

DEBA: Deterministic Emergence By Actualization A Unified Cosmological Framework from Atemporal Foundations

Michel Debailleul
Geophysicist
Belgium
michel.debailleul@yahoo.fr

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We propose DEBA (Deterministic Emergence By Actualization), a complete cosmological framework resolving numerous outstanding problems through organizational emergence from atemporal foundations. Starting from a non-geometric, acausal configuration space (\mathcal{C}, μ) , we demonstrate that: (1) The Big Bang is not a creative singularity but the embarked portion Φ_i of an organizational flash; (2) Physical time emerges as an internal metric parameter; (3) Effective constants $\{G_i, \Lambda_i, c_i\}$ are functionals of the stabilized portion; (4) Dark matter manifests as stabilizing coherence; (5) Dark energy represents dynamic adaptation; (6) CMB anomalies (Cold Spot, Axis of Evil) arise naturally from intra-beam bubble interactions; (7) Primordial black holes form as organizational condensation nodes, explaining JWST observations; (8) All physical quantities remain rigorously finite. The framework makes specific falsifiable predictions testable with current and near-future observations.

Introduction: The Crisis in Contemporary Cosmology

Foundational Problems

The Λ CDM model, while remarkably successful at fitting observational data, rests on problematic conceptual foundations:

1. **The Big Bang Singularity:** Standard cosmology posits infinite density at $t = 0$
2. **Fine-Tuning:** Cosmological constant discrepancy of $\sim 10^{120}$
3. **Dark Sector Mysteries:** No dark matter particle detected after 50 years
4. **Inflation's Ad Hoc Nature:** Fine-tuned scalar fields without evidence
5. **The Meaning of Time:** What existed before the Big Bang?

Observational Anomalies

Recent measurements reveal persistent anomalies:

CMB Anomalies:

- **Cold Spot:** $\sim 70 \mu\text{K}$ temperature depression spanning $\sim 10^\circ$

- **Axis of Evil:** Unexpected alignment of quadrupole/octopole moments
- Large-scale power deficit and hemispherical asymmetries

Early Supermassive Black Holes: JWST discovered SMBHs ($M_{BH} \sim 10^{6-8} M_{\odot}$) at $z > 8.5$, only 600-700 Myr after Big Bang. Standard formation cannot explain such rapid growth.

H_0 **Tension:** Local measurements (~ 73 km/s/Mpc) disagree with CMB values (~ 67 km/s/Mpc) at $> 5\sigma$.

The DEBA Solution

We propose a radical alternative where the universe emerges through organizational actualization from an atemporal, non-geometric substrate. This framework:

- Derives physical reality from mathematical structure
- Reconceives the Big Bang as an embarked organizational state
- Derives time, space, and physical laws (not assumed)
- Explains dark matter and dark energy without new particles
- Treats anomalies as organizational signatures
- Maintains rigorous finitude

Atemporal Foundations

The Configuration Space

The fundamental substrate is a measured space (\mathcal{C}, μ) where:

- \mathcal{C} is an abstract space of potential organizational configurations
- μ is a finite measure: $\mu(\mathcal{C}) < \infty$
- \mathcal{C} possesses NO geometry, NO metric, NO topology
- \mathcal{C} is atemporal: no time parameter
- \mathcal{C} is acausal: no causal structure
- \mathcal{C} has NO spatial extension

This represents pure potentiality—configurations that could actualize but have not. This is the **first rigorous formalization of atemporality** in cosmology.

The Organizational Field

Dynamics are encoded by a scalar field:

$$\Phi: \mathcal{C} \times \mathbb{R}^+ \rightarrow \mathbb{R}$$

where $\Phi(x, \tau)$ represents organizational potential at configuration x and evolution parameter τ .

Critical distinction: τ is NOT physical time but an organizational progression parameter.

The DEBA Principle

Core principle: Any potential organizational configuration with non-zero measure must actualize somewhere in configuration space through coherent transitions.

