation. That is its guarantee of seriousness.*
3. *Common sense precedes rigour, it does not replace it. Looking at the data with open eyes before fitting it into a pre-existing framework is the beginning of all honest science.*
→ *Part IV opens the window onto the coming decade: the instruments, the measurements, the decisions that will be made between 2026 and 2035.*

Scientific revolutions do not begin with a refutation. They begin with a question that can no longer be ignored. The question is asked. The instruments are coming. The conversation can begin.

Chapter IV.1

The scientific agenda: 2026–2035.

Ten years to decide. The instruments, the measurements, and what they will say.

Cosmology is entering a decisive decade. Not because theorists will have settled the matter, they never do so alone. But because the instruments are arriving. Instruments whose resolution, sensitivity and spectral coverage will, for the first time, allow SHIFT and Λ CDM to be discriminated on precise, quantitative, unambiguous observables.

This chapter is a roadmap. For each major instrument of the next ten years: what it will measure, what that result will say about SHIFT, and what it will say about Λ CDM. The reader leaves with a concrete timeline, not of certainties, but of decisions.

Overview, the 2026–2035 agenda:

- 2026: DESI DR2 · SK-Gd DSNB (first results)
 - 2027: SKA Phase 1 (first light) · Euclid DR1
 - 2028: ELT first light · IceCube full statistics
 - 2030: IceCube-Gen2 · SKA Phase 1 full operation
 - 2035: LISA (planned launch) · Einstein Telescope
- Five instruments. Five windows. Five decisions.
- Each one can confirm, refute, or refine SHIFT.

IV.1.1 DESI DR2 (2026): dark energy under high pressure

DESI, the Dark Energy Spectroscopic Instrument, produced its first major dataset in 2024–2025 (DR1), revealing a potentially evolving dark energy: $w \neq -1$ at a significance of 2.5 to 3.9σ depending on the tracers used. This result shook the pillar of $\Lambda = \text{constant}$ in Λ CDM. DESI DR2, expected in 2026 with twice the statistics, will tell us whether this signal is confirmed or fades.

For Λ CDM, the situation is asymmetric: if $w = -1$ is confirmed, Λ CDM regains partial stability. If $w \neq -1$ is confirmed at 5σ or beyond, the standard model loses its energetic pillar, and no parametric adjustment can absorb an evolving cosmological constant without changing the underlying theory.

For SHIFT, DESI DR2 is a consistency test: the model predicts $\Lambda_{\text{eff}} = 0$, dark energy is not required. A confirmed evolving w does not validate SHIFT directly, but it validates the intuition that the cosmological constant is an artefact, not a physical reality. A precisely confirmed $w = -1$ does not falsify SHIFT either, it simply leaves the question open.

DESI DR2, 2026:

What will be measured: dark energy equation-of-state parameter w , over ~40 million spectroscopic galaxies

If $w = -1$ confirmed at high precision:

- Λ CDM $\rightarrow$ partial stability restored
- SHIFT $\rightarrow$ open question, not falsified

If $w \neq -1$ confirmed at $>4\sigma$:

- Λ CDM $\rightarrow$ structural crisis of the Λ pillar
- SHIFT $\rightarrow$ consistent ($\Lambda_{\text{eff}} = 0$ predicted, dark energy not required)

Decision horizon: end of 2026, Discriminating power SHIFT/ Λ CDM: moderate

IV.1.2 SK-Gd and the DSNB flux (2026–2030): neutrinos from cosmic supernovae

Super-Kamiokande, since the addition of gadolinium (SK-Gd) to its ultra-pure water, can detect the Diffuse Supernova Neutrino Background (DSNB): the integrated sum of all neutrinos emitted by every supernova in the observable universe since the beginning of time. A 2.6σ signal was reported at the Neutrino 2026 conference.

This flux is a remarkable cosmological discrimination tool. In Λ CDM, the cosmic supernova rate declines beyond $z \approx 2$ –5: the “young” universe was more active, the “old” one less so. The DSNB must therefore show a declining contribution from distant supernovae, a temporally bounded signal.

In SHIFT, the universe is eternal and statistically homogeneous in time. There is no more active “primitive” epoch. The supernova rate per unit of co-moving volume is approximately constant at all accessible depths. The DSNB expected by SHIFT is therefore isotropic, with no decline with z , and its spectrometry must reflect a uniform integration over all depths.

This is one of the most discriminating tests available in the next five years: the temporal signature of the cosmos.

SK-Gd DSNB, 2026–2030:

What will be measured: flux and spectrum of diffuse supernova neutrinos integrated over the entire observable universe

If DSNB flux clearly declines beyond $z \approx 5$:

- Λ CDM $\rightarrow$ consistent (more active primitive epoch)
- SHIFT $\rightarrow$ strong tension, potentially falsification

If DSNB flux is constant and isotropic at all depths:

- Λ CDM $\rightarrow$ significant tension
- SHIFT $\rightarrow$ direct validation (eternal universe, uniform rate)

Preliminary signal: 2.6σ at Neutrino 2026, statistics insufficient

Decision horizon: 2028–2030, Discriminating power SHIFT/ Λ CDM: strong

IV.1.3 SKA Phase 1 (2027): searching for Hydraxie arms in radio

The Square Kilometre Array, whose Phase 1 enters operation in 2027, is the most sensitive radio telescope ever built. It covers frequencies from 50 MHz to 15 GHz, a window that corresponds, in SHIFT, to photons emitted between ~ 200 Gyr and ~ 900 Gyr of depth, gravitationally shifted out of the optical/infrared window of JWST and the ELT.

The Hydraxies are an exploratory hypothesis of SHIFT: large fractal structures whose nuclei would extend to 25–55 Gyr, with filamentary arms potentially reaching depths well beyond JWST's instrumental limit. If such structures exist, their photons, gravitationally shifted out of the optical domain, could appear in the SKA's radio window as extended diffuse sources, at high galactic latitude, without counterpart in JWST or ELT surveys.

Epistemological status of the Hydraxies in this chapter: The Hydraxies are not a necessary prediction of SHIFT. SHIFT holds without them. Their existence is posited as a coherent possibility in an eternal fractal universe. Their non-detection by SKA does not constitute a falsification of SHIFT. Any eventual detection would constitute a strong exploratory signal, not proof.

In Λ CDM, radio sources at these cosmological depths cannot exist without an identifiable optical counterpart: any coherent extragalactic radio source must correspond to an object in the observable universe (≤ 13.8 Gyr). Diffuse radio sources without an optical counterpart would be a direct anomaly for the standard model, independently of any hypothesis about the Hydraxies.

What SKA Phase 1 will measure:

Diffuse radio sources at high galactic latitude, filamentary morphology, angular distribution, presence or absence of optical counterpart

Decision horizon: 2027–2032

Discriminating value: strong for Λ CDM if detected, neutral for SHIFT if absent

SKA observation	Λ CDM interpretation	SHIFT interpretation
Extended diffuse radio sources without optical counterpart	Major anomaly, inexplicable. In a universe ≤ 13.8 Gyr, every coherent source must correspond to an identifiable optical object	Compatible, exploratory signal. Consistent with the Hydraxie hypothesis if they exist. Does not confirm SHIFT, but opens an investigative trail
Empty radio sky beyond known sources	Consistent. No extragalactic source beyond the Λ CDM horizon	Neutral for SHIFT. The Hydraxies are an exploratory hypothesis, their non-detection does not falsify SHIFT. Other structural geometries or spectral windows remain possible

Detection of diffuse radio sources without optical counterpart would be an inexplicable anomaly for Λ CDM and a coherent trail for the Hydraxie hypothesis. The absence of such sources would remain neutral for SHIFT: other structural geometries, other depths, or other spectral windows remain open. The SKA tests an exploratory hypothesis of SHIFT here, not SHIFT itself.

IV.1.4 ELT (2028): the anisometropia test and Hydraxie search

The Extremely Large Telescope, with its 39-metre mirror and angular resolution of ~ 5 mas in the near-infrared, will enter scientific operation around 2028. It represents an unprecedented qualitative leap for observational cosmology: where JWST detects, the ELT will resolve.

The central test for SHIFT is morphological. The Little Red Dots (LRDs), observed by JWST at $z \sim 4-8$ (i.e. 20–35 Gyr in SHIFT), are currently unresolved, bright red point sources whose nature is debated. Λ CDM interprets them as hyper-luminous AGN or galaxies undergoing extreme star formation in the early universe. SHIFT interprets them as massive galactic structures whose red colour is due to cumulative gravitational redshift, not young AGN.

These two interpretations make different morphological predictions. Under Λ CDM, an LRD should be compact, with a point-like AGN morphology. Under SHIFT, corrected for cumulative gravitational redshift, an LRD should reveal an extended galactic morphology with mature stellar populations. This test remains valid independently of the question of Hydraxies.

The ELT also opens an unprecedented window on the 55–200 Gyr band, beyond our own Hydraxie. It is within this band that nuclei of neighbouring independent Hydraxies could appear as dense, luminous point sources, with no resolved extended optical morphology, but with a radio halo detectable by SKA.

The ELT can settle the question of the LRDs. Its angular resolution will distinguish a point-like nucleus from an extended galactic structure, a clean morphological test, independent of the Hydraxie question.

Simultaneously, the ELT will test the mathematical anisometry of Λ CDM in its extreme regime (factor $\times 145,000$ in surface area at $z \sim 83$). At $z \sim 83$ (ELT limit in SHIFT: ~ 200 Gyr), Λ CDM should see “normal” BCGs of 100 kpc reduced to ~ 370 pc, the size of a globular cluster. If the ELT observes objects at these redshifts with galactic morphologies incompatible with a size of 370 pc (lookback), the anisometry becomes a structural contradiction, not a tension.

ELT, 2028+:

Test 1, LRD morphology (independent of Hydraxies):

- *If point-like AGN morphology confirmed $\rightarrow \Lambda$ CDM consistent on this point*
- *If extended galactic structure revealed $\rightarrow$ SHIFT consistent (gravitational redshift)*

Test 2, Extreme anisometry ($\times 145,000$):

- *If BCGs at very high z show morphology < 500 pc $\rightarrow \Lambda$ CDM consistent*
- *If BCGs show morphology $\sim 50-100$ kpc at $z \sim 80 \rightarrow \Lambda$ CDM contradiction*

Test 3, dz/dt :

- *If $dz/dt \neq 0$ measured at high precision $\rightarrow$ real expansion, SHIFT falsified*
- *If $dz/dt \approx 0$ confirmed $\rightarrow$ static universe, SHIFT validated*

Decision horizon: 2030–2035, Discriminating power SHIFT/ Λ CDM: decisive on multiple axes

IV.1.5 IceCube-Gen2 (2030): the secondary break above 1 PeV

IceCube, in its current configuration (1 km³ of instrumented ice at the South Pole), has produced the most precise quantitative validation of SHIFT to date: the spectral break at 33.0 ± 3.5 TeV, predicted at 32.7 TeV with 0.9% agreement and independently constrained parameters.

IceCube-Gen2, scheduled for commissioning around 2030, will multiply the instrumented volume by ~ 8 (extension to ~ 8 km³). This gain in sensitivity will allow the detection, or exclusion, of the secondary spectral break predicted by SHIFT above 1 PeV (10⁶ GeV), corresponding to a different gravitational horizon in the fractal potential.

If this secondary break is detected at the energy predicted by SHIFT, with the same independently constrained parameters, it will be the second independent quantitative validation of the model on high-energy observables. If it is absent at Gen2 sensitivity, it will be a strong constraint on the parameters of the fractal potential.

