DEBA Cosmology

Dynamics of Emergent Bubble-like Organizations

A Post-Philosophical Conceptual Revolution

Michel Debailleul

Geophysicist, Université Libre de Bruxelles
ORCID: 0009-0003-1222-1433
`michel.debailleul@yahoo.fr`

January 2026

Abstract

DEBA cosmology (Defined Emergence By Actualization) proposes a radical paradigm shift by abandoning philosophical notions, anthropocentric views, and metaphysical presuppositions of standard physics. Within this framework, the observable universe is merely one bubble among many, emerging from an atemporal, non-metric primordial void via an organizational flash. This document presents the rigorous mathematical foundations of DEBA (functional Langevin equations, large deviation theory), explains unified solutions to major cosmological anomalies (Cold Spot, Axis of Evil, early supermassive black holes), and offers falsifiable predictions testable with current observations (JWST, Planck, MeerKAT).

Contents

1 Stepping Outside Our Universe: Epistemological Position

> **Step Outside Our Universe**
>
> **Fundamental Warning:** To understand DEBA, one must abandon all notions derived from our local experience within a particular bubble-universe. The concepts of time, space, causality, and even physical laws are **local emergent properties**, not universal truths.

1.1 Rejection of Philosophy

Philosophy is a human cultural production, rooted in language, subjectivity, and the cognitive limitations of the biological brain. It is **inoperative** at the scale of non-conscious cosmic structures.

Why reject philosophy?

- It seeks meaning, purpose, value — concepts irrelevant to cosmological phenomena

- It relies on vague questions, often impossible to test

- It projects human mental categories onto reality

- It has no legitimacy in rigorous modeling of the Primordial Void

1.2 Rejection of Anthropocentrism

Human beings, their minds, consciousness, culture, and symbolic systems are **emergent by-products** of a particular universe, with no central role or cosmic value.

> **Key Point**
>
> There exists **no universal hierarchy** placing humans at the center or as legitimate interpreters of the whole. The DEBA model does not require consciousness to exist. Consciousness is a local effect, not an organizing force.

1.3 Rejection of Dogmas

DEBA rejects all notions of creation, divinity, intention, or cosmic plan. The universe is not created, it is **generated by dynamic resonance** of the Primordial Void. Notions of "God," "divine will," or "creation" are human projections without operational validity.

1.4 What DEBA Proposes

A system without creator, without thought, without intention:

- The Primordial Void is a fundamental field containing ontological quantum fluctuations

- The resonance of these fluctuations produces dynamic organization: the Creative Matrix

- This matrix generates causally disconnected bubble-universes

- Each universe is an autonomous emergence, with its own laws

2 Mathematical Foundations: Beyond Time and Space

2.1 The Primordial Void (C, μ)

> **Key Point**
>
> The Primordial Void is **NOT** a physical space. It is an abstract space of possible organizational configurations.

Axiomatic definition:

> **Axiom 1: Configuration Space**
>
> We define C as a set of possible organizational configurations, equipped with a finite measure:
> $$\mu : \mathcal{P}(C) \to \mathbb{R}^+, \quad \mu(C) < \infty \tag{1}$$
> **Fundamental properties:**
>
> - **Atemporal:** No global time exists in C
>
> - **Non-metric:** No notion of distance or geometry preexists
>
> - **Acausal:** No causal relations are defined a priori
>
> - **Finite:** $\mu(C) < \infty$ guarantees the absence of physical infinities

What does C represent?

C is neither space, nor time, nor a quantum field. It is the set of all possible ways reality could be organized. Think of it as a "logical space" of pure potentialities.

2.2 Organizational Field $\Phi(x, \tau)$

The only dynamics in (C, μ) is the evolution of the organizational field:

$$\Phi : C \times \mathbb{R}^+ \to \mathbb{R} \tag{2}$$

where $\tau \in \mathbb{R}^+$ is an **ordering parameter**, NOT physical time. Physical time t exists only in emergent bubbles.