Formally: If $A \subset \mathcal{C}$ with $\mu(A) > 0$, then configurations in A actualize via condensation when organizational coherence exceeds critical threshold.

This replaces creation ex nihilo with mathematical actualization of pre-existing potentialities.

Coherence Function

Local organizational coherence:

$$s(x) = \sigma \left(\int_{\mathcal{C}} K(x, y) \Phi(y) d\mu(y) \right)$$

where $K(x, y)$ is a correlation kernel and $\sigma: \mathbb{R} \rightarrow [0, 1]$ is a sigmoid. Regions where $s(x) \geq s_{crit}$ are candidates for bubble formation.

Flash Dynamics and Bubble Formation

Stochastic Dynamics

Evolution follows a functional Langevin equation:

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

This describes drift toward coherent states and stochastic exploration.

Bistable Potential

Organizational emergence is driven by a double-well potential:

$$V[\Phi] = \int_{\mathcal{C}} \left[\frac{1}{4} (\Phi(x)^2 - \phi_0^2)^2 - \epsilon \Phi(x) \right] d\mu(x)$$

with two minima: weak coherence ($\Phi \approx 0$) and strong coherence ($\Phi \approx \phi_0$).

Organizational Instantons

Transitions follow paths minimizing action:

$$\mathcal{A}[\Phi] = \frac{1}{2} \int d\tau \int_{\mathcal{C}} D(x)^{-1} \left(\partial_\tau \Phi(x) + C \int_{\mathcal{C}} K(x, y) \frac{\delta V}{\delta \Phi(y)} d\mu(y) \right)^2 d\mu(x)$$

The minimizing path is the **organizational instanton**—the most probable condensation trajectory.

The Flash as Beam

Crucial innovation: A flash does NOT produce a single bubble but FRAGMENTS into disjoint domains:

$$\mathcal{C} = \bigcup_{i=1}^N D_i, \quad D_i \cap D_j = \emptyset \text{ for } i \neq j$$

Each domain D_i stabilizes as bubble-universe \mathcal{U}_i , forming a **beam**:

$$\text{Flash}(\tau^*) \rightarrow \text{Beam } \mathcal{B}(\tau^*) = \{\mathcal{U}_1, \mathcal{U}_2, \dots, \mathcal{U}_N\}$$

This beam structure explains observed correlations (CMB anomalies, PBH clustering).

The Big Bang Reconcived

Revolutionary Redefinition

Standard cosmology treats the Big Bang as a generative event. DEBA offers radical reconception:

The Big Bang is NOT a creative process. It is the **initial organizational state** Φ_i that bubble i inherits from the flash—the embarked portion of actualized coherence:

$$\text{Big Bang}_i \equiv \Phi_i(x) = \Phi_{flash}(x)|_{x \in D_i}$$

This portion IS the universe in its initial state—it does not generate the universe.

The Portion Mechanism

Each bubble stabilizes the restriction of the flash field to its domain:

$$\Phi_i: D_i \rightarrow \mathbb{R}, \quad \Phi_i(x) = \Phi_{flash}(x) \text{ for } x \in D_i$$

This embarked portion Φ_i contains:

- Encoded constants (effective physical constants as functionals)
- Initial coherence structure (seeds of organization)

- Information content (integrated information θ_i)
- Evolutionary potential (capacity for structure formation)

The universe does not arise FROM its Big Bang; it IS its Big Bang in potential form, which unfolds.

Implications

No Singularity: No infinite density. Φ_i is finite organizational configuration.

No Fine-Tuning: Constants are functionals of the embarked portion.

No Creation Ex Nihilo: Flash actualizes pre-existing potentialities.

Observer-Independent Time: $t = 0$ is coordinatization choice, not absolute beginning.

Emergence of Physics from Mathematics

Time Emergence

Physical time does not exist in (\mathcal{C}, μ) but emerges within stabilized bubbles:

$$t_i = f_i(s(x, \tau))$$

Different bubbles have different time parameters. There is NO universal time.