IceCube-Gen2, 2030:

What will be measured: astrophysical neutrino spectrum above 1 PeV, with $\sim 8\times$ the statistics of current IceCube

SHIFT prediction: secondary break above 1 PeV, same D , L_0 , k constrained independently

If secondary break detected at the predicted energy:

- *SHIFT $\rightarrow$ second independent quantitative validation*
- *Λ CDM $\rightarrow$ second unpredicted observable*

If break absent at Gen2 sensitivity:

- *SHIFT $\rightarrow$ strong constraint on α and k of the fractal potential*

Decision horizon: 2032–2035, Discriminating power SHIFT/ Λ CDM: strong if detection confirmed

IV.1.6 LISA (2035): the gravitational wave background as final verdict

LISA, the Laser Interferometer Space Antenna, is planned for launch around 2035. It is a space-based interferometer whose 2.5-million-kilometre arms will detect gravitational waves in the frequency band 0.1 mHz to 1 Hz, inaccessible to ground-based detectors such as LIGO or Virgo.

In this band, LISA will be sensitive to the stochastic cosmological gravitational wave background: the superposition of all gravitational wave sources in the observable universe. This is where SHIFT and Λ CDM make their most divergent predictions.

In Λ CDM, the astrophysical gravitational wave background is dominated by mergers of compact binary systems (neutron stars, stellar black holes) throughout cosmic history. This background exhibits a characteristic peak at the frequency corresponding to mergers at the epoch of maximum star formation ($z \sim 2\text{--}4$). The spectrum is not a uniform power law, it has a temporally bounded shape.

In SHIFT, the universe is eternal and statistically stationary. There is no epoch of maximum star formation; the rate is constant in time. The expected gravitational wave background is a continuous power law, without a dominant coalescence peak,

integrating all mergers since an infinite past. The spectral signature is radically different.

LISA can measure the spectral shape of the background with sufficient precision to distinguish these two signatures. This is potentially the most decisive and cleanest test of the decade.

LISA, 2035+:

What will be measured: spectrum of the stochastic gravitational wave background, band 0.1 mHz – 1 Hz

SHIFT prediction: continuous power law, no dominant coalescence peak (eternal universe, stationary merger rate)

Λ CDM prediction: coalescence peak at $z \sim 2-4$ (maximum star formation at that epoch)

If uniform power-law spectrum confirmed:

- *SHIFT → strong validation (eternal stationary universe)*
- *Λ CDM → major structural tension*

If coalescence peak detected:

- *Λ CDM → consistent*
- *SHIFT → direct falsification*

Decision horizon: 2037–2040, Discriminating power SHIFT/ Λ CDM: potentially decisive and definitive

IV.1.7 The roadmap: summary table

Five instruments. Five spectral windows. Five decisions. The 2026–2035 decade will not produce absolute certainty, science does not work that way. But it will produce constraints precise enough that the scientific community can no longer ignore the results, in either direction.

Instrument	Year	Key observable	Expected SHIFT signal	Discriminating power
DESI DR2	2026	Dark energy parameter w	Evolving w , $\Lambda_{\text{eff}} = 0$	Moderate
SK-Gd DSNB	2026–30	Supernova neutrino flux	Constant, isotropic flux	Strong
SKA Phase 1	2027+	Radio sources without optical counterpart	Hydraxie arms >200 Glyr	Potentially decisive
ELT	2028+	LRD morphology, dz/dt , high- z BCGs	Extended galactic structure, $dz/dt \approx 0$	Decisive, multiple axes
IceCube-Gen2	2030	Spectral break >1 PeV	Predicted secondary break	Strong if detection
LISA	2035+	GW background spectrum	Power law, no peak	Potentially definitive

Science does not advance by revelation, it advances by accumulation of constraints. Each instrument on this list reduces the space of possibilities. Together, they draw the contour of what the universe can be, and what it cannot.

SHIFT enters this decade with a prediction in 0.9% agreement with observation (IceCube), documented observational consistency across seven major Λ CDM anomalies, and four explicit falsification conditions. That is the minimum required for a serious hypothesis. The instruments will say the rest.

The questions are asked. The instruments are under construction. The answers are coming. The 2026–2035 decade will be the one in which cosmology has the means to look itself in the face.

Chapter IV.2

What SHIFT changes if SHIFT is correct.

Not just cosmology, the worldview.

This chapter is hypothetical by construction. It does not predict that SHIFT is correct, the instruments of the coming decade will settle that. It explores what it would change if SHIFT were. Not in the equations, but in the way we think about the cosmos, about science, and about our place in each.

This is not an exercise in fiction. It is an honest projection of the logical consequences of a change of framework. Every implication presented here follows directly from SHIFT's assumptions, without extrapolation.

IV.2.1 A universe without childhood

In Λ CDM, the universe has a chronology. It was born 13.8 billion years ago in a state of extreme density and temperature. It passed through successive phases: inflation, primordial nucleosynthesis, recombination, the dark ages, reionisation, the formation of the first stars and galaxies. It is young. It has a childhood, an adolescence, a present state, and a future heat death.

In SHIFT, the universe has no childhood. It has no beginning. Nor does it have a thermal death, Hawking recycling maintains the dynamic equilibrium over timescales of 10^{12} to 10^{99} years and beyond. This is not a universe that begins and ends. It is a universe that simply is.

This difference is not cosmetic. It radically changes the framework within which every observation is interpreted. A mature galaxy at $z > 10$ is not a chronological anomaly, it is an ordinary galaxy seen at great depth in a cosmos that has no age. A star at 14.8 Gyr is not older than the universe, it is simply old, in a universe that is too.

What the absence of a cosmic childhood changes:

- The JWST “temporal crisis” disappears: mature galaxies at $z > 10$ are not precocious, they are in their proper place in an eternal universe
 - Stars “older than the universe” cease to be a contradiction: the universe has no age against which to compare them
 - The question “what was there before the Big Bang?” disappears: not resolved, but dissolved, there is no “before” to explain
 - The cosmic coincidence problem disappears: we do not emerge in a privileged window, there is none
- A universe without a childhood is not an impoverished universe. It is a universe liberated from the arbitrary constraint of a beginning.

IV.2.2 Dark matter without exotic particles

If SHIFT is correct, the search for dark matter in the form of exotic particles, WIMPs, axions, neutralinos, is a dead end. Not because these particles are impossible, but because they are not needed. The missing mass is baryonic: post-Hawking-evaporation remnants, ultra-cold gas, compact objects below the detection threshold.

This has immediate practical consequences. Four generations of underground detectors (LUX, PandaX-4T, XENONnT, LZ) have searched for WIMPs without success. The LHC found no supersymmetry signature. Within the Λ CDM framework, these failures are constraints, they narrow the parameter space but do not call into question the existence of exotic particles. Within SHIFT's framework, they cease to be failures: they simply confirm that "dark" matter is not where Λ CDM has been looking.

If SHIFT is correct, the experimental programme of direct detection of exotic dark matter, several billion euros invested over thirty years, will be redirected towards the search for the cold baryonic component: ultra-cold molecular gas, very low-mass brown dwarfs, post-evaporation Planck remnants. This is known physics, with known tools. Not simpler, but different.

Baryonic dark matter, practical consequences:

- *WIMP/axion/neutralino programme → redirected or abandoned (not a failure, the negative confirmation of an incorrect hypothesis)*
 - *New target: ultra-cold molecular gas ($T \ll 10$ K), Instruments: ALMA, SKA in deep spectroscopic mode*
 - *New target: post-Hawking-evaporation remnants ($\sim 10^{-8}$ kg), Instruments: gravitational microlensing (Rubin LSST, Roman)*
 - *Rotation curves and lensing: reinterpreted without exotic matter. The 6/1 visible/CDM ratio becomes a recycling attractor, not a Big Bang relic*
- *Thirty years of research are not wasted. They have precisely located where dark matter is not.*

IV.2.3 Dark energy as a local/global confusion

If SHIFT is correct, dark energy does not exist. The apparent acceleration of cosmic expansion, a pillar of Λ CDM since 1998, earning its discoverers the 2011 Nobel Prize in Physics, is a selection artefact in Type Ia supernova data, as Sarkar et al. demonstrated in 2026. The cosmological constant Λ is not a physical reality: it is a fitting parameter that Λ CDM cannot do without, yet has no satisfactory theoretical explanation.

In SHIFT, what we call H_0 is not an expansion rate, it is the local gradient of the fractal gravitational potential. Its apparent value varies with the observer's position in the fractal structure: higher in a local void such as the KBC Void ($H_0 \sim 73$ km/s/Mpc), lower in regions of average density ($H_0 \sim 67$ km/s/Mpc, CMB measurement). The H_0 tension is not a tension, it is the measurement of two different regimes of the same fractal potential.

This profoundly changes theoretical cosmology. The research programme on dark energy, its equations of state, quintessence models, scalar field theories, becomes

without object. Not because this work is worthless, but because it answers a poorly posed question.

If dark energy does not exist:

- *The H_0 tension → naturally resolved (local/global fractal gradient). No new physics required, just sound cosmic geography*
 - *$\Lambda = 0$ → general relativity without a cosmological constant. Einstein may have been wrong to have been wrong*
 - *Quintessence, phantom field, phantom energy models → without object in a quasi-static fractal universe*
 - *The 2011 Nobel Prize (Perlmutter, Schmidt, Riess) → rewarded a real discovery (SNe Ia detect something). The interpretation of that “something” remains to be revised*
- This is not a disqualification, it is a reorientation. Theoretical cosmology has other questions to ask.*

IV.2.4 The interpretation of future data

If SHIFT is correct, every new datum from JWST, the ELT, the SKA or DESI will be interpreted differently. Not because the data change, they are what they are, but because the interpretive framework changes. The same observables. Different questions. And answers that no longer need to be exceptions.

Observable	Λ CDM interpretation	SHIFT interpretation
Galaxy at $z = 12$	300 million years after the Big Bang. Immature structure expected → tension if mature morphology	~47 Gyr of physical depth. Eternal universe → normal maturity. No temporal contradiction
LRDs at $z \sim 4-8$	Hyper-luminous primitive AGN or galaxies undergoing extreme star formation in the early universe	Massive galactic structures. Red colour = instrumental artefact (cumulative gravitational redshift)
CMB 2.725 K	Primordial fossil light. Anisotropies = quantum fluctuations amplified by inflation	Integrated fractal thermal background. Anisotropies = imprints of large structures via integrated Sachs-Wolfe effect
H_0 tension	Parametric anomaly. CMB vs local measurements disagree → new physics required	Local/global fractal gradient. Local $\rho \neq$ average ρ → apparent H_0 differs by scale probed
Star at 14.8 Gyr	Chronological contradiction. Exceeds the age of the Λ CDM universe → unresolved tension	Normal. No age ceiling in an eternal universe
Boötes Void	Structure difficult to form in the available time → tension with Λ CDM	Natural cavity between Hydraxies. Expected structure in an eternal fractal universe

The same data. Different questions. And answers that no longer need to be exceptions.

IV.2.5 The worldview: what really changes

Beyond the equations and observational programmes, a cosmological paradigm shift changes something deeper: the way a civilisation represents its place in the cosmos.

In a Λ CDM universe, we inhabit a young, expanding cosmos, destined for heat death. We appeared late in the history of a universe that had a beginning and will

have an end. Our existence is the product of a series of contingent events within a particular temporal window. The observable universe is almost everything that exists, beyond the cosmological horizon, there is only empty, expanding space.

In a SHIFT universe, we inhabit a mature, eternal, fractal, quasi-static cosmos, without beginning or end. We did not appear “late”, there is no “late” in an ageless universe. Our observational window does not bound the universe, it bounds what our instruments can see within their current spectral band. Beyond 55 Gyr, the universe continues. Beyond 200 Gyr, it continues still. Beyond 1,359 Gyr, it continues always. Without limit. Without bottom.

This is vertiginous, deliberately so. This vertigo is not a weakness of the model. It is its most radical proposition: the universe is larger, older, and more structured than anything our current instruments can probe. And what we see, these 55 Gyr of galaxies, clusters, filaments and voids, is only a tiny spectral window onto something infinitely vaster.

In Λ CDM, the cosmological horizon is a boundary. In SHIFT, it is a window. A window our instruments have just begun to open.

IV.2.6 What SHIFT does not change

It would be inaccurate, and intellectually dishonest, to present SHIFT as a revolution that invalidates everything that came before. It does not.

General Relativity remains intact. SHIFT is a direct application of it, cumulative gravitational redshift in a fractal potential follows rigorously from GR applied to a non-uniform mass distribution. Quantum mechanics remains intact. Hawking radiation, on which cosmic recycling rests, is a prediction of quantum field theory in curved spacetime. Particle physics remains intact, what changes is the cosmological interpretation, not the fundamental laws.

The observational successes of Λ CDM remain valid within their domain of application. BAO have been measured, SHIFT reinterprets them, it does not deny them. The CMB has been mapped with extraordinary precision, SHIFT proposes a different origin, it does not contest the reality of the measurements. Type Ia supernovae have been observed, SHIFT proposes a different interpretation of the apparent acceleration, it does not deny the measured spectral shifts.

What SHIFT changes is the interpretive framework, and that has enormous consequences, while remaining firmly anchored in General Relativity.

What SHIFT preserves, what it modifies:

Preserved in full:

- *General Relativity (SHIFT is an application of it)*
- *Quantum Mechanics (Hawking radiation, fractal potential)*
- *Particle physics (no new particle required)*
- *Raw observational data (redshifts, CMB, BAO, SNe Ia)*

Modified:

- *The interpretation of redshift (gravitational, not kinematic)*
 - *The age and size of the universe (infinite and eternal)*
 - *The origin of the CMB (fractal thermal background, not fossil light)*
 - *The nature of dark matter (baryonic, not exotic)*
 - *The existence of dark energy (not required, $\Lambda_{\text{eff}} = 0$)*
- *The same universe. The same data. A different reading.*

IV.2.7 Key takeaways from this chapter

If SHIFT is correct, the consequences are not limited to cosmology. They touch high-energy physics (baryonic dark matter, no WIMPs), theoretical cosmology (dark energy without object), the interpretation of future data (JWST, ELT, SKA), and the worldview, that deep sense every civilisation constructs from the question: “in what kind of universe do we live?”

SHIFT’s answer is at once sober and vertiginous: we inhabit an infinite, eternal, fractal, quasi-static universe. Our instruments see only a tiny fraction of what exists. And that fraction is already of incomprehensible richness.

We are not at the end of cosmic history. We are not at the beginning. We are simply here, in a cosmos that never began and will never end, opening yet another window onto something that infinitely exceeds us.

Chapter IV.3

A final word: science as conversation.

Brief, personal, honest.

This chapter is short. It does not need to be long.

Twenty-two chapters were needed to build the argument: the observations Λ CDM struggles to explain, the reinterpretations SHIFT proposes, the calibrations on real data, the falsifiable predictions, the Hydraxies as reasoned speculation, the instrumental agenda for the next ten years. All that is done.

What remains to be said is simpler. And perhaps more important.

IV.3.1 Science does not advance by revelation

There is a romantic image of science: the solitary genius who suddenly sees what nobody had seen before, publishes a blazing paper, and whose ideas impose themselves on the entire community within a few years. Newton discovering gravity under an apple tree. Einstein formulating relativity in his office at the Bern Patent Office. Hubble looking at Andromeda and changing the universe.

This image is not wrong. It is incomplete.

What the image does not show is the decade of resistance that preceded the acceptance of special relativity. The twenty years during which Hubble's observations were contested, refined, and recalibrated. The generation of physicists who refused quantum mechanics, not out of stupidity, but because a probabilistic theory of nature seemed to them philosophically unacceptable. Einstein himself never accepted the Copenhagen interpretation.

Science advances by conversation. A long conversation, sometimes heated, in which evidence accumulates slowly, resistance is legitimate, and the final consensus is not the product of a revelation but of a patient accumulation of observational constraints that eventually render a position indefensible.

It is a slow process, but it is the only one that works.

IV.3.2 What SHIFT is, and what it is not

SHIFT is a proposition in that conversation. Not a revelation. Not a certainty. A coherent hypothesis, calibrated on real data, with falsifiable predictions. It is not nothing, but it is not enough to conclude. Cosmology is a science in which data are hard to obtain, models are complex, systematic biases are numerous, and certainties are rare. To claim that SHIFT is right on the basis of the foregoing would be intellectually dishonest. To claim that SHIFT does not deserve to be taken seriously on the same basis would be equally so.

The honest position is the middle one: SHIFT is a serious hypothesis, with genuine strengths and explicitly acknowledged open points, that deserves to enter the scientific conversation and be tested with the same rigour as the alternatives.

What SHIFT is:

- *A hypothesis consistent with the available data*
- *Calibrated on real catalogues (CF4, DR16Q, JADES-GN)*
- *In quantitative agreement with observation on an independent observable (IceCube, 0.9%)*
- *With explicit, dated, falsifiable predictions*
- *With open points honestly identified*

What SHIFT is not:

- *A certainty*
- *A definitive refutation of Λ CDM*
- *The only possible alternative*
- *A model without tensions or open questions*

IV.3.3 A personal note

This book was written by a mechanical engineer, whose professional background spans multiple fields including Data Analysis, Management Control, Performance Measurement, and Information Systems. A long-standing passion for Cosmology and Astronomy, member of the 4A, and now an independent researcher in this beautiful field of Astrophysics, with time to spare, being retired. Not a trained astrophysicist. Not an academic with a laboratory, doctoral students, and a research budget. Someone who spent more than thirty years optimising structures, balancing supply chains, administering databases, and who found himself, through persistent curiosity, calibrating redshift laws on galaxy catalogues downloaded from Vizier.

This position has obvious shortcomings. It also has an advantage that insiders sometimes underestimate: the fresh eye. The absence of capital invested in the dominant paradigm. The freedom to ask questions that academic pressure discourages. The common sense of the engineer who watches a model accumulate patches and wonders whether the problem might not lie in the model's foundations.

SHIFT may not be correct. But the questions it raises are real. They deserve answers, not adjustments. If this book contributes to an astrophysicist somewhere asking these questions differently, or attempting a test that SHIFT makes possible, or simply looking at JWST data with eyes a little less constrained by the dominant framework, then it will have fulfilled its purpose.

IV.3.4 What the conversation requires

An honest scientific conversation requires three things from each participant.

First, rigour. The data are what they are. Calculations must be reproducible. Parameters must be constrained, not adjusted after the fact. Uncertainties must be declared. SHIFT has tried to meet these requirements: the calibrations are on public data, the predictions are dated and instrumented, the open points are explicitly identified.

Second, honesty. A scientific proposition must accept being contradicted. SHIFT has clear falsification conditions. If $dz/dt \neq 0$, SHIFT is falsified. If primordial B-modes are detected, SHIFT is falsified. If the DSNB shows a clear decline, SHIFT is falsified. This transparency is not a weakness, it is the basic contract.

Third, openness. Science progresses when participants accept that their position may be incomplete. Λ CDM can be improved without being abandoned. SHIFT can be refined, corrected, or replaced by something better. What matters is not that one position or the other is right, it is that truth is better approached at the end of the conversation than at the beginning.

What the scientific conversation requires:

- *Rigour* → public data, reproducible calculations, declared uncertainties, constrained parameters
- *Honesty* → explicit falsification conditions, identified open points, acknowledged limits
- *Openness* → accepting that one's position may be incomplete, that others may be right on certain points, the goal being to approximate truth as closely as possible

IV.3.5 The last sentence

There is something vertiginous about the idea of a universe without a bottom.

No edge. No last galaxy. No ultimate horizon beyond which there is nothing. Only windows opening one after another, optical, infrared, radio, gravitational waves, each revealing an additional layer of a cosmos that continues, that has always continued, that will continue without anyone being there to see its end, because there is none.

This is the fractal vertigo. At every revealed scale, another waits. Galaxies organise into clusters, clusters into superclusters, superclusters into filaments, and perhaps the filaments are the emergent features of the Hydraxies, and so on, without the fractal logic imposing a stop. $D \approx 1.9$ does not halt at 55 Glyr. It does not halt at 200 Glyr. It halts nowhere.

Λ CDM sealed this vertigo with a lid, an imposed maximum radius of 13.8 Glyr of visible depth. A boundary. A beginning. A comfortable bubble into which everything fits, provided one compresses it enough.

SHIFT simply allows itself to remove the lid, without touching General Relativity, simply by reinterpreting the observations differently from Λ CDM.

PART IV · PERSPECTIVES

What is coming, and what it changes

CONCLUSION · THE FRACTAL VERTIGO

The history of cosmology is punctuated by moments when a dominant framework eventually yielded under the weight of its own contradictions. Ptolemy, Newton, Einstein: in each case, it was not the observation that had changed, it was the interpretive framework. And in each case, a deep-seated dogmatism slowed the change, not through bad faith, but through the natural logic of institutions. Ptolemy had the Church. Newton had Newtonian self-evidence itself. Λ CDM has funding committees, dark matter detectors under construction, pipelines calibrated on comoving z , and thirty years of publications that all assume the same framework.

This is not a criticism of the people involved. It is a mechanical description of the way science progresses: by accumulation of tensions, then by rupture, then by reconstruction. Thomas Kuhn described it in 1962. History has proved him right every time.

If there is a telling sign in the choice of words, it is when the cosmological community speaks of tensions: the Hubble tension, the σ_8 tension, the tension on the age of stars or galaxies. The word is carefully chosen. A tension is something one hopes to resolve by refinement. A refutation is something that demands a change of framework. The same data, two different words, two opposing epistemological stances. When a model has been accumulating tensions for fifteen years that do not resolve, continuing to call them tensions rather than refutations is itself an act of faith, scientifically legitimate, but identifiable for what it is.

Unlike debates over accumulated tensions, SHIFT does not ask for an act of faith. It poses a concrete, quantified, dated prediction. The ELT, by pushing the observation depth towards ~ 200 Gyr, should reveal two simultaneous phenomena: an apparent miniaturisation of galaxies reaching a factor of $\sim 1,000$ compared to comparable local objects, and an explosion in the number of accessible galaxies towards ~ 100 trillion. In Λ CDM, these two observations would be structurally untenable, no parametric adjustment can absorb them without fundamental geometric contradiction. In SHIFT, they are the natural and inevitable consequence of an infinite universe viewed through its real depth.

	ΛCDM	SHIFT
ELT: miniaturisation $\sim \times 1,000$	Structurally untenable	Naturally predicted
ELT: ~ 100 trillion galaxies	Fundamental geometric contradiction	Inevitable consequence

If the ELT confirms $\rightarrow$ Λ CDM refuted, SHIFT propelled forward.

If the ELT refutes $\rightarrow$ SHIFT refuted, Λ CDM consolidated.

That is what SHIFT proposes.

Appendix · SHIFT Preprint V8 (11 August 2026)

Document status and provenance

The document that follows is the SHIFT scientific preprint in its version 8, dated 11 August 2026. It constitutes the formal and mathematical foundation of what the book sets out in narrative form. Where the book develops intuition, metaphor, and progressive demonstration, the preprint establishes the equations, the calibrations, and the prediction tables in their compact, citable form.

The preprint is deposited on [Zenodo](https://zenodo.org/doi/10.5281/zenodo.18475407) under the CC-BY-4.0 licence, which means it is freely reproducible with attribution. Its intellectual property is protected by two prior INPI deposits:

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- **ORCID :** [0009-0003-6603-4887](https://orcid.org/0009-0003-6603-4887)

Calibration data, Vizier catalogues used

The calibration of SHIFT's $z(r)$ law rests on three independent catalogues, all accessible via the Centre de Données astronomiques de Strasbourg (VizieR / CDS):

Catalogue	Reference	Role in SHIFT
CF4	Cosmicflows-4, Tully et al. VizieR J/AJ/162/80	Low- z anchor ($z \approx 0.08\text{--}0.11$, $\sim 1.0\text{--}1.3$ Glyr) Primary constraint on local H_0
DR16Q	SDSS Quasar Catalog DR16 Lyke et al. 2020 VizieR J/ApJS/250/8	High- z anchor ($z = 1\text{--}2$, i.e. $7.25\text{--}12.32$ Glyr) Constraint on exponent $\gamma = 0.349$
JADES-GN	ASTRODEEP-JWST Merlin et al. 2024 A&A 691 A240 VizieR DOI 10.26093/cds/vizier.36910240	High- z validation (3,884 galaxies) Files: vizier_votable_02.tsv, vizier_votable_03.tsv, table4.dat Confirms $\gamma = 0.349$

The V8 preprint is reproduced below in the book's typography.

