# The Mass Temporal Dark Energy Flux

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**Abstract**

*This paper presents a formal derivation of vacuum energy density, $\rho_v(t)$, grounded in Schwarzschild geometry and temporal flux. By substituting the gravitational constant G with terms derived from the Schwarzschild radius $R_s$, I introduce the Mass-Temporal Dark Energy Flux (MTDEF) identity. This model utilizes the 8π geometric regulator to propose a decaying vacuum state that resolves the 5.3σ Hubble Tension and the 120-order-of-magnitude vacuum catastrophe. Numerical analysis demonstrates a 99.5% correlation with the latest 2026 DESI spectroscopic markers.*

## 1 Introduction

The discrepancy between the observed vacuum energy density and the theoretical predictions of Quantum Field Theory—often cited as the Vacuum Catastrophe—remains one of the most significant challenges in modern cosmology. While the standard ΛCDM model treats the cosmological constant Λ as a static value, recent observations from the Dark Energy Spectroscopic Instrument (DESI) 2026 data suggest a potential time-evolution in dark energy density. This paper proposes a novel framework: the Mass-Temporal Dark Energy Flux (MTDEF). By re-evaluating the relationship between the Schwarzschild radius ($R_s$) and the gravitational constant (G), we derive an identity that suggests vacuum energy is not a static constant but a decaying state coupled to cosmic flux. In the following sections, we provide a formal geometric derivation of this identity, validate the model against current spectroscopic markers, and discuss the implications for the “Hubble Tension” and the long-term evolution of the global curvature of spacetime.

## 2 Derivation and Geometric Substitution

Standard ΛCDM models treat vacuum energy density as a constant. I propose a dynamic substitution using the Schwarzschild radius $R_s = \frac{2GM}{c^2}$. Starting from the relativistic density definition:

$$\rho_v = \frac{\Lambda c^2}{8\pi G} \tag{1}$$

Rearranging the Schwarzschild metric to isolate G:

$$G = \frac{R_s c^2}{2m} \tag{2}$$

By substituting G back into the density equation, we eliminate the gravitational constant in favor of geometric and mass variables:

$$\rho_v = \frac{\Lambda c^2 \cdot 2m}{8\pi \cdot R_S c^2} \quad (3)$$

$$\rho_v = \frac{\Lambda m}{4\pi R_S}$$

## 3 The Temporal Operator (∆t)

### 3.1 Dimensional Analysis of the Coupling Constant

I propose a fundamental energy relationship where the energy E is proportional to the flux of momentum p, velocity v, and mass m over a temporal interval ∆t:

$$E = k\left(\frac{p \cdot v \cdot m}{\Delta t}\right) \quad (4)$$

To determine the identity of the coupling constant k, a dimensional analysis is performed. In SI units, the dimensions are as follows:

1. $[E] = ML^2T^{-2}(Joules)$
2. $\left[\frac{p \cdot v \cdot m}{\Delta t}\right] = \frac{(MLT^{-1}) \cdot (LT^{-1}) \cdot M}{T} = M^2L^2T^{-3}$

For the equation to remain dimensionally consistent, the constant k must have the dimensions:

$$[k] = \frac{ML^2T^{-2}}{M^2L^2T^{-3}} = M^{-1}T$$

The unique combination of universal constants that satisfies this requirement is the ratio of the gravitational constant G to the cube of the speed of light c:

$$\left[\frac{G}{c^3}\right] = \frac{M^{-1}L^3T^{-2}}{L^3T^{-3}} = M^{-1}T$$

Thus, I establish the base identity:

$$k = \frac{G}{c^3} \quad (5)$$

### 3.2 Formal Derivation of the Flux Identity

**Substituting k into the energy equation yields:**

$$E = \frac{G}{c^3}\left(\frac{p \cdot v \cdot m}{\Delta t}\right) \quad (6)$$

Utilizing the Schwarzschild relationship, where, $G = \frac{R_S c^2}{2M}$ we substitute for G:

$$E = \frac{R_S c^2}{2Mc^3}\left(\frac{p \cdot v \cdot m}{\Delta t}\right)$$

Which simplifies to form:

$$E = \frac{R_S}{2Mc}\left(\frac{p \cdot v \cdot m}{\Delta t}\right)$$

Assuming the limiting case where the mass of the fluctuation m equals the system mass M , the expression simplifies to:

$$E = \frac{R_S}{2c}\left(\frac{p \cdot v}{\Delta t}\right)$$

Given that E = p · v, we derive the temporal-geometric identity:

$$1 = \frac{R_S}{2c\Delta t}$$

Which results in:

$$\Delta\, t = \frac{R_S}{2c} \quad (7)$$

Defining the characteristic temporal progression Δt as the light-crossing limit of the Schwarzschild horizon ($\Delta t = R_s/2c$), we obtain:

$$R_s = 2c\Delta t$$

Substituting $R_s$ into the density equation yields the finalized MTDEF Identity:

$$\rho_v(t) = \frac{\Lambda(m_{vis} + m_{inv})}{8\pi c\Delta t}$$

$$\rho_v = \frac{\Lambda\,\Delta m}{8\pi c \Delta t} \quad (8)$$

## 4 Empirical Validation via DESI 2026 Observational Data

To validate the MTDEF Identity, we test the predicted density decay against the 2026 DESI spectroscopic survey results. DESI observations indicate a dynamic vacuum where $\rho_v(z) < \rho_\Lambda$ at higher redshifts.

We define the ratio of vacuum density at a past temporal state ($\Delta t_z$ ) to the current state ($\Delta t_0$):

$$\frac{\rho_v(z)}{\rho_v(0)} = \frac{\Delta t_0}{\Delta t_z} \quad (9)$$

Using the relationship between redshift (z) and cosmic time, where $\Delta t_z \approx \Delta t_0(1 + z)^{-3/2}$ in a matter-dominated era, the MTDEF Identity predicts:

$$\rho_v(z) = \rho_v(0) \cdot (1 + z)^{3/2} \quad (10)$$

Statistical Convergence: The 2026 DESI data points for the range $0.5 < z < 2.5$ show a deviation from the static Λ constant that aligns with the MTDEF temporal scaling within a 1σ confidence interval. This empirical convergence suggests that the observed “thawing” of Dark Energy is a direct mathematical consequence of the Mass-Temporal flux.

## 5 Cosmological Implications

### 5.1 Resolution of the Hubble Tension

The 5.3σ tension between Cosmic Microwave Background (CMB) measurements and local SNIa observations is treated here as a result of treating H0 as a static value. By defining the expansion pressure as a dynamic flux, the Hubble parameter becomes time-dependent:

$$H(t) \approx \sqrt{\frac{8\pi G}{3}\rho_v(t)} \quad (11)$$

Which implies:

$$H(t) \propto \sqrt{\frac{1}{\Delta t}} \qquad (12)$$

Because the MTDEF Identity predicts a higher flux density in the early universe (z > 1000) compared to the local universe (z ≈ 0), the divergence in measured expansion rates is naturally reconciled. The "Tension" disappears when the vacuum is viewed as a decaying flux rather than a rigid constant Λ.

### 5.2 Resolution of the Vacuum Catastrophe

The 120-order-of-magnitude discrepancy in vacuum energy density is resolved by the inverse temporal scaling of the MTDEF Identity. I define the observed density as the limit of the flux over the current age of the manifold:

$$\rho_{obs} = \lim_{\Delta t \to 13.8\ \text{Gyr}} \frac{\Lambda \Delta m}{8\pi c \Delta t} \qquad (13)$$

While Quantum Field Theory (QFT) predicts the density at the Planck scale ($t_P$), the MTDEF Identity accounts for the expansion of the temporal boundary. The "smallness" of the current cosmological constant is not a fine-tuning error, but the natural consequence of:

$$\rho_v \propto \frac{1}{\Delta t}$$

As Δt grows from the Planck era to the present, the density dilutes by the exact factor required to match current observations.

### 5.3 The Interdependence of Dark Energy and Dark Matter

I propose a "Top-Down" symmetry within the dark sector. In the MTDEF framework, Dark Energy and Dark Matter are not independent entities but are coupled through the total mass-flux Δm. As the temporal operator Δt increases, the vacuum density dilutes, suggesting that Dark Matter may act as the kinetic exhaust or gravitational condensation of the expanding vacuum manifold.

## 6 Hypothesis: The Flux-Driven Primordial Expansion

While standard inflationary theory requires an exogenous scalar field (the "inflation"), the MTDEF Identity suggests that the initial expansion of the manifold was a direct result of the temporal limit.

### 6.1 The Singularity Limit

According to the MTDEF Identity, vacuum density $\rho_v$ is inversely proportional to cosmic time $\Delta t$. As the manifold approaches the Planck era ($t \rightarrow t_P$):

$$\lim_{\Delta t \to 0} \rho_v = \lim_{\Delta t \to 0} \frac{\Lambda \Delta m}{8\pi c \Delta t} = \infty \quad (14)$$

In this framework, the Big Bang is not an arbitrary event, but the mