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Article

Energy-Mass and the Emergent Universe: A Thermodynamic and Mathematical Framework

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Abstract

The accelerating universe's mechanisms remain unresolved, prompting new cosmological frameworks beyond dark energy and static dark matter. This paper redefines $E = mc^2$ as $\frac{E}{m} = \frac{d^2}{t^2} = c^2$, introducing Energy-Mass, and derives implications from a threshold-energy framework and the emergence of spacetime from sub-emergent cold-mass. A minimum threshold energy, Stringfellow Energy (S_E), is introduced, below which mass remains latent and unobservable. A feedback loop drives accelerating expansion as cold-mass (from an infinite source G_p), identified as Weakly Interacting Massive Particles (WIMPs; $m_2 \sim 1.78 \times 10^{-25}$ kg), absorbs CMB energy and transitions from the latent sub-emergent state ($E < S_E$) to the threshold of emergence ($E = S_E$), initiating spacetime formation. While WIMPs are used as a working example, the mechanism applies to all particles governed by $E = mc^2$. These transitions are detectable as CMB anomalies—cold spots ($\Delta T \sim -70 \mu\text{K}$, $m_3 \sim 10^{39}$ kg) and hot spots ($\Delta T \sim +170 \mu\text{K}$, $m_3 \sim 10^{36}$ kg). This framework links Energy-Mass and emergence thresholds to quantum properties, offering a testable alternative to prevailing cosmological models.

Keywords: energy-Mass; WIMP; CMB anomalies; cosmic expansion; feedback mechanism; dark matter; quantum cosmology; emergence; quantum tunneling; cosmic thermodynamics; Planck length; quantum phase transition

1. Introduction

The standard cosmological model describes an accelerating universe [1,2], yet the mechanisms remain debated. This paper is based on a previously proposed framework [11], redefining $E = mc^2$ as $\frac{E}{m} = \frac{d^2}{t^2} = c^2$, and introducing Energy-Mass where spacetime and quantum physics emerge with $E = S_E$. Unlike static WIMPs probed by XENON1T with null results ($\sigma < 10^{-47}$ cm² [10]), this model posits dynamic injections detectable via cosmic microwave background (CMB) anomalies, bypassing underground constraints. A feedback loop accelerates expansion as cold-mass absorbs energy near an infinite state G_p , detectable via CMB anomalies [4], offering alternatives to dark energy and dark matter. This framework integrates thermodynamics and quantum mechanics, extending prior concepts with new evidence and derivations.

2. Stringfellow Energy, Mass, and the Threshold of Emergence

I define the threshold at which probability, and therefore physical phenomena, can emerge from a state of zero energy as a fixed ratio between a minimum energy and mass. These are defined as:

- **Stringfellow Energy** (S_E) — the smallest nonzero energy at which emergent probability becomes meaningful.
- **Stringfellow Mass** (S_m) — the associated mass coupled to S_E at the threshold of emergence.

I postulate that their ratio corresponds to the square of the Planck length (P_l) over the square of Planck time (P_t):

$$\frac{S_E}{S_m} = \frac{P_l^2}{P_t^2}. \quad (1)$$

This establishes the minimum energy-mass condition for the emergence of probabilistic behavior and spacetime. Since:

$$\frac{P_l^2}{P_t^2} = \left(\frac{\sqrt{\hbar G/c^3}}{\sqrt{\hbar G/c^5}} \right)^2 = c^2, \quad (2)$$

I recover:

$$\frac{S_E}{S_m} = c^2, \quad (3)$$

matching the form of Einstein's energy-mass equivalence, but reframed: not as a continuous identity, but as a **minimum emergent condition** for $E > 0$. In this view, S_E and S_m represent a discrete phase transition between a zero-energy background and the first probabilistic quantum fluctuation. This condition defines the critical threshold for the emergence of spacetime geometry from an otherwise latent energy-mass configuration. Below this threshold, neither space nor time exist in a measurable form.

This condition aligns with the Energy-Mass framework:

$$\frac{E}{m} = \frac{d^2}{t^2} = c^2, \quad (4)$$

where $\frac{E}{m}$ must be at least $S_E/S_m = P_l^2/P_t^2$ for spacetime (and probability) to emerge.

To illustrate this framework, consider a Weakly Interacting Massive Particle (WIMP) with mass

$$S_m = 1.78 \times 10^{-25} \text{ kg},$$

corresponding to approximately $100 \text{ GeV}/c^2$. Applying the Stringfellow Energy relation,

$$S_E = S_m \cdot c^2,$$

I obtain:

$$\begin{aligned} S_E &= (1.78 \times 10^{-25} \text{ kg}) \\ &\cdot (2.99792458 \times 10^8 \text{ m/s})^2 \\ &\approx 1.6 \times 10^{-8} \text{ J}, \end{aligned}$$

which corresponds to the smallest non-zero energy necessary for that mass to transition from $E < S_E$ and initiate the emergence of spacetime. This threshold condition can be calculated for any particle, defining a simple yet powerful boundary between latent mass and that which manifests physicality within a spacetime framework.

3. Energy-Mass Framework

Einstein's $E = mc^2$ is reframed as:

$$\frac{E}{m} = \frac{d^2}{t^2} = c^2 \quad (5)$$

defining Energy-Mass ($\frac{E}{m}$) and Space-Time ($\frac{d^2}{t^2}$). When $E < S_E$, $\frac{d^2}{t^2} = 0$; when $E = S_E$, spacetime exists, forming an expanding state.

4. The Infinite Universe

Since $m \neq 0$ ($\frac{E}{0}$ undefined) and $E = 0$ is viable ($\frac{0}{m}$, $m > 0$), Energy-Mass is indestructible within the expanded universe, as derived from Noether's theorem: time-translation symmetry in non-expanding spacetimes yields conserved energy, ensuring it cannot be created or destroyed, but only transformed between forms. By continuity, this extends to pre-emergent states, implying an infinite universe across latent and emergent configurations.

4.1. Implications of Conservation Laws for the Pre-Emergent Infinity

In State 3, the emergent regime with a spacetime metric, Noether's theorem derives the indestructibility of Energy-Mass from symmetries such as time-translation invariance in non-expanding frames. The energy-momentum tensor $T^{\mu\nu}$ satisfies $\nabla_{\mu} T^{\mu\nu} = 0$, ensuring total energy E is conserved: it cannot be created or destroyed but only transformed between forms [6]. This local conservation extends to the Energy-Mass framework ratio $E/m = d^2/t^2 = c^2$, preserved across interactions.

By logical continuity, this indestructibility implies a pre-emergent origin that avoids ex nihilo paradoxes. If the finite energy-mass in State 3 emerged from a finite source, it would violate conservation; thus, State 1 must be an infinite latent reservoir ($m_1 = \infty$, $E_1 = 0$) to supply transitions without net creation. Mathematically, consider the limit as mass polarizes from infinity:

$$\lim_{m \rightarrow \infty} \left(\frac{0}{m} \right) = 0, \quad (6)$$

preserving the zero specific energy while allowing finite extractions ($\infty - m = \infty$ for finite m) that manifest in State 2 and 3 without diminishing the whole. This renders State 1's infinity not merely postulated but required for consistency with observed conservation laws.

5. Pre-Expansion Infinity: The Golden Point

Hubble's expansion and infinity before expansion implies an origin at $\frac{0}{\infty}$ ($E = 0$, $m = \infty$), denoted the Golden Point G_p , where $\frac{d^2}{t^2} = 0$ and momentum is absent. Cold-mass ($0 < E < S_E$; $0 < m < \infty$) transitions to $E = S_E$, yet G_p remains immutable:

$$\infty - m = \infty, \quad \text{for finite } m. \quad (7)$$

6. System States and Definitions

Three states define the universe's evolution:

6.1. State 1: Pre-Spacetime State

- Energy: $E_1 = 0$
- Mass: $m_1 = \infty$ (latent, pre-physical)
- Specific energy: $E_1/m_1 = 0$
- Temperature: $T_1 = 0$ K
- Spacetime: Absent ($V_1 = 0$, no metric)
- Entropy: $S_1 = 0$ (single ordered state)