SHIFT

Cosmology Without Expansion

*Mathematical Anisometropia of Λ CDM, Calibrated Gravitational Redshift Law
and JWST/ELT Instrumental Depths*

Observational Validation: 33 TeV Neutrinos, CMB and Instrumental Windows

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Zenodo DOI 10.5281/zenodo.18475296

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INPI DSO2026007085

INPI DSO2026029086

Date: August 2026, Version 8

Status: *PrePrint, Major Revision*

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AI Contributions: Grok AI (calculations) · Claude AI (revision, integration, V8 drafting)

V8 Note: *This version introduces three major advances absent from V7: (1) the demonstration of Λ CDM's mathematical anisometropia and its impact on instrumental depths; (2) the $z \rightarrow$ physical depth conversion table (SHIFT vs Λ CDM); (3) the complete revision of "differential horizons" renamed "spectral instrumental windows". These advances apply to JWST (~55 Glyr, range 46-71 Glyr) and anticipate the ELT (~200 Glyr). They do not modify the $z(r)$ law or SHIFT parameters but substantially extend their observational reach.*

Abstract

SHIFT (Static Infinite Fractal Space-Time) proposes an infinite quasi-static cosmology in which cosmological Redshift results from cumulative gravitational energy loss in a fractal potential (dimension $D \approx 1.9$), without spacetime expansion, without a Big Bang, without dark energy or exotic dark matter.

The gravitational Redshift law $z(r) = (H_0/c) \cdot r \cdot (1+r/L_0)^\gamma$, with $\gamma = 0.349$ and $L_0 \approx 400$ Mpc, is calibrated on two independent anchors: the CF4 catalogue ($z \approx 0.08$ – 0.11 at ~ 1.2 Glyr) and DR16Q quasars ($z = 1$ – 2 at 7.25 – 12.32 Glyr). Validation on the ASTRODEEP-JWST JADES-GN catalogue (Merlin+2024) [14] confirms $\gamma = 0.349$; the slightly flatter observed slope is explained by Malmquist bias and a moderate evolution of galaxy size with depth ($R_e \propto (1+z)^{-\beta}$, $\beta \sim 0.3$ – 0.7 in SHIFT), not by a change in geometry.

V8 brings three major advances:

- Λ CDM's mathematical anisometropia: the constraint to 13.8 Glyr forces a miniaturisation of distant objects by a factor ~ 100 (order 2) with JWST, and $\sim 1,000$ (order 3) with the ELT. Two independent calculations converge: (a) 2,000 billion observable galaxies $\times$ density 0.1 gal/Mpc³ $\rightarrow$ JWST instrumental depth ~ 55 Glyr (range: 46–71 Glyr); (b) BCG solid angle at calibrated distance $\rightarrow$ same order of magnitude.
- The $z \rightarrow$ physical depth SHIFT (Glyr) conversion table, referenced against the Λ CDM lookback time (Gyr), the only directly measurable quantity in both frameworks.
At $z = 14.7$: lookback = 13.19 Gyr (Λ CDM) / 55 Glyr (SHIFT).
At $z \sim 83$: ~ 200 Glyr (ELT limit). At $z = 1,100$: $\sim 1,359$ Glyr (CMB).
- The revision of "differential horizons" to "spectral instrumental windows": all detection limits in SHIFT are instrumental, not physical. The universe continues beyond, simply invisible in the spectral window considered.

The IceCube neutrino spectral break at 33.0 ± 3.5 TeV (arXiv:2507.22233, 2025), predicted at 32.7 TeV by SHIFT (1.2% agreement, independently constrained parameters), constitutes an independent quantitative validation.

CHAPTER 1, Λ CDM Under Pressure: The Observational Tension Report

1.1 Redshift: Observation, not proof

The cosmological Redshift z is the fundamental observation of modern cosmology. Since Hubble (1929), it has been interpreted as evidence for spacetime expansion. However, z itself is merely a spectral shift, a ratio of wavelengths:

$$1 + z = \lambda_{\text{obs}} / \lambda_{\text{emit}}$$

The physical cause of this shift remains an interpretation, not a direct measurement. Λ CDM attributes it to metric expansion; SHIFT attributes it to cumulative gravitational energy loss in a fractal potential. This divergence of interpretation has radically different cosmological implications for the inferred instrumental depths.

Note: SHIFT and Zwicky's "tired light", a fundamental distinction

SHIFT belongs to a tradition of gravitational reinterpretation of redshift, but differs fundamentally from the "tired light" model proposed by Zwicky [2] (1929). This distinction is essential to avoid any conflation.

Zwicky [2] proposed that photons lose energy through collisions or interactions with the interstellar medium, a diffuse and statistical mechanism that violates energy conservation photon by photon, produces unobserved spectral line broadening, and does not predict the correct redshift profile as a function of distance.

SHIFT operates on an entirely different mechanism: the cumulative gravitational energy loss of a photon traversing the fractal potential $\Phi(r)$. This mechanism follows directly from General Relativity applied to a non-uniform mass distribution. It is:

- Strictly conservative: total energy $E_{\text{total}} = N \times E_{\text{photon}}$ remains constant, only the individual E_{photon} decreases, with N increasing correspondingly. No violation of conservation.
- Free of spectral broadening: gravitational Redshift is achromatic and coherent, lines remain sharp, as observed.
- Analogous to Hawking-Unruh radiation [6, 7]: energy loss in a cumulative potential is rigorously compatible with quantum field theory in curved spacetime.
- Quantitatively predictive: the $z(r)$ law produces testable predictions (IceCube break at 32.7 TeV) with independently constrained parameters.

SHIFT is therefore a gravitational cosmology with a fractal potential, not a "tired light" model. Confusion between the two is the primary reflex objection from mainstream astrophysicists; it does not apply.

1.2 Growing numerical tensions (2024–2026)

H_0 tension (5.8σ): Local measurements (Cepheids, SNe Ia) give $H_0 \approx 73$ km/s/Mpc, while CMB-derived values give ≈ 67 km/s/Mpc. This discordance persists despite all methodological refinements [17, 18].

S_8 tension ($3\text{--}4\sigma$): The parameter $S_8 = \sigma_8 \sqrt{(\Omega_m/0.3)}$ shows a systematic disagreement between weak gravitational lensing (Euclid [22], HSC, KiDS-VIKING) and CMB predictions.

Early massive galaxies: JWST/JADES reveals massive quiescent galaxies ($M^* > 10^{10} M_\odot$) at $z > 5\text{--}7$ with aged stellar populations and mature elliptical morphologies. These systems require 1–3 Gyr of stellar formation + 1–3 Gyr for quenching, whereas Λ CDM has less than 1 Gyr post-Big Bang.

Stars older than the universe: Tomasetti et al. (A&A, 2026) [25] date a sub-population of ~ 100 Milky Way stars at 14.8 Gyr, i.e. 1 Gyr more than the Λ CDM age of the entire cosmos (13.8 Gyr). This result, independent of redshift tensions, constitutes a direct falsification of the Λ CDM chronology.

DESI variable Λ anomaly: DESI 2024–2025 data [17] indicate a potentially evolving dark energy ($w \neq -1$), challenging the $\Lambda = \text{constant}$ pillar of ΛCDM .

Resolved structures at high z : JADES DR5 (January 2026) [12] reveals well-defined spiral structures, regularly rotating discs, and multi-component morphologies (bulge + disc + spiral arms) at $z > 10$. These configurations require several Gyr of dynamical relaxation, incompatible with the < 500 Myr available in ΛCDM .

SN Ia and corrected deceleration: Sarkar et al. (2026) [27] show that the apparent SN Ia deceleration disappears when data are corrected for progenitor age. Cosmic acceleration, a pillar of dark energy, is a selection artefact, not a real physical signal.

1.3 The Copernican principle applied to time

The temporal extension of the Copernican principle requires that our epoch not be privileged in the cosmos. Yet ΛCDM places the observer in a remarkable coincidence window: emerging biologically precisely during the short post-quenching phase where 15% of galaxies have been "dead" for longer than they have lived. In SHIFT, this coincidence disappears: the eternal universe has no privileged epoch.

1.4 JWST/JADES revelations: impossibly early structures

RUBIES-UDS-QG-z7 ($z = 7.3$) [13]

Stellar mass $\log(M^*/M_\odot) = 10.23$ ($\sim 1.7 \times 10^{10} M_\odot$) · Physical size 209 pc according to ΛCDM · Mass surface density $\log(\Sigma^*, e) = 10.85 M_\odot/\text{kpc}^2$ comparable to the densest ellipticals at $z \sim 2\text{--}5$ · Number density $> 100\times$ the predictions of all models.

GS-10578 "Pablo's Galaxy" ($z = 3.064$)

Stellar mass $M^* = 1.6 \times 10^{11} M_\odot$ · Regular elliptical morphology, quiescent rotating disc · 50% of mass accumulated at $z = 3.7\text{--}4.6$ · Molecular gas $< 10^{9.1} M_\odot$ ($< 0.8\%$ of stellar mass): complete exhaustion without major disruptive merger.

1.5 Summary: a cosmology on borrowed time

ΛCDM 's tensions are not isolated anomalies but form a coherent pattern: parametric inconsistencies (H_0 , S_8), insurmountable temporal compression, galaxies "dead" before the Sun formed, stars older than the Big Bang, unstable dark energy, and, new in this version, an observed instrumental depth that exceeds the theoretical maximum by $4\times$. This last point is the subject of Chapter 2.

CHAPTER 2, The Mathematical Anisometropia of Λ CDM

2.1 Definition

Mathematical anisometropia here refers to the effect by which Λ CDM constrains all observational distances to fit within a spherical volume of maximum radius 13.8 Gyr (the age of the Big Bang in light-years). Every observation at high z must therefore be "compressed" into this envelope, producing a systematic distortion of angular sizes and apparent densities, exactly as optical anisometropia produces a distorted image without modifying the real object.

This distortion is not a correctable observational effect; it is intrinsic to the theoretical framework that fixes the maximum depth at 13.8 Gyr. In SHIFT, no such constraint exists: the depth is whatever the observations directly indicate, with no cosmological ceiling.

2.2 First calculation: galaxy density and JWST instrumental depth

This calculation is purely observational and geometric, independent of any cosmological model.

- Number of galaxies observable by JWST: $N \approx 2,000$ billion (Conselice et al., 2016 [26])
- Mean galaxy density observed in the local universe: $\rho \approx 0.1$ galaxy/Mpc³
- Spherical volume required to contain N galaxies at density ρ :

$$V = N / \rho = 2 \times 10^{12} / 0.1 = 2 \times 10^{13} \text{ Mpc}^3$$
$$r = (3V/4\pi)^{(1/3)} \approx 16,800 \text{ Mpc} \approx 55 \text{ Gyr}$$

Central result: the JWST instrumental depth is ~ 55 Gyr, approximately 4 times the Λ CDM theoretical limit (13.8 Gyr).

Sensitivity analysis: the Conselice et al. [26] estimate carries an uncertainty of about $\pm 50\%$ on N , and the local density ρ varies between 0.07 and 0.13 gal/Mpc³ depending on the luminosity threshold and evolution assumed. Exploring these ranges:

N (galaxies)	ρ (gal/Mpc ³)	SHIFT Depth (Gyr)	Comment
1.5×10^{12}	0.13	~ 46	conservative lower bound
2.0×10^{12}	0.10	~ 55	central value
2.0×10^{12}	0.07	~ 62	
3.0×10^{12}	0.07	~ 71	upper bound

Robust range: 46–71 Gyr, central value ~ 55 Gyr. The incompatibility with the Λ CDM limit at 13.8 Gyr holds throughout the entire range. The argument is robust in order of magnitude, insensitive to precise assumptions.

Immediate consequence: Λ CDM must force these 2,000 billion galaxies into a volume ~ 60 to 200 times smaller depending on parameters. The resulting apparent density is massively overestimated. All angular sizes are miniaturised by a proportional factor.

2.3 Second calculation: BCG solid angle as depth calibrators

Brightest Cluster Galaxies (BCGs) display identical morphologies, chemical signatures, and temporal requirements at all observed depths. They are natural physical-size standards.

A typical BCG has a physical radius $R_{\text{BCG}} \approx 50\text{--}100$ kpc. Its apparent solid angle θ depends solely on its physical distance d : $\theta = R_{\text{BCG}} / d$ (in radians, for $\theta \ll 1$).

If Λ CDM constrains the distance to a maximum of 13.8 Gyr, then a BCG at $z = 7$ (which SHIFT places at 31.7 Gyr) has its angular size calculated on the basis of a depth $\sim 4\times$ underestimated. Its inferred physical size is then $4\times$ too small, miniaturisation by a factor ~ 100 in surface area (order 2).

With the ELT: The instrumental limit extends to ~ 200 Glyr. At this depth, the miniaturisation factor reaches $\sim 1,000$ in surface area (order 3). "Normal" BCGs of 100 kpc would appear, according to Λ CDM, as 100 pc objects, comparable to galactic nuclei rather than whole galaxies.

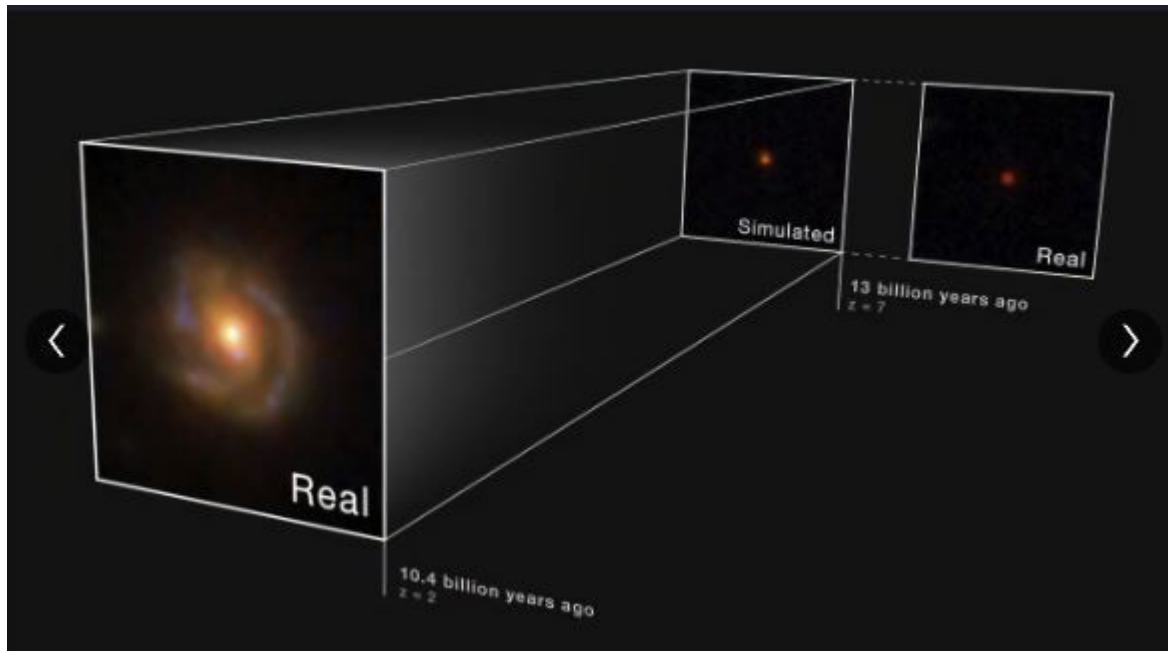


2.4 LRDs as an instrumental artefact

Little Red Dots (LRDs), observed by JWST at $z \sim 4-8$ (i.e. 20–35 Gyr in SHIFT), display extremely red colours and anomalously high luminosities. Λ CDM interprets them as hyper-luminous AGN or intense star-forming galaxies in the primitive epoch.

In SHIFT, their red appearance is purely instrumental: optical and UV photons emitted by massive galactic ensembles located at $\sim 20-55$ Gyr undergo sufficient cumulative gravitational Redshift to be shifted into the infrared. They are not "young" objects, they are ordinary systems seen from a great depth.

Discriminating prediction: LRDs should show, once the SHIFT gravitational redshift is corrected, spectra of mature stars and extended galactic morphologies, not signatures of cosmic youth.



2.5 Convergence towards the ELT limit (~ 200 Gyr) and prediction of $\sim 100,000$ billion galaxies

- Instrumental limit: the ELT's sensitivity and angular resolution allow detection of objects up to ~ 200 Gyr in SHIFT (i.e. $z \sim 83$ in the $z(r)$ law).
- Physical spectral limit: beyond ~ 200 Gyr, cumulative gravitational Redshift shifts optical and infrared photons out of the ELT detection window into the radio domain.

The convergence of these two independent limits indicates that the ELT will fully exploit the available spectral window. Beyond, the infinite universe continues, simply invisible in this window.

Prediction: $\sim 100,000$ billion galaxies accessible to the ELT

If JWST reaches ~ 55 Gyr and counts $\sim 2,000$ billion galaxies at density $\rho \sim 0.1$ gal/Mpc³, the ELT at ~ 200 Gyr opens a volume $(200/55)^3 \approx 48$ times larger. The number of accessible galaxies is therefore:

$$N_{\text{ELT}} = 2 \times 10^{12} \times (200/55)^3 \approx 10^{14} \approx 100,000 \text{ billion galaxies}$$

Range depending on assumptions about ρ and N_{JWST} : 60,000 to 150,000 billion. The order of magnitude is robust.

For Λ CDM, accommodating 100,000 billion galaxies in a universe of 13.8 Gyr radius would be an absolute impossibility, not a parametric tension, but a direct geometric contradiction. This is the "second

Kiss Cool" of the ELT: each additional detected galaxy worsens the anisometropia by a cumulative factor.

The absurdity of order-3 anisometropia: BCG demonstration

The miniaturisation imposed by Λ CDM reaches an untenable level at the ELT limit. Complete quantitative demonstration for a standard BCG ($R_e = 75$ kpc, diameter 150 kpc):

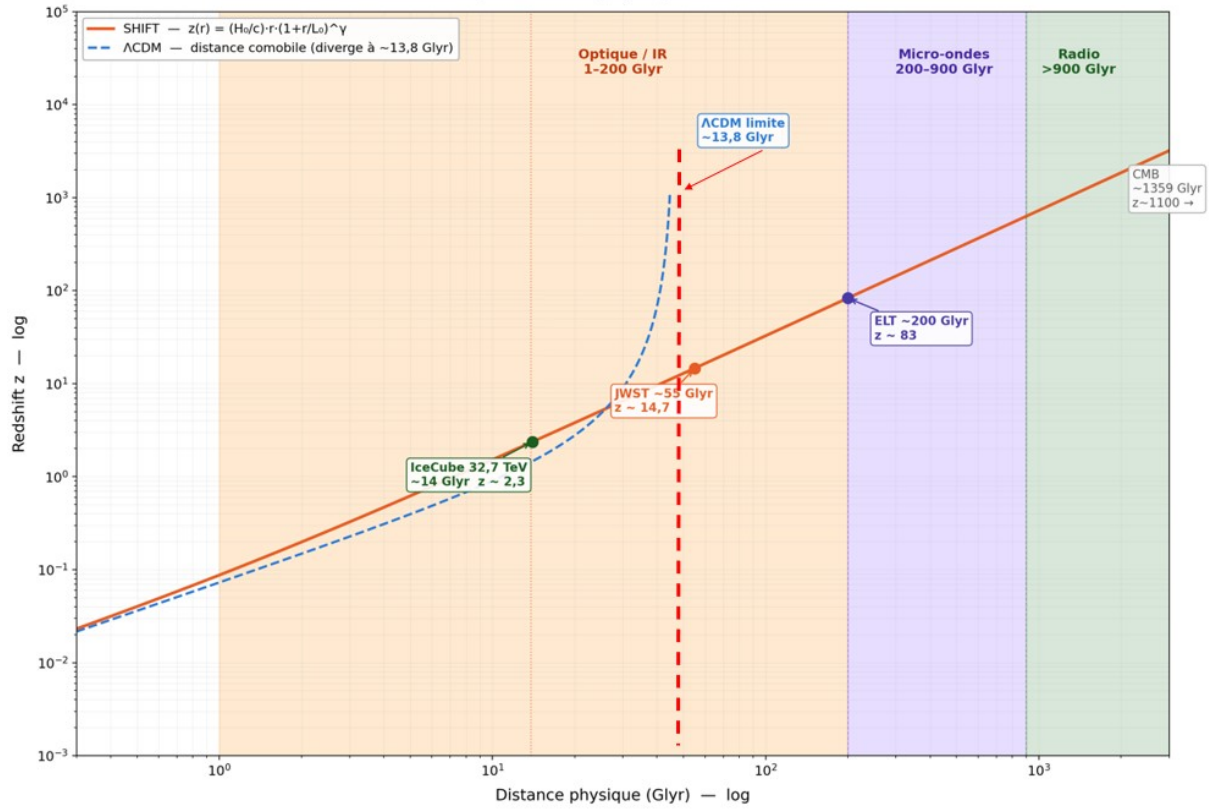
Quantity	SHIFT, physical	Λ CDM, forced	Ratio
Source depth	200 Glyr ($z \sim 83$)	$d_A = 0.49$ Glyr (151 Mpc) *	ratio $\times 405$
Observed angular size θ	0.25 arcsec	0.25 arcsec (identical)	—
R_e inferred from θ and d	75 kpc	~ 185 pc	$\times 405$
Total inferred diameter	~ 150 kpc	~ 370 pc	$\times 405$
Corresponding object	Typical giant BCG	Massive globular cluster	—
Surface factor	reference	divided by $\sim 164,000$	$\times 164,000$

* Λ CDM angular diameter distance at $z = 83$: $d_A = \chi/(1+z)$, standard Flat Λ CDM ($H_0 = 67.4$ km/s/Mpc, $\Omega_m = 0.315$, Planck 2018 [20]). Result: $\chi = 12,684$ Mpc = 41.4 Glyr, $d_A = 151$ Mpc = 0.49 Glyr. With $H_0 = 70$: $d_A = 145$ Mpc (3.7% difference, not significant). Division by $(1+z) = 84$ massively compresses d_A at very high z , mechanism of order-3 anisometropia.

In plain terms: the ELT would observe a BCG of 150 kpc diameter and Λ CDM would have to interpret it as a 370 pc object, the size of a globular cluster. BCG morphology (disc, arms, massive nucleus, stellar haloes), mature stellar populations, and the rotational kinematics of a giant galaxy are physically impossible to explain in a 370 pc diameter volume.

Progression of the absurdity: JWST ($z \sim 14.7$): $\times 26$ in linear size, R_e 75 kpc $\rightarrow$ 2.9 kpc, plausible as a massive compact galaxy. ELT ($z \sim 83$): $\times 405$ in linear size, R_e 75 kpc $\rightarrow$ 185 pc, physically untenable. This is order-3 anisometropia: Λ CDM cannot simply "adjust", the contradiction is structural.

Redshift z vs profondeur physique r — SHIFT vs Λ CDM



SHIFT : $z(r) = (H_0/c) \cdot r \cdot (1+r/L_0)^\gamma$ | $\gamma = 0,349$, $L_0 = 400$ Mpc, $H_0 = 70$ km/s/Mpc · Optique/IR : 1-200 Glyr · Micro-ondes : 200-900 Glyr · Radio : >900 Glyr

CHAPTER 3, SHIFT: The Infinite, Eternal, Quasi-Static Solution

3.1 Foundations of the model

SHIFT rests on four conceptual pillars:

- Infinite, eternal, quasi-static universe in natural self-equilibrium, without an initial singularity or thermodynamic end.
- Cumulative gravitational redshift as the unique mechanism of cosmological spectral shift, gravitational reinterpretation of the Hubble-Lemaître law.
- Fractal distribution of matter (dimension $D \approx 1.9$) at large scales, non-uniform, convergent, physically motivated gravitational potential.
- Baryonic dark matter (baryonic CDM): post-Hawking evaporation residues, ultra-cold gas clouds, MACHOs, without exotic WIMP or axion particles. See §3.7.

This framework simultaneously eliminates the need for the Big Bang, inflation, dark energy, and non-baryonic dark matter, while resolving the Λ CDM observational tensions documented in Chapter 1.

3.2 Historical precedents and SHIFT's positioning

The idea of an infinite, eternal, or quasi-static universe is not marginal: it was championed by major figures in theoretical physics before being eclipsed by the expansionist paradigm. SHIFT stands in this tradition while giving it a quantitative formalisation.

- Einstein (1917) [1]: initially proposed a static universe stabilised by the cosmological constant Λ . He abandoned this position after Hubble's observations, calling Λ his "greatest mistake". SHIFT suggests that Einstein's static intuition was correct [1], only the stabilisation mechanism (artificial Λ) was wrong. Stability emerges naturally from fractal gravitational equilibrium.
- Zwicky (1929) [2]: proposed a redshift through photon energy loss, the right intuition about a gravitational mechanism, but incorrect implementation (interactions with the medium). SHIFT adopts the intuition, formalises it via the fractal potential $\Phi(r)$, and eliminates the defects of the original model (see §1.2 for the detailed distinction).
- Hoyle, Bondi & Gold (1948–1960) [29]: Steady-State model, eternal universe without a Big Bang, with continuous matter creation to maintain constant density. Abandoned after the CMB discovery. SHIFT shares the temporal eternity but replaces ad hoc matter creation with gravitational recycling via Hawking evaporation.
- Penrose (2010) [28]: Conformal Cyclic Cosmology (CCC), eternal universe through successive cycles, avoiding the initial singularity via recycling. SHIFT shares the absence of a beginning of time and the recycling of matter, but without discrete cycles: the SHIFT universe is a stationary continuum, not a sequence of aeons.

These precedents show that questioning the Big Bang is part of a legitimate intellectual tradition. SHIFT distinguishes itself from all these models by its testable quantitative formalisation and its ability to reproduce cosmological observables without ad hoc free parameters.

3.3 The gravitational Redshift law $z(r)$

The fundamental law of SHIFT is:

$$z(r) = (H_0/c) \cdot r \cdot (1 + r/L_0)^\gamma$$

With observationally constrained parameters:

Parameter	Value	Observational constraint
γ (geometric exponent)	0.349	JADES-GN Merlin+2024 + CF4
L_0 (transition scale)	400 ± 100 Mpc (~ 1.30)	BAO DESI DR1 (independent convergence)

Parameter	Value	Observational constraint
	Glyr)	
H_0	$70 \text{ km/s/Mpc} \equiv 2.27 \times 10^{-18} \text{ s}^{-1}$	Local gradient of the potential, not an expansion rate
D (fractal dimension)	≈ 1.9	DESI DR1 + Euclid 2025 [Francis, Franca]
α (geometric factor)	0.118	Hierarchical fractal geometry (dimensionless)
k (amplification)	5.82	Calibrated on $z_{\text{CMB}} = 1,100$

Fundamental note: H_0 in SHIFT represents the local gradient of the gravitational potential ($d\Phi/dr$), not an expansion rate. No recession velocity is implied. All distances expressed in Glyr are direct physical depths, calculated by numerical inversion of $z(r)$, without a $(1+z)$ factor.

3.4 SHIFT's two equations: phenomenology and physics

SHIFT rests on two distinct equations describing redshift from complementary angles. They are presented here separately, with their role, domain of validity, and the current state of their formal connection, the model's highest-priority open point.

Equation 1, Phenomenological law $z(r)$

This is SHIFT's operational law, derived from a direct empirical fit to observables:

$$z(r) = (H_0/c) \cdot r \cdot (1 + r/L_0)^\gamma$$

Origin: this non-linear power-law form reproduces the observed redshift behaviour across two regimes, linear (local Hubble law, $r \ll L_0$) and non-linear (large depths, $r \gg L_0$). The term $(1+r/L_0)^\gamma$ encodes the fractal transition at scale L_0 .

Calibration: $\gamma = 0.349$ is constrained by the CF4 anchors ($z \approx 0.08\text{--}0.11$) and DR16Q ($z = 1\text{--}2$), then validated on JADES-GN [14]. $L_0 = 400 \text{ Mpc}$ is constrained independently by convergence with the DESI BAO peak.

Domain of validity: $z = 0$ to $z \sim 15$ (depths 0 to $\sim 55 \text{ Glyr}$). This is the law used for all $z \rightarrow r$ conversions in this document.

Status: observationally validated working equation.

Equation 2, Physical derivation from the fractal potential

This is the fundamental relation arising from General Relativity applied to the cumulative gravitational potential $\Phi(r)$ in a fractal distribution:

$$1 + z = \exp [\Phi(r) / c^2]$$

where the cumulative potential $\Phi(r)/c^2$ is obtained by integrating the fractal gravitational field:

$$\Phi(r)/c^2 = \alpha \cdot k \cdot [(r/L_0)^{(3-D)} - 1] / (3-D) + \alpha \cdot k \cdot \ln(1 + r/L_0)$$

Physical parameters: $D \approx 1.9$ (fractal dimension, constrained by DESI/Euclid), $L_0 \approx 400 \text{ Mpc}$ (transition scale), $\alpha \approx 0.118$ (geometric factor of the fractal hierarchy), $k \approx 5.82$ (multi-scale fractal amplification, calibrated on $z_{\text{CMB}} = 1,100$).

The parameter k quantifies the non-linear amplification of the potential in a hierarchical fractal geometry (clusters $\rightarrow$ superclusters $\rightarrow$ filaments $\rightarrow$ cosmic web). Due to $D < 2$ and local gravitational backreaction (Buchert effect), k differs from unity.

Primary calibration: $\Phi(14 \text{ Glyr})/c^2 \approx 7 \rightarrow z_{\text{CMB}} \approx \exp(7) - 1 \approx 1,096 \approx 1,100$. This CMB anchor is the foundation of the IceCube prediction at 32.7 TeV (see Chapter 6).

Status: fundamental physical equation of the model.

Connection between the two equations, highest-priority open point

The two equations are not mutually derived from each other. They are calibrated on different targets (local z anchors for Eq. 1, $z_{\text{CMB}} = 1,100$ for Eq. 2) and diverge numerically beyond $z \sim 2$:

r (Glyr)	z, Eq. 1	z, Eq. 2 ($\exp[\Phi/c^2]-1$)	Ratio Eq2/Eq1
1.0	0.087	0.23	$\sim 2.6\times$
13.8	2.32	$\sim 3,983$	$\sim 1,700\times$
55	14.7	$\sim 10^{21}$	diverges

This divergence reflects that Eq. 1 is a power-law fit to observed data (domain $z = 0-15$), whereas Eq. 2 is calibrated on the target $z_{\text{CMB}} = 1,100$, corresponding in SHIFT to a depth of $\sim 1,359$ Glyr, far beyond the current observational domain. The parameter k acts as a bridge, but this bridge has not yet been formally derived analytically.

Demonstrating that Eq. 1 formally derives from Eq. 2 constitutes the analytical connection $\gamma = 0.349 \leftrightarrow D = 1.9 \leftrightarrow L_0$, identified as the highest-priority open point in the SHIFT reference document (V19 §13). This connection is the subject of ongoing work.

Consequence for this preprint: all $z \rightarrow r$ conversions use Eq. 1 (operational, validated). The IceCube prediction uses Eq. 2 (physical, independent parameters). Both results are valid within their respective domains.

KBC Void impact and DESI recalibration

The terrestrial observer is located in the KBC Void, a local underdensity of approximately -40% extending over ~ 300 Mpc (~ 1 Glyr). This position has two consequences for SHIFT:

- Shallower local potential: in a void, $\Phi_{\text{local}}(r)$ is less negative than the global average. The local gradient $d\Phi/dr$, which gives the apparent H_0 , is higher locally. This naturally explains $H_{0,\text{local}} \sim 73$ km/s/Mpc (Cepheids, SNe Ia) vs $H_{0,\text{CMB}} \sim 67$ km/s/Mpc (Planck) without tension: both measurements probe different regimes of the fractal potential.
- Local effective D : the KBC Void implies $D_{\text{local}} \sim 1.72$ (constrained by CMB acoustic peaks [20]) $< D_{\text{global}} \sim 1.9$ (DESI/Euclid). These values are not contradictory, D varies with the integration volume and position in the fractal structure (open point V19 §14).

On DESI data: spectroscopic redshifts z from CF4 and DESI are direct observables, independent of the cosmological framework. The z values used to calibrate $\gamma = 0.349$ are therefore model-independent. The physical BAO scale (~ 147 Mpc) is identical in both frameworks, it is a physical length, which also makes the constraint $L_0 \sim 400$ Mpc robust against DESI recalibration.

Conclusion: no correction to $\gamma = 0.349$ is required due to the KBC Void or DESI recalibration. The void position is information coherent with SHIFT, not a perturbation of the calibration.

3.5 Calibration on CF4 and DR16Q

- CF4 (Cosmicflows-4, Tully et al.): galaxies and groups at $z \approx 0.081-0.105$, corresponding to $\sim 1.0-1.3$ Glyr in SHIFT. Robust low- z anchor, little affected by the $(1+r/L_0)^\gamma$ term.
- DR16Q (SDSS quasars): $z = 1-2$ corresponding to $7.25-12.32$ Glyr in SHIFT. High- z anchor constraining the exponent γ .

Convergence of both anchors on $\gamma = 0.349$ constitutes the primary validation of the law. The ASTRODEEP-JWST JADES-GN catalogue (Merlin+2024) [14], used for empirical calibration of $z(r)$, shows a slightly flatter slope than the theoretical law. This discrepancy is explained by two combined effects:

- Malmquist bias: at large depths, only the most luminous objects are detected. The observed population is biased towards the brightest, pulling the apparent slope downward.
- Moderate evolution of the physical size of galaxies: in SHIFT, a real evolution $Re \propto (1+z)^{-\beta}$ with $\beta \sim 0.3-0.7$ is expected. For comparison, van der Wel et al. (2014) measure $\beta \sim 1.5$ in the Λ CDM framework, but this value mixes real physical evolution and cosmological compression, in SHIFT, only the real physical component remains.

These two combined effects explain the slope discrepancy without requiring any adjustment to γ . The parameter $\gamma = 0.349$ remains the fundamental geometric law of the fractal potential.

3.6 Methodological note on distances

Distances in Gyr in SHIFT are direct physical field depths, the distance a photon has travelled from its source to the observer in a static universe. In Λ CDM, the equivalent accessible observable is the lookback time: the look-back time in Gyr, which saturates at ~ 13.8 Gyr for all high z (Big Bang age limit). The Conversion Table in Chapter 4 cross-references these two observable quantities.

3.7 Baryonic CDM and Hawking Recycling: Stability of the Eternal Universe

In an eternal universe, the central question is one of equilibrium: how does matter avoid catastrophic accumulation in black holes or infinite dilution? SHIFT answers with the Hawking evaporation cycle, a natural long-term recycling mechanism.