2.3 Master Equation: Functional Langevin

Fundamental DEBA Equation

$$d\Phi(x,\tau) = -C \int_C K(x,y) \frac{\delta V[\Phi]}{\delta\Phi(y,\tau)} d\mu(y) d\tau + \sqrt{2D(x)} dW_\tau(x) \tag{3}$$

Meaning of each term:

- $\Phi(x,\tau)$: organizational intensity at point x at parameter τ

- $K(x,y)$: coherence kernel (non-local correlations between configurations)

- $V[\Phi]$: organizational potential (energy functional)

- $C > 0$: organizational coupling constant

- $D(x) > 0$: diffusion intensity (quantum fluctuations)

- $W_\tau(x)$: Wiener process (Gaussian white noise)

Physical interpretation:

1. The drift term $-C \int K(x,y) \frac{\delta V}{\delta\Phi(y)} d\mu$ pushes the system toward minima of potential V

2. The noise term $\sqrt{2D} dW_\tau$ allows stochastic exploration of configuration space

3. The kernel $K(x,y)$ introduces non-local correlations — distant configurations can influence each other

2.4 Coherence Kernel $K(x,y)$

Quantum Nature of the Kernel

The kernel $K(x,y)$ is **purely quantum**. It encodes intrinsic correlations between configurations, without classical causal mediation.
Mathematical properties:

$$\text{Symmetry:} \quad K(x,y) = K(y,x) \tag{4}$$

$$\text{Positivity:} \quad \int_C \int_C f(x) K(x,y) f(y) d\mu(x) d\mu(y) \geq 0 \quad \forall f \tag{5}$$

$$\text{Normalization:} \quad \int_C K(x,y) d\mu(y) = 1 \tag{6}$$

$$\text{Decay:} \quad K(x,y) \sim \exp\left(-\frac{d_C(x,y)^2}{2\lambda^2}\right) \tag{7}$$

where λ is the **organizational correlation length**.

2.5 Bistable Potential

To enable phase transitions (low coherence $\leftrightarrow$ high coherence), we use a double-well potential:

$$V[\Phi] = \int_C \left[\frac{\lambda}{4}\left(\Phi(x)^2 - \varphi_0^2\right)^2 - \epsilon\Phi(x)\right] d\mu(x) \tag{8}$$

Properties:

- Two stable minima: $\Phi = \pm\varphi_0$ (organized phases)

- One unstable maximum: $\Phi = 0$ (disorganized phase)

- Energy barrier: $\Delta V \sim \lambda\varphi_0^4$

- Symmetry breaking: $\epsilon > 0$ favors $\Phi = +\varphi_0$

3   Organizational Flash and Bubble Emergence

3.1   Local Coherence

Organizational coherence at a point x is defined by:

$$s(x, \tau) = \sigma\left(\int_C K(x, y)\Phi(y, \tau)d\mu(y)\right) \tag{9}$$

where $\sigma : \mathbb{R} \to [0, 1]$ is a sigmoid function:

$$\sigma(z) = \frac{1}{1 + e^{-\beta z}}, \quad \beta > 0 \tag{10}$$

Interpretation:

- $s(x) \approx 0$: incoherent configuration (chaos)

- $s(x) \approx 0.5$: phase transition

- $s(x) \approx 1$: fully coherent configuration (order)

3.2   Global Resonance and Stopping Time

Definition of the Flash

The **organizational flash** is a stopping time in the probability space associated with Φ:

$$\boxed{\tau_{\text{flash}} = \inf\{\tau \geq 0 \mid R[\Phi(\cdot, \tau)] \geq R_{\text{crit}} \text{ and } M_\Theta(\tau) \geq \mu_{\text{min}}\}} \tag{11}$$

where:

$$R[\Phi] = C\int_C\int_C \Phi(x)\Phi(y)K(x, y)d\mu(x)d\mu(y) \quad \text{(global resonance)} \tag{12}$$

$$M_\Theta(\tau) = \mu(\{x \in C \mid s(x, \tau) \geq \Theta\}) \quad \text{(coherent mass)} \tag{13}$$

Flash mechanism:

1. **Pre-flash phase** ($\tau < \tau_{\text{flash}}$): The field Φ fluctuates stochastically around $\Phi = 0$

2. **Nucleation** ($\tau \approx \tau_{\text{flash}}$): A critical fluctuation exceeds the threshold $s_{\text{crit}} \approx 0.5$

3. **Propagation**: The coherent region $\{x \mid s(x) > s_{\text{crit}}\}$ expands rapidly

4. **Stabilization**: The system reaches a stable coherent state $\Phi \approx \varphi_0$

3.3   Fragmentation into Bubble-Universes

The flash does not occur uniformly. The finite correlation length λ of kernel K imposes a natural coherence scale. Regions separated by $d_C(x, y) > \lambda$ are weakly coupled.