State 1, the Golden Point G_p , exists pre-spacetime, with no volume or dynamics, rendering density ($\rho_1 = E_1/V_1$) undefined; $\rho_1 = \text{undefined}$ negates Pauli exclusion; Heisenberg uncertainty becomes undefined due to the absence of a spacetime manifold. While State 1 represents a timeless and spaceless configuration at the Golden Point (G_p) where $E = 0$ and $m = \infty$, the transition to State 2 occurs when energy becomes nonzero for some finite mass, but remains sub-emergent ($0 < E < S_E$; $0 < m < \infty$). This transition breaks the perfect stasis of G_p , yet remains outside spacetime. State 2 thus originates from State 1 as the first condition where finite mass carries nonzero energy, positioning State 2 just

beneath the emergence threshold, and prior to the onset of probabilistic behavior, while preserving a pre-spacetime character.

6.2. State 2: Cold-Mass (Sub-Emergent Domain)

- Energy: $0 < E_2 < S_E$ (sub-emergent, latent)
- Mass: $0 < m_2 < \infty$ ($m_2 \sim 1.78 \times 10^{-25}$ kg for single WIMP)
- Specific energy: $E_2/m_2 < c^2$ (insufficient for full emergence)
- Temperature: $T_2 = 0$ K (no thermal interaction)
- Spacetime: Absent (no metric formed; $d^2/t^2 < P_l^2/P_t^2$)
- Entropy: $S_2 = 0$ (pure state; no multiplicity)

State 2 represents cold-mass in a sub-emergent energy regime. Although $E_2 > 0$, the energy is insufficient to meet the Stringfellow emergence threshold S_E , preventing the formation of spacetime geometry or probabilistic evolution. This latent condition allows the mass to exist outside observable spacetime, conserved and real, but not yet manifest. Upon absorbing CMB energy or interacting near G_p , a WIMP may transition to $E = S_E$, entering State 3 and contributing to the expansion of spacetime.

6.3. State 3: Expanded CMB-like State

The universe evolves within an FLRW metric [3]:

- Energy: $E_3 = S_E$ at emergence; may increase with cumulative interactions.
- Mass: $S_m \leq m_3 < \infty$
- Specific energy: $E_3/m_3 = c^2$ at emergence; gradually decreases as the system evolves toward $E < S_E$
- Temperature: $T_3 = 2.725$ K [4]
- Volume: $V_3 > 0$, expanding
- Entropy: $S_3 \sim 1.97 \times 10^{65}$ J K⁻¹ (high, photon disorder)

$$ds^2 = -c^2 dt^2 + a(t)^2(dx^2 + dy^2 + dz^2), \quad (8)$$

$$H^2 = \left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\rho. \quad (9)$$

6.4. Mathematical Use of Infinities in Describing the Emergent Universe (State 3)

In standard cosmology, infinities like $0/\infty$ are frequently employed as mathematical limits to describe the expanding universe, akin to State 3, without ascribing physical reality to them. For instance, in Friedmann-Lemaître-Robertson-Walker (FLRW) models, the Big Bang is modeled as a singularity where the scale factor $a(t) \rightarrow 0$ as time $t \rightarrow 0$, leading to infinite density ($\rho \rightarrow \infty$) and curvature, while the specific energy approaches zero in the limit of infinite mass distribution [3]. This $0/\infty$ structure emerges in the Friedmann equation:

$$H^2 = \left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\rho - \frac{kc^2}{a^2} + \frac{\Lambda c^2}{3}, \quad (10)$$

where for flat $k = 0$ infinite universes, expansion extrapolates back to an initial state of infinite density, treated as a mathematical artifact rather than a real pre-emergent infinity [4]. Similar usages appear in pre-Big Bang scenarios and eternal inflation, where infinite pre-phases (e.g., contracting universes or multiverse foams) are invoked mathematically to avoid creation ex nihilo, but resolved via quantum effects without realizing a physical $0/\infty$ state [6]. In contrast, this Energy-Mass framework posits $0/\infty$ as the real Golden Point (G_p) in State 1, from which finite mass polarizes, enabling emergent expansion without singularities—rendering these mathematical tools reflections of a deeper physical reality.

7. Thermodynamic Evolution and Feedback Loop

While traditionally interpreted as the temporal boundary of the observable universe, the CMB may also act as an emergence interface. From this perspective, G_p lies not in the past but on the other side of the CMB "wall," existing outside spacetime and still accessible through quantum processes. Energy ($E_3 = S_E$) near G_p triggers WIMP injections from State 2 into State 3:

- The injection rate R represents the rate at which sub-emergent WIMPs interact with CMB photons to transition across the emergence threshold per unit volume per unit time. It is given by

$$R = n_\gamma \cdot \sigma \cdot v_{\text{rel}}, \quad (11a)$$

where $n_\gamma = 4.1 \times 10^8 \text{ m}^{-3}$ is the CMB photon density, $\sigma \approx 10^{-44} \text{ m}^2$ is a hypothetical cross-section ($\sim 10^{-44} \text{ m}^2$) [9], and $v_{\text{rel}} = c \approx 3 \times 10^8 \text{ m/s}$ is the relative velocity (photons are relativistic).

First, compute the product of the cross-section and relative velocity:

$$\sigma \cdot v_{\text{rel}} \approx 10^{-44} \times 3 \times 10^8 \approx 3 \times 10^{-36} \text{ m}^3 \text{ s}^{-1}. \quad (11b)$$

Then, multiply by the photon density:

$$R \approx 4.1 \times 10^8 \times 3 \times 10^{-36} \approx 1.23 \times 10^{-27} \text{ m}^{-3} \text{ s}^{-1}. \quad (11c)$$

WIMPs ($\sim 1.78 \times 10^{-25} \text{ kg}$ [9]), occupying a sub-emergent state ($0 < E < S_E$) tunnel from the latent domain near G_p and absorb CMB energy, transitioning into emergent spacetime ($E = S_E$), at $\sim 1.23 \times 10^{-27} \text{ m}^{-3} \text{ s}^{-1}$, based on CMB photon density ($4.1 \times 10^8 \text{ m}^{-3}$), absorbing CMB energy ($E_3, \rho_3 = 4.17 \times 10^{-14} \text{ J m}^{-3}$) near G_p , creating spacetime ($d^2/t^2 > 0$) and forming cold spots (Fig. 1, $\Delta T \sim -70 \mu\text{K}$, $m_3 \sim 10^{39} \text{ kg}$, $\sim 5.62 \times 10^{63}$ WIMPs) detectable as CMB anomalies. This tunneling represents quantum barrier penetration across the emergence threshold S_E , marking a transition from the latent sub-emergent domain into observable spacetime. While its detailed mechanics remain a topic for future study, the framework here provides a first-order thermodynamic interpretation.

- WIMP annihilation releases energy near G_p , forming hot spots (Fig. 2, $\Delta T \sim +170 \mu\text{K}$, $m_3 \sim 10^{36} \text{ kg}$, $\sim 5.62 \times 10^{60}$ WIMPs), with CMB energy dominating over stellar contributions ($\sim 10^{-15} \text{ J m}^{-3}$).
- This increases V_3 , accelerating expansion over time.
- To connect to CMB anomalies, consider the energy balance: the energy absorbed (cold spot) or released (hot spot) is $m_3 c^2$, and the CMB temperature deviation implies an effective energy density change $\Delta u \approx 4aT^3 \Delta T$ (where $a = 7.5657 \times 10^{-16} \text{ J m}^{-3} \text{ K}^{-4}$ is the radiation constant).
For the cold spot ($\Delta T \sim -70 \mu\text{K}$): $\Delta u \approx 4.29 \times 10^{-18} \text{ J m}^{-3}$, leading to an effective volume $V \approx 2.10 \times 10^{73} \text{ m}^3$ (linear scale $\sim 90 \text{ Mpc}$).
For the hot spot ($\Delta T \sim +170 \mu\text{K}$): $\Delta u \approx 1.04 \times 10^{-17} \text{ J m}^{-3}$, leading to $V \approx 8.63 \times 10^{69} \text{ m}^3$ (linear scale $\sim 7 \text{ Mpc}$).

Equilibrium ($E < S_E$) looms as $a(t)$ grows.