Effective Constants as Functionals

Physical constants of bubble i are functionals of embarked portion:

$$G_i = G_0 \exp \left(\int_{D_i} \alpha(x) \Phi_i(x) d\mu(x) \right)$$

$$\Lambda_i = \Lambda_0 \left(\int_{D_i} \beta(x) \Phi_i^2(x) d\mu(x) \right)$$

$$c_i = c_0 \sqrt{\int_{D_i} \gamma(x) |\nabla \Phi_i(x)|^2 d\mu(x)}$$

These constants are:

- **Local:** Different for each bubble
- **Finite:** Integrals over finite measure
- **Determined:** By portion content

- **Emergent:** Not fundamental entities

Information Content

Total organizational information:

$$\theta_i = \int_{D_i} |\Phi_i(x)|^2 d\mu(x)$$

This bounds structural complexity and remains finite.

Physics Derives from Mathematics

Resolution of Wigner's puzzle: Mathematics describes physics because physical reality *emerges from* mathematical structure (\mathcal{C}, μ, Φ) .

Physics is not described by mathematics—it is a property of organizational actualization in configuration space.

The Dark Sector Redefined

Dark Matter as Stabilizing Coherence

Dark matter is not a particle but manifestation of local coherence maintaining structural integrity:

$$\rho_{dark}(x) = \kappa s^2(x) |\nabla\Phi(x)|$$

This captures:

- Concentration near structures
- Gradient dependence
- No particle required

Observational signatures: Galaxy rotation curves, gravitational lensing, Bullet Cluster, structure formation—all explained.

Dark Energy as Dynamic Adaptation

Dark energy represents system's adaptive response to expansion:

$$\rho_{darkenergy}(\tau) = \beta \left(\frac{\dot{a}}{a}\right)^2 - \rho_{dark}(x)$$

Key features:

- Dynamic (not fixed Λ)

- Responsive to expansion
- Balancing coherence
- Naturally small (no fine-tuning)

Coherence Pockets

Coherence varies locally:

$$s_{local}(x) = s_{mean} + \delta s(x)$$

These pockets:

- Affect local gravitational balance
- Modify apparent expansion rate (H_0 variations)
- Generate CMB temperature fluctuations
- Influence structure formation

Unified Explanation of Observational Signatures

CMB Anomalies

The Cold Spot: Represents interaction with sibling bubble from our flash beam.

Interaction term from coherence interface:

$$\Sigma_{ij}(x) = s_i(x)s_j(x)$$

between our bubble (i) and sibling (j).

This explains size, depth, stability, and hot ring.

Axis of Evil: Reflects directional structure of beam $\mathcal{B}(\tau^*)$. Preferred orientation manifests as quadrupole/octopole alignment.

Predictions:

1. Cold Spot direction correlates with Axis
2. Other siblings produce weaker anomalies in correlated directions
3. Multipole alignments trace beam geometry

Primordial Black Holes

JWST discoveries of SMBHs at $z > 8.5$ naturally explained:

PBHs in DEBA: Form as **primary organizational condensation nodes** during flash. Direct actualizations of maximal coherence concentrations.

Key features:

1. Rapid formation (no growth time)
2. Clustering traces beam structure
3. Mass distribution from local Φ intensity
4. Early existence (present from flash)

JWST observations explained:

- High M_{BH} at early epochs: Direct condensation
- High M_{BH}/M_* ratios: BH forms first, galaxy assembles around it
- Spatial clustering: Traces portion boundaries

H_0 Tension Resolution

Hubble tension arises from coherence pocket variations.

Local measurements probe regions with $s_{local} = s_{mean} + \delta s_{local}$.

CMB measurements probe mean coherence.

If $\delta s_{local} > 0$: $H_{0,local} > H_{0,CMB}$.

Prediction: H_0 varies directionally, correlating with CMB anomalies.

Rigorous Finitude

All physical quantities are finite by construction.

Finite Measure

$$\mu(\mathcal{C}) < \infty \Rightarrow \mu(D_i) < \infty$$

Finite Information

$$\theta_i = \int_{D_i} |\Phi_i|^2 d\mu < \|\Phi_i\|_\infty^2 \mu(D_i) < \infty$$

Finite Constants

All effective constants remain finite through bounded integrals.

No Spatial Infinity

NO space between bubbles. \mathcal{C} is non-geometric: no metric, no distances, no extension.

No Temporal Infinity

Each bubble's internal time emerges from coherence. No universal infinite time.

Falsifiable Predictions

DEBA makes specific testable predictions distinguishing it from alternatives:

Predictions

- 1. CMB Correlations:** Cold Spot and Axis directions correlated within $\pm 30^\circ$.
- 2. Additional Spots:** Weaker anomalies in beam geometry directions.
- 3. PBH Clustering:** Anisotropic clustering correlating with CMB anomalies.
- 4. PBH Mass Function:** Reflects portion intensity, not accretion.
- 5. GW Anisotropy:** Stochastic background shows directional anisotropy.
- 6. PBH Mergers:** Follow organizational resonance patterns.
- 7. H_0 Variations:** Directional dependence $H_0(\theta, \phi)$.
- 8. DM Fine Structure:** Not smooth halos, reflects coherence variations.
- 9. DM Deficits:** Anomalously low in predicted coherence deficit regions.

Observational Tests

- Planck data reanalysis: Angular correlations
- JWST deep fields: PBH clustering at $z > 7$
- LIGO/Virgo/KAGRA: GW background anisotropy
- Euclid: H_0 directional dependence, DM fine structure
- SKA: Radio source distribution vs CMB anomalies

Discussion

Comparison with Alternatives

Inflation: Addresses horizon/flatness but requires fine-tuned scalar field, creates multiverse landscape, doesn't explain dark sector or singularity. DEBA resolves these without inflation.

String Theory: Proposes extra dimensions but lacks testable predictions, doesn't address observations. DEBA operates in configuration space.

Loop Quantum Gravity: Attempts spacetime quantization but incomplete cosmologically, doesn't explain dark sector. DEBA derives spacetime emergently.

Primordial Black Hole DM: Constrained by observations, doesn't explain CMB anomalies. DEBA incorporates PBHs as organizational nodes.

Philosophical Implications

Ontological Priority of Mathematics: Mathematical structure (\mathcal{C}, μ) is ontologically prior. Physics IS mathematics in actualized form.

No Creation Moment: No ex nihilo creation. Actualization replaces creation.

Local Realism: Physical laws local to each bubble, not universal absolutes.

Observer-Dependent Time: Time is internal metric parameter, not external container.

Open Questions

1. Fragmentation mechanism determining portion boundaries?
2. Statistical distribution of portion sizes $\mu(D_i)$?
3. Inter-beam bubble interactions possible?
4. Quantum mechanics emergence within bubbles?
5. Numerical simulation feasibility?
6. Anthropic considerations and portion properties?

Conclusion

We have presented DEBA, a complete cosmological framework that:

1. **Resolves foundational problems:** Eliminates singularity, explains constants, derives time
2. **Explains dark sector:** As coherence/adaptation—no particles required

3. **Accounts for anomalies:** CMB anomalies, early SMBHs, H_0 tension unified
4. **Maintains rigor:** All quantities finite, mathematically well-defined
5. **Makes predictions:** Specific, testable, falsifiable

Key insight: The Big Bang is not a creative event but an embarked organizational state. Physics emerges from mathematical structure through actualization.

DEBA represents paradigm shift: from geometric spacetime with pre-existing laws to organizational emergence from atemporal foundations. It is both explanatory and predictive, offering resolution to longstanding puzzles while opening new observational avenues.

The framework awaits empirical verdict. The predictions are clear, the tests feasible, the stakes fundamental.

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