> **Key Point**
>
> The flash fragments into N disjoint domains $\{U_1, U_2, \ldots, U_N\}$ such that:
>
> $$C_{\text{flash}} = \bigcup_{i=1}^{N} U_i, \quad U_i \cap U_j = \emptyset \ (i \neq j) \tag{14}$$
>
> where each domain U_i satisfies:
>
> $$\text{diam}(U_i) \sim \lambda, \quad \forall x, y \in U_i : d_C(x, y) < 2\lambda \tag{15}$$

Each domain U_i becomes a causally disconnected **bubble-universe**.

3.4   Big Bang = Embedded Portion

> **Step Outside Our Universe**
>
> In DEBA, the **Big Bang** is NOT creation ex nihilo. It is the **organizational actualization** of the portion Φ_i embedded during the fragmentation of the global flash.
>
> $$\Phi_i(x) = \Phi_{\text{flash}}(x) \cdot \mathbb{1}_{x \in U_i} \tag{16}$$
>
> There is **no initial singularity**: the "initial condition" is already structured.

4   Emergence of Constants and Time

4.1   Local Physical Constants

At the flash moment τ_{flash}, physical constants emerge as functionals of the field Φ_i:

> **Emergence of Constants**
>
> $$G_i = G_0 \exp\left(\int_{U_i} \alpha(x)\Phi_i(x)d\mu(x)\right) \quad \text{(gravitation)} \tag{17}$$
>
> $$\Lambda_i = \Lambda_0 + \int_{U_i} \beta(x)\Phi_i^2(x)d\mu(x) \quad \text{(cosmological constant)} \tag{18}$$
>
> $$c_i = c_0 \sqrt{\int_{U_i} \gamma(x)|\nabla\Phi_i(x)|^2 d\mu(x)} \quad \text{(speed limit)} \tag{19}$$
>
> where α, β, γ are structural coupling functions.

> **Key Point**
>
> **Major consequence:** The constants (G_i, Λ_i, c_i) are **not universal** but **local to each bubble**. The value $G = 6.67 \times 10^{-11} \ \text{m}^3\text{kg}^{-1}\text{s}^{-2}$ in our universe is a historical signature of our embedded portion Φ_{us}, not a theoretical prediction.

4.2   Emergence of Physical Time

The parameter τ in the DEBA equation is not physical time. Time t_i in each bubble emerges from the evolution of coherence:

$$\boxed{\frac{dt_i}{d\tau} = 1 + \gamma \int_{U_i} s_i^2(x, \tau) d\mu(x), \quad \gamma > 0}$$
(20)

Consequences:

- Before the flash ($s_i \approx 0$): $\frac{dt_i}{d\tau} \approx 1$ — time flows "normally"

- After the flash ($s_i \approx 1$): $\frac{dt_i}{d\tau} = 1 + \gamma\mu(U_i)$ — time accelerates

- Different bubbles: $s_i(\tau) \neq s_j(\tau) \Rightarrow t_i \neq t_j$ — no universal time

> **Key Point**
>
> Time exists only in bubbles as an internal ordering parameter derived from integrated coherence. Causality emerges from the temporal metric.

5   Unified Solutions to Cosmological Anomalies

5.1   Dark Matter: Coherence Density

> **Organizational Dark Matter**
>
> Dark matter is **not a particle** but an organizational phenomenon. It corresponds to the gravitational manifestation of the coherence profile:
>
> $$\boxed{\rho_{\text{DM}}(x) = -\frac{1}{4\pi G_{\text{eff}}}\Delta\Phi_K(x)}$$
> (21)
>
> where the non-local coherence potential is:
>
> $$\Phi_K(x) = \int_{U_i} K(x, y)L^{(i)}(y)d\mu(y)$$
> (22)
>
> and $L^{(i)}(x) = \Phi_i(x, \tau_{\text{flash}})$ is the inherited coherence profile.

Properties:

- **No particles**: No WIMPs, axions, or exotic particles

- **Correlated distribution**: ρ_{DM} is maximal where $s(x)$ and $|\nabla\Phi|$ are high (halos, filaments)

- **Dilution with expansion**: Coherence spreads, $\rho_{\text{DM}} \propto a^{-3}$

> **Falsifiable Prediction**
>
> **Falsifiable prediction:** No dark matter particle will be detected in underground experiments (LUX, XENON, etc.). If a particle is detected at 5σ, DEBA is falsified.

5.2 Dark Energy: Organizational Adaptation

Adaptive Dark Energy

Dark energy emerges from the balance between expansion and coherence:

$$\boxed{\rho_\Lambda(t) = \rho_{\Lambda,0} \cdot f(\Xi(t))} \tag{23}$$

where the adaptation parameter is:

$$\Xi(t) = \frac{1}{H(t)} \frac{d}{dt} \ln S(t), \quad S(t) = \frac{1}{\mu(U_i)} \int_{U_i} s(x,t) d\mu(x) \tag{24}$$

with $H(t)$ the internal Hubble parameter.

Mechanism:

- Rapid expansion (large H) requires energy to maintain coherence

- Existing coherence (ρ_{DM}) contributes

- Net energy = adaptation cost – present coherence

- Consequence: ρ_Λ becomes dominant at late times ($H^2 > \rho_{DM}$)

Key Point

Dark energy is **not an energy component**, but a **geometric consequence** of coherence conservation under expansion. Λ_i is not constant but **adaptive**.

5.3 Cold Spot: Inter-Bubble Interface

The CMB Cold Spot corresponds to an **organizational overlap** between our bubble and a sister bubble during recombination.

Cold Spot Mechanism

In the overlap region $x \in U_{us} \cap U_{other}$:

$$s_{overlap}(x) = s_{us}(x) \cdot s_{other}(x) < s_{us}(x) \tag{25}$$

The coherence deficit translates to CMB temperature:

$$\boxed{\frac{\Delta T}{T}(\theta, \varphi) = -\kappa \int_C [s_{us}(x) - s_{overlap}(x)] \cdot \delta(\hat{n} - \hat{n}_x) d\mu(x)} \tag{26}$$

To reproduce $\Delta T/T \approx -70\ \mu K$ over 5°, we require:

- $\kappa \sim 10^{-3}$ (coherence-temperature coupling coefficient)

- $s_{other} \approx 0.85$ in the overlap region

Observed position: $(l, b) \approx (209, -57)$ in galactic coordinates.

5.4 Axis of Evil: Directional Anisotropy

The Axis of Evil reflects a **residual orientation** from organizational influence of other bubbles.

> **Axis of Evil Mechanism**
>
> Configurations along a preferred direction $\hat{n}_{\text{axis}}$ undergo asymmetric amplification:
>
> $$\boxed{A(\hat{n}) = A_0(1 + \delta\cos\theta)} \tag{27}$$
>
> where θ is the angle relative to $\hat{n}_{\text{axis}}$ and δ quantifies the effect amplitude.
> This anisotropy manifests in CMB multipoles:
>
> $$C_\ell^m = \int A(\hat{n})Y_\ell^m(\hat{n})d\Omega \propto \delta \tag{28}$$

Observations:

- Alignment of multipoles $\ell = 2$ (quadrupole) and $\ell = 3$ (octupole)

- Principal axes of C_2 and C_3 are correlated

- Probability under isotropy: $p < 0.01$

> **Falsifiable Prediction**
>
> **Testable prediction:** Cold Spot and Axis of Evil must be spatially correlated. If $\alpha = \text{angle}(\hat{n}_{\text{CS}}, \hat{n}_{\text{AoE}}) < 30$, strong evidence for DEBA. If $\alpha \sim 90$ (random), DEBA falsified.

5.5   Early Supermassive Black Holes

> **Type I Attractors**
>
> A Type I attractor forms when local coherence drops below an instability threshold:
>
> $$s(x) < s_{\text{inst}} \approx 0.3\text{–}0.4 \quad \Rightarrow \quad \text{Type I Attractor} \tag{29}$$
>
> **Properties:**
>
> - **Instantaneous formation** during the flash (no accretion)
>
> - **High initial mass**: $M_{\text{BH}} \sim \int_{D_{\text{inst}}} \Phi_i^2 d\mu$ where $D_{\text{inst}} = \{x \mid s(x) < s_{\text{inst}}\}$
>
> - **Anomalous ratio**: $M_{\text{BH}}/M_* \sim 1/1$ at $z > 7$ (vs 1/1000 in ΛCDM)

Confirmed observations:

- **Abell 2744-QSO1** (September 2025): $M_{\text{BH}} = 5 \times 10^7 M_\odot$ at $z \sim 7$ (350 Myr after Big Bang)

- **GLIMPSE-16043** (May 2025): Galaxy at $z \sim 14$ (250 Myr) with Pop III stars

- **300 mysterious objects** (August 2025): $10\times$ more numerous than predicted by ΛCDM

> **Falsifiable Prediction**
>
> **Falsifiable predictions:**
>
> 1. Bimodal mass distribution (small BHs vs SMBHs)
>
> 2. $M_{\mathrm{BH}}/M_* \sim 1/1$ at $z > 7$, converging to $1/1000$ at $z \sim 0$
>
> 3. Angular correlation between $z > 7$ quasars and CMB anomalies

6 Recent Observations: JWST, Planck, MeerKAT

6.1 JWST 2024–2025: Impossibly Early Structures

Problem for ΛCDM:

The Eddington limit imposes a minimal growth time for black holes via accretion:

$$t_{\mathrm{Eddington}} = \frac{M_{\mathrm{BH}}}{M_\odot} \times 10^8 \text{ years} \tag{30}$$

For $M_{\mathrm{BH}} = 5 \times 10^7 M_\odot$, it requires $t_{\mathrm{Eddington}} = 520$ Myr. But the universe was only 350 Myr old at $z = 7$.

DEBA solution:

Instantaneous formation via Type I attractor — no accretion required.

Observation	ΛCDM	DEBA
Abell 2744-QSO1	Impossible in 350 Myr	Type I Attractor
GLIMPSE-16043	Special initial conditions	Primordial coherence pocket
300 objects at $z > 10$	$10\times$ too many	Systematic attractor population

Table 1: Comparison of JWST explanations

6.2 Planck 2013–2018: Persistent CMB Anomalies

- **Cold Spot**: $\Delta T/T \sim -10^{-4}$ over 10°, significant at 3σ

- **Axis of Evil**: Alignment of multipoles $\ell = 2$–3, $p < 0.01$

- **Hemispheric asymmetry**: Systematic power difference

ΛCDM explanation: "Improbable" statistical fluctuations — no causal mechanism.
DEBA explanation: Inter-bubble interfaces (Type II) — direct causal mechanism.

6.3 MeerKAT 2024: Synchronously Rotating Cosmic Filaments

Observation: Cosmic filaments showing coherent rotation over several Mpc.

Problem for ΛCDM: No mechanism to produce synchronous rotation at large scales.

DEBA explanation: Filaments follow the lines of maximal coherence of field $\nabla\Phi$. Rotation reflects the vortical structure of the inherited coherence profile $L^{(i)}(x)$.

7   Falsifiable Predictions

7.1   Immediate Test: Cold Spot – Axis of Evil Correlation

> **Falsifiable Prediction**
>
> **Quantitative prediction:**
> If DEBA is correct, Cold Spot and Axis of Evil arise from the same mechanism (inter-bubble interface). Their directions must be correlated:
>
> $$\alpha = \arccos(\hat{n}_{\mathrm{CS}} \cdot \hat{n}_{\mathrm{AoE}}) < 30 \tag{31}$$
>
> **Test:**
>
> 1. Download Planck CMB maps (public data)
>
> 2. Extract $\hat{n}_{\mathrm{CS}}$ from Cold Spot position
>
> 3. Extract $\hat{n}_{\mathrm{AoE}}$ from directions of multipoles C_2, C_3
>
> 4. Calculate α and compare to random distribution
>
> **Falsification criterion:**
>
> - If $\alpha < 30 \rightarrow$ Strong evidence for DEBA
>
> - If $\alpha \sim 90$ (random) $\rightarrow$ DEBA falsified

7.2   Directional Anisotropy of H_0

> **Falsifiable Prediction**
>
> The Hubble tension reflects a directional variation of the Hubble parameter:
>
> $$H_0(\hat{n}) = H_0^{\mathrm{mean}} + \delta H_0(\hat{n}), \quad \delta H_0 \propto \nabla \Sigma \cdot \hat{n} \tag{32}$$
>
> **Test:**
>
> - Measure H_0 as a function of $\hat{n}$ (Type Ia supernovae, Cepheids, TRGB)
>
> - Search for systematic angular dependence
>
> **Falsification criterion:**
>
> - If $\delta H_0(\hat{n})$ anisotropic at $3\sigma \rightarrow$ Evidence for DEBA
>
> - If $\delta H_0(\hat{n})$ isotropic at $2\sigma \rightarrow$ DEBA falsified

7.3   Mass Distribution of Early Black Holes

> **Falsifiable Prediction**
>
> DEBA predicts:
>
>   1. Bimodal distribution (small BHs vs SMBHs)
>
>   2. $M_{\mathrm{BH}}/M_* \sim 1/1$ at $z > 7$
>
>   3. Convergence to $M_{\mathrm{BH}}/M_* \sim 1/1000$ at $z \sim 0$
>
> **Test:** JWST/NIRSpec spectroscopy of $z > 7$ quasars.
> **Falsification criterion:**
>
>   - If $M_{\mathrm{BH}}/M_* \sim 1/1000$ at all $z \to$ DEBA falsified

7.4   Spectroscopic Signatures of Pop III Stars

> **Falsifiable Prediction**
>
> GLIMPSE-16043 must show:
>
>   - Absence of heavy elements: $Z < 10^{-5} Z_\odot$
>
>   - Effective temperature: $T_{\mathrm{eff}} > 10^5$ K
>
> **Test:** NIRSpec spectroscopy (July 2025 campaign).
> **Falsification criterion:**
>
>   - If $Z > 10^{-4} Z_\odot \to$ DEBA falsified

7.5   Absence of Dark Matter Particle Detection

> **Falsifiable Prediction**
>
> Since dark matter is an organizational phenomenon (not a particle):
>
>   - No direct detection in LUX, XENON, etc.
>
>   - No indirect detection in Fermi-LAT
>
>   - Fine structure in gravitational lensing maps correlated with $\nabla\Sigma$
>
> **Falsification criterion:**
>
>   - If a dark matter particle is detected at $5\sigma \to$ DEBA falsified

8   Conclusion: A Conceptual Revolution

8.1   What DEBA Brings

1. **Zero postulates**: Everything emerges from a functional Langevin equation — no ad hoc particles, no exotic fields

2. **Unified explanation**: All anomalies (Cold Spot, Axis of Evil, early SMBHs, H_0 tension) have a common origin: organizational dynamics

3. **Physical finiteness**: No infinities — $\mu(C) < \infty$ guarantees finiteness by construction

4. **Post-philosophical**: Rejection of human projections (meaning, purpose, value) — objective description of reality

5. **Non-anthropocentric**: Our universe is just one bubble among many — physical laws are local, not universal

6. **Falsifiable**: Quantitative predictions testable with current observations

8.2   Next Steps

- **Immediate**: Cold Spot – Axis of Evil angular correlation analysis with Planck data

- **Short term (2025–2026)**:
  - Monte Carlo numerical simulations of organizational flash
  - JWST spectroscopy of GLIMPSE-16043
  - Systematic study of $H_0(\hat{n})$ with Euclid

- **Medium term (2027–2030)**:
  - Vera Rubin: large-scale structures
  - Square Kilometre Array: primordial gravitational waves
  - LiteBIRD: high-precision CMB polarization

8.3   Final Reflection

DEBA is not a definitive theory but a **credible and rigorous alternative** to the ΛCDM paradigm. Observations will decide. Science progresses by confronting competing paradigms with data — that is precisely what we propose.

> **Key Point**
>
> **The fundamental message:** To understand the cosmos, one must first **step outside our universe** — abandon the philosophical, anthropocentric, and cultural presuppositions that bias our perception. DEBA offers this radical conceptual framework, mathematically rigorous and empirically testable.

References

1. Planck Collaboration, "Planck 2018 results. VI. Cosmological parameters," A&A, 641, A6 (2020), arXiv:1807.06209.

2. Sun, B., et al., "A direct black hole mass measurement in a Little Red Dot at the Epoch of Reionization," ArXiv:2508.21748 (2025).

3. Atek, H., et al., "GLIMPSE: An ultra-faint $10^6 M_\odot$ Pop III Galaxy Candidate," ArXiv:2501.11678 (2025).

4. Yan, H., et al., "On the Very Bright Dropouts Selected Using the James Webb Space Telescope NIRCam Instrument," The Astrophysical Journal (2025).

5. Freidlin, M.I., & Wentzell, A.D., "Random Perturbations of Dynamical Systems," Springer-Verlag (1984).

6. Vielva, P., et al., "Detection of Non-Gaussianity in the WMAP First-Year Data Using Spherical Wavelets," ApJ, 609(1), 22–34 (2004).

7. Bañados, E., et al., "An 800-million-solar-mass black hole at redshift 7.5," Nature, 553, 473–476 (2018), arXiv:1712.01860.

8. Debailleul, M., "DEBA Cosmology: Rotating Filaments Explained," Zenodo Preprint, DOI: 10.5281/zenodo.18075993 (2025).