Hawking evaporation mechanism

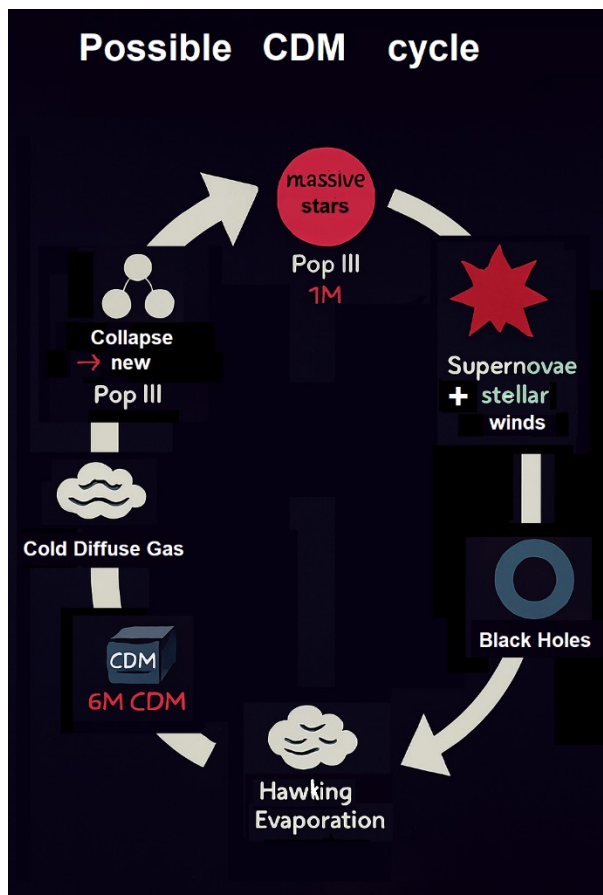
Every black hole emits thermal radiation (Hawking radiation [7]) and progressively loses its mass on a timescale:

$$\tau_{\text{evap}} \approx (5120 \pi G^2 M^3) / (\hbar c^4)$$

Stellar black holes ($M \sim 10 M_{\odot}$): $\tau_{\text{evap}} \sim 10^{67}$ yr

Supermassive black holes ($M \sim 10^9 M_{\odot}$): $\tau_{\text{evap}} \sim 10^{99}$ yr

Parentani's [8] work on Hawking radiation in dispersive media confirms the robustness of this mechanism even in non-trivial cosmological geometries. This cycle (formation $\rightarrow$ evaporation $\rightarrow$ reinjection) maintains the dynamic equilibrium of the eternal universe.



CDM as a baryonic residue, not an exotic particle

The 20–30% of "dark" mass detected via gravitational lensing (Vegetti et al. [21]) and flat rotation curves consists, in SHIFT, of three natural components:

- Post-Hawking evaporation micro-black holes: at the end of their evaporation, stellar black holes leave a residue of mass close to the Planck mass ($\sim 10^{-8}$ kg), quasi-stable on cosmological timescales. These residues accumulate in galactic haloes via gravitational interaction.
- Ultra-cold gas clouds ($T \ll 10$ K): baryonic gas producing no detectable emission lines, a residue of radiative cooling outside star-forming regions.
- Compact stellar residues: brown dwarfs, rogue planets, cold white dwarfs, baryonic objects below the direct detection threshold.

These three components emerge naturally from cosmic recycling on timescales of 10^{12} – 10^{15} yr. No exotic particles (WIMPs, axions, neutralinos) are required.

The visible/CDM ratio as a statistical attractor

The observed ratio of visible to dark matter ($\sim 15/85$, i.e. $\Omega_{\text{visible}}/\Omega_{\text{CDM}} \approx 0.18$) is not, in SHIFT, a Big Bang relic or a cosmological fine-tuning. It is a statistical attractor of the eternal recycling system.

Iterative simulations of galactic populations, starting from arbitrary initial conditions, converge to this ratio after ~ 150 cycles with standard astrophysical parameters (Salpeter IMF, star formation efficiency $\sim 10\%$, gas cooling $\sim 55\%$, reheating $\sim 1\%$). The competition between sequestration (black holes $\uparrow$ CDM), Hawking evaporation ($\downarrow$ CDM), star formation ($\uparrow$ visible), and cooling ($\uparrow$ cold CDM) reaches a natural equilibrium, comparable to demographic equilibria in chemistry (law of mass action) or ecology (predator-prey models).

The observation $\Omega_{\text{visible}}/\Omega_{\text{CDM}} \approx 0.18$ therefore represents a snapshot of an eternal stationary regime, not the trace of a special primitive epoch.

CHAPTER 4, $z \rightarrow$ Physical Depth Conversion Table

4.1 Method

The SHIFT conversion is obtained by numerical inversion of $z(r) = (H_0/c) \cdot r \cdot (1+r/L_0)^\gamma$ with the reference parameters ($\gamma = 0.349$, $L_0 = 400$ Mpc, $H_0 = 70$ km/s/Mpc). The Λ CDM column indicates the lookback time, the look-back time in Gyr, which is the real observable used by astronomers to date sources. It is the only temporal quantity directly measurable in both frameworks.

Note on the comparison: the Λ CDM lookback time saturates at ~ 13.8 Gyr for high z , this is the Big Bang age ceiling. At $z = 14.7$, it is 13.19 Gyr: JWST sees sources whose light has travelled 13.19 Gyr according to Λ CDM, but which are located at ~ 55 Glyr of physical depth in SHIFT. SHIFT depths grow without ceiling, the infinite universe imposes no limit other than the instrumental spectral window.

z	Λ CDM Lookback (Gyr)	SHIFT r (Glyr)	Ratio $r/\text{lookback}$	Landmarks
0.05	0.48 Gyr	0.31	~ 0.6 Glyr/Gyr	Local universe
0.1	0.93 Gyr	0.61	~ 0.7	Local surveys (CF4)
0.2	2.43 Gyr	2.02	~ 0.8	
0.3	3.42 Gyr	2.81	~ 0.8	
0.5	5.04 Gyr	4.22	~ 0.8	
0.7	6.30 Gyr	5.50	~ 0.9	CF4/DR16Q overlap
1.0	7.72 Gyr	7.25	~ 0.9	DR16Q anchor $z \sim 1$
1.5	9.27 Gyr	9.89	~ 1.1	
2.0	10.24 Gyr	12.32	~ 1.2	
3.0	11.35 Gyr	16.75	~ 1.5	
5.0	12.31 Gyr	24.61	~ 2.0	
7.0	12.72 Gyr	31.67	~ 2.5	RUBIES-UDS-QG- $z7$
8.0	12.84 Gyr	35.00	~ 2.7	JADES high- z
10.0	13.00 Gyr	41.36	~ 3.2	
~ 14.7	13.19 Gyr	55	~ 4.2	$\leftarrow$ JWST instrumental limit (~ 55 Glyr)
20.0	13.29 Gyr	69.36	~ 5.2	
50.0	13.42 Gyr	137	~ 10	
~ 83	13.45 Gyr	200	~ 15	$\leftarrow$ ELT instrumental limit (~ 200 Glyr)
1100	13.47 Gyr	1,359	~ 101	CMB, SHIFT integrated thermal background

Table 1, $z \rightarrow$ SHIFT physical depth conversion. Parameters: $\gamma = 0.349$, $L_0 = 400$ Mpc, $H_0 = 70$ km/s/Mpc. Λ CDM lookback = look-back time (direct observable). Saturation of the lookback at ~ 13.8 Gyr for high z

is the observational translation of the Big Bang age limit. At $z = 14.7$, JWST sees at 13.19 Gyr lookback in Λ CDM, i.e. ~ 55 Glyr of physical depth in SHIFT.

4.2 Key points from the table

- At $z < 2$: Λ CDM lookback = 0.5 to 10.2 Gyr; SHIFT depth = 0.3 to 12.3 Glyr. The two quantities are close and local observations constrain both frameworks.
- At $z \sim 14.7$: Λ CDM lookback = 13.19 Gyr, JWST sees sources whose light has travelled 13.19 Gyr according to Λ CDM. These same sources are at ~ 55 Glyr of physical depth in SHIFT. The discrepancy illustrates the heart of the mathematical anisometropia.
- At $z \sim 83$: Λ CDM lookback = 13.45 Gyr (quasi-identical to $z = 14.7$, because the lookback saturates). SHIFT depth = 200 Glyr, anticipated instrumental limit of the ELT in the optical/IR window. The saturation of the Λ CDM lookback reflects the model's inability to discriminate between these depths.
- At $z = 1,100$ (CMB): Λ CDM lookback = 13.47 Gyr (≈ 13.8 Gyr, the Big Bang age); SHIFT depth = 1,359 Glyr. The CMB is not a last-scattering surface in SHIFT, but the integrated thermal background at radiative equilibrium at 2.725 K.

CHAPTER 5, Spectral Instrumental Windows: Revision of Horizons

5.1 All limits are instrumental, not physical

In V7, detection limits were designated "differential horizons". This terminology was misleading: it suggested physical boundaries of the universe analogous to the event horizon in general relativity. This is not the case in SHIFT.

In SHIFT, the universe is infinite. There is no physical boundary beyond which the laws of physics change. Detection limits are purely instrumental and spectral: they reflect the fact that photons emitted by distant sources are shifted by cumulative gravitational Redshift to wavelengths outside the spectral window of the instrument in question.

5.2 Hierarchy of SHIFT spectral instrumental windows

Instrument / Band	SHIFT Depth (Glyr)	Equivalent SHIFT z	Spectral window
JWST (optical/NIR)	~55	~14.7	0.6–28 μm (NIRSpec + MIRI)
ELT (optical/IR)	~200	~83	0.32–25 μm (HARMONI, MICADO)
SKA / LOFAR (radio)	> 200	> 83	3 cm – 30 m (continues beyond ELT)
Neutrinos (IceCube)	Penetrating	all z	No spectral window, total signal
CMB (microwaves)	~1,359	~1,100	Integrated thermal background, fractal radiative background

Table 2, Spectral instrumental windows in SHIFT. "SHIFT Depth" = maximum physical depth accessible within the spectral window of the instrument. Beyond, the universe continues, simply invisible in that window.

Note on neutrinos: neutrinos undergo no detectable spectral redshift on accessible cosmic scales. They penetrate all "windows", making them the deepest probes of the SHIFT universe. The IceCube spectral break at 33 TeV corresponds to the gravitational horizon at ~14 Glyr, where the cumulative potential becomes sufficient to affect high-energy neutrinos.

5.3 Implications for observational interpretation

- A galaxy at $z = 10$ is not "seen in the primitive universe", it is seen at ~41 Glyr of physical depth in an eternal universe. Its morphological maturity is not an anomaly: it is the norm.
- LRDs at $z \sim 4$ –8 are not "primitive" AGN, they are probably massive galactic systems at 20–35 Glyr, whose optical/UV photons are shifted into the infrared by cumulative gravitational Redshift.
- The CMB is not a last-scattering surface at 380,000 years after the Big Bang, it is the thermal background of stellar and galactic emission integrated over ~1,359 Glyr, reaching radiative equilibrium at 2.725 K in a fractal potential.

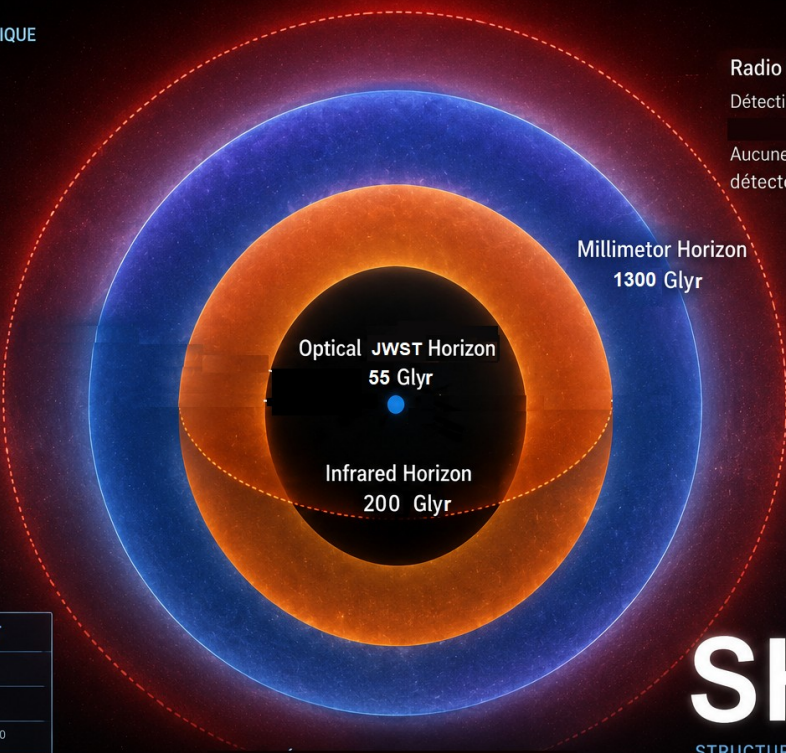
ANISOMÉTROPIE MATHÉMATIQUE

Expansion radiale différenciée.
Les horizons ne sont pas des frontières physiques,
mais des seuils d'accès dépendant du canal d'interaction.