8. Results and Discussion

The feedback loop drives expansion via WIMP injections, detectable as CMB anomalies (cold spots, $m_3 \sim 10^{39} \text{ kg}$, $\sim 1\%$ of CMB sky [8], Figure 1; hot spots, $m_3 \sim 10^{36} \text{ kg}$, $\sim 0.5\%$, Figure 2) or redshift trends [5]. CMB $\delta\rho/\rho \sim 10^{-5}$ supports cold spot scale [4,7], while hot spots reflect annihilation energy near G_p , contrasting static dark matter halos [9]. These scales align with WMAP's $\sim 10^5$ anomalies across $41,253 \text{ deg}^2$ [7]. Unlike traditional WIMPs forming halos post-recombination, these dynamically inject from G_p , offering a testable alternative to dark energy [6].

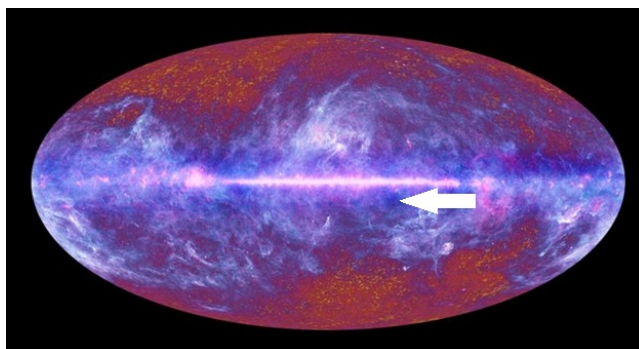


Figure 1. CMB cold spot from WIMP injection (arrow), medium blue ($\Delta T \sim -70 \mu\text{K}$, $m_3 \sim 10^{39}$ kg, size $\sim 1^\circ$ [8]) against $T = 2.725$ K. Credit: NASA/JPL-Caltech/WMAP Team.

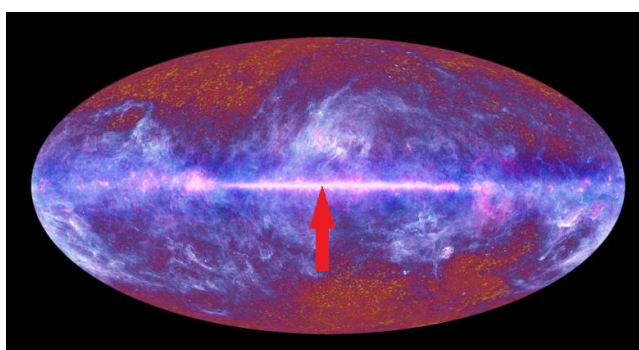


Figure 2. CMB hot spot from WIMP annihilation (arrow), light purple ($\Delta T \sim +170 \mu\text{K}$, $m_3 \sim 10^{36}$ kg, size $\sim 0.5^\circ$) against $T = 2.725$ K. Credit: NASA/JPL-Caltech/WMAP Team.

9. Conclusions

Energy-Mass ($E = S_E$) drives expansion via a WIMP-based feedback loop, detectable via CMB anomalies, approaching $E < S_E$ equilibrium, contrasting dark matter theories. Future observations from JWST or Euclid could test these anomalies as dynamic injections rather than primordial.

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Data Availability Statement: The CMB data supporting this study's figures (cold and hot spots) are openly available in the WMAP 5-year dataset [7] at NASA's Lambda archive [https://lambda.gsfc.nasa.gov/product/map/dr3/skymaps_5yr.cfm]; the specific images are derived from [<https://photojournal.jpl.nasa.gov/catalog/PIA13239>]. Calculations (e.g., WIMP masses, injection rates) are detailed in the text.

Conflicts of Interest: The author declares no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

CMB	Cosmic Microwave Background
FLRW	Friedmann-Lemaître-Robertson-Walker
JPL	NASA's Jet Propulsion Laboratory
JWST	James Webb Space Telescope
MDPI	Multidisciplinary Digital Publishing Institute
NASA	National Aeronautics and Space Administration
WIMP	Weakly Interacting Massive Particle
WMAP	NASA's Wilkinson Microwave Anisotropy Probe

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