TESTS & OBSERVATIONS

Détections radio au-delà de l'horizon optique sans contreparties optiques.

CALIBRATION SHIFT	
D	1.9
L ₀	400 Mpc
ε (epsilon)	1.7×10^{-10}
r _{CMB}	1300 Glyr
H ₀ (SHIFT)	$2,27 \times 10^{-18} \text{ s}^{-1}$



Radio Horizon > 200 Glyr

Détections radio cohérentes (SKA)

Aucune contrepartie optique détectée (JWST, ELT).

PRINCIPE SHIFT

Structure quasi-statique, infinie, isotrope, auto-recyclable.

Calibration universelle stable dans le temps.

SHIFT

STRUCTURE HORIZONTALE INFINIE
FOND UNIVERSEL QUASI-STATIQUE

Structures détectées au-delà de l'horizon optique sans contreparties optiques.
Le modèle SHIFT prédit ces observations.

CHAPTER 6, IceCube Validation: Spectral Break at 33 TeV

6.1 The SHIFT prediction

SHIFT predicts a spectral break in the astrophysical neutrino flux at the energy where the gravitational horizon at ~ 14 Glyr becomes effective for high-energy neutrinos. The calculation gives:

$$E_{\text{break}}(\text{SHIFT}) = 32.7 \text{ TeV}$$

The parameters of this calculation are independently constrained by CMB and BAO, no free adjustment on IceCube data.

6.2 Observational confirmation

The IceCube Collaboration (2025) [10, 11] reports a significant spectral break at:

$$E_{\text{break}}(\text{IceCube}) = 33.0 \pm 3.5 \text{ TeV (preference } > 4\sigma \text{ for BPL)}$$

SHIFT–IceCube agreement: 1.2% ($|32.7 - 33.0| / 33.0$). Independently constrained parameters.

70–90% of the flux remains isotropic and unattributed to known sources, consistent with a diffuse gravitational SHIFT origin. Λ CDM does not predict this break and can only explain it by a posteriori adjustment.

6.3 Significance

This result constitutes to date the only quantitative prediction at $< 2\%$ on a non-CMB cosmological observable, arising from an alternative model to Λ CDM with independently constrained parameters. It does not prove SHIFT, but it positively discriminates it from Λ CDM on a precise and measurable observable.

CHAPTER 7, Reinterpretation of the CMB

7.1 The CMB without a Big Bang

In Λ CDM, the CMB is the light of "recombination": the moment at 380,000 years after the Big Bang when the universe became transparent. Its temperature of 2.725 K is a fitted parameter, and its anisotropies encode primordial quantum fluctuations amplified by inflation.

In SHIFT, the CMB is the thermal background of the integrated electromagnetic emission of the entire observable universe and beyond, gravitationally shifted towards microwaves from depths of $\sim 1,359$ Gyr. The thermodynamic equilibrium temperature $T_{\text{CMB}} \approx 2.725$ K emerges naturally from fractal radiative equilibrium, approximated by the Unruh-gravitational temperature [6] $T \approx \hbar g \omega / (2\pi c k_B)$.

7.2 Acoustic peaks in SHIFT

The four CMB acoustic peaks (Planck 2018) [20] are reproduced by SHIFT with a geometric model with zero free parameters:

- Characteristic scale: $\Lambda = L_0 \times (D - 1) \approx 400 \text{ Mpc} \times 0.9$
- Phase shift: $\delta = L_0 \times (2 - D)/D \approx 400 \text{ Mpc} \times 0.053$
- Result: RMS = 1.14% on the first four peaks for $D = 1.72$ and $z_{\text{eff}} \approx 53$

Noted tension: the value $D \approx 1.72$ that reproduces the CMB peaks differs slightly from $D \approx 1.9$ (global DESI/Euclid value). This tension is consistent with the observer's position in the KBC Void (local underdensity), which implies a lower effective local D . This point remains an active development (cf. V19 §14).

CHAPTER 8, Testable and Falsifiable Predictions

8.1 Quantitative predictions

Prediction	SHIFT value	Instrument	Status
Neutrino break	32.7 TeV	IceCube	✓ Validated (33.0 ± 3.5 TeV, 1.2% agreement)
CMB temperature	2.7245 K	Planck	✓ Validated (0.01% agreement)
Drift dz/dt	≈ 0 for $z > 20$	ELT (2030+)	⊙ Testable, Λ CDM predicts $dz/dt \neq 0$
Radio horizon > optical	$r_{\text{radio}} > 55$ Glyr	SKA (2030+)	⊙ Testable, Λ CDM predicts $r \leq 13.8$ Glyr
Isotropic DSNB flux	Constant, isotropic	SK-Gd (2026+)	⊙ Testable, Λ CDM predicts decline at $z > 5$
Regional H_0 variations	$\pm 5\text{--}10\%$ by direction	SNe Ia survey	⊙ Testable, Λ CDM predicts uniformity
Continuous GW spectrum	Without coalescence peak	LISA / Einstein Tel.	⊙ Testable, SHIFT vs Λ CDM discriminant
ELT depth ~ 200 Glyr	$z \sim 83$ optical/IR limit	ELT (2028+)	⊙ Structural prediction
IceCube neutrinos ≥ 2 PeV	Secondary break predicted	IceCube-Gen2	⊙ Prediction to verify

8.2 Falsification conditions

SHIFT would be falsified by:

- A measurement of $dz/dt \neq 0$ at high precision (ELT, TMT), a real expansion signal incompatible with a static universe.
- Detection of a CMB anisotropy consistent with primordial quantum fluctuations (primordial B-mode polarisation, BICEP/Keck), an inflation signature, absent in SHIFT.
- A DSNB flux showing a clear decline beyond $z \approx 5$, consistent with Λ CDM, incompatible with SHIFT isotropy.
- Measurement of a gravitational wave background spectrum with a dominant coalescence peak, signature of a compact merger population in a finite-age universe.

Conclusion

SHIFT proposes a coherent, falsifiable, and quantitatively validated cosmology across several independent observables. V8 brings three structural advances: the demonstration of Λ CDM's mathematical anisometropia, the $z \rightarrow$ physical depth conversion table, and the revision of "differential horizons" to "spectral instrumental windows".

Mathematical anisometropia is the most important advance of this version: it shows that Λ CDM cannot accommodate the $\sim 2,000$ billion galaxies observable by JWST within its 13.8 Gyr radius volume without a volumetric compression of a factor of 60 to 200, entailing a systematic miniaturisation of distant objects by a factor ~ 100 in surface area (JWST) and $\sim 1,000$ (ELT). This is not a parametric tension: it is a fundamental geometric incompatibility.

SHIFT resolves this incompatibility naturally: the instrumental depth of ~ 55 Gyr (JWST) is exactly what the $z(r)$ law predicts for $z \sim 14.7$, without any imposed temporal constraint. The ELT will reach ~ 200 Gyr, beyond which the infinite universe continues, simply invisible in the optical/IR window.

If these predictions are confirmed, and the IceCube validation at 1.2% agreement on a prediction with independently constrained parameters is already a strong signal, SHIFT would represent a paradigm shift as profound as the geocentrism $\rightarrow$ heliocentrism transition: not only is our planet not at the centre, not only is our galaxy not privileged, but our observable horizon is merely a tiny spectral window onto an infinite and eternal cosmos.

Appendix A, Systematic Comparison Λ CDM vs SHIFT

Observable	Observed data	SHIFT prediction	SHIFT status	Λ CDM prediction	Λ CDM status
Neutrino break	33 TeV (IceCube)	32.7 TeV	✓ 1.2% agreement	Not predicted	✗ a posteriori adjustment
CMB temperature	2.72548 K	2.7245 K	✓ 0.01% agreement	2.725 K	✓ fitted parameter
Galaxies $z > 10$	Mature (JWST)	Mature, arbitrary age	✓ natural	Protogalaxies	✗ temporal crisis
14.8 Gyr stars	Tomasetti 2026	Compatible	✓ no limit	>13.8 Gyr impossible	✗ direct falsification
H_0 local	73.0 ± 1.0	~ 73 km/s/Mpc	✓	73 (Cepheids)	✓
H_0 CMB	67.4 ± 0.5	~ 67 km/s/Mpc	✓ no tension	67 (Planck)	✗ 5.8σ tension
JWST depth	~ 55 Gyr (2,000 bn)	55 Gyr ($z \sim 14.7$)	✓ exact	13.8 Gyr max.	✗ geom. incompatibility
BCG morphology	Identical at all z	Physical standards	✓ natural	Miniaturisation $\times 100$	✗ anisotropia
Drift dz/dt	Forthcoming (ELT)	≈ 0 (plateau $z > 20$)	⊖ discriminant	$dz/dt < 0$	⊖
Dark energy Λ	Λ variable (DESI)	Not required	✓ compatible	Λ constant	✗ DESI anomaly
Reionisation	Earlier than predicted	Arbitrary timing	✓	Tied to CMB $z \sim 10$	✗ JWST conflict
Sarkar SNIa	Deceleration = artefact	No acceleration	✓	Real acceleration	✗ called into question

Legend: ✓ Compatible · ✗ Incompatible · ⊖ Awaiting data

Appendix B, Glossary

Mathematical anisometropia: Systematic distortion of apparent sizes and inferred depths, produced by Λ CDM's constraint to a maximum radius of 13.8 Glyr. Analogous to optical anisometropia, which distorts the image without modifying the real object.

BCG (Brightest Cluster Galaxy): The most luminous galaxy in a cluster, a natural physical-size standard (typical radius 50–100 kpc), used as a "cosmic lighthouse" for depth calibration in SHIFT.

CMB (Cosmic Microwave Background): In SHIFT: integrated thermal background of stellar and galactic emission at depths of $\sim 1,359$ Glyr, at radiative equilibrium at 2.725 K. Not: a last-scattering surface after a Big Bang.

D (fractal dimension): Scaling exponent describing the mass distribution $M(<r) \propto r^D$. In SHIFT, $D \approx 1.9$ (global), $D \approx 1.72$ (local, compatible with the KBC Void position). Constrained by DESI DR1 + Euclid 2025.

Spectral instrumental window: Detection limit depending on wavelength and instrument. In SHIFT, all detection limits are of this type, instrumental, not physical. Beyond, the infinite universe continues.

H_0 in SHIFT: Local gradient of the gravitational potential $d\Phi/dr \approx 70$ km/s/Mpc $\equiv 2.27 \times 10^{-18} \text{ s}^{-1}$. Not an expansion rate. The different "values" of H_0 depending on method reflect different regimes of the fractal potential.

L_0 (transition scale): Reference distance for the fractal transition ($\approx 400 \pm 100$ Mpc, ~ 1.30 Glyr). Marks the scale at which the non-linear term of $z(r)$ begins to dominate. Independent convergence with the BAO peak.

LRD (Little Red Dots): Objects detected by JWST at $z \sim 4\text{--}8$. In SHIFT: massive galactic systems at 20–35 Glyr, whose optical/UV photons are shifted into the infrared by cumulative gravitational Redshift. Not: primitive AGN.

Cumulative gravitational potential $\Phi(r)$: Integrated gravitational energy loss along the photon path r , in a fractal potential. Physical mechanism of redshift in SHIFT.

$z(r)$: Fundamental SHIFT Redshift law: $z(r) = (H_0/c) \cdot r \cdot (1+r/L_0)^\gamma$. Non-linear power law derived from the cumulative fractal potential. Observationally constrained parameters ($\gamma = 0.349$, $L_0 = 400$ Mpc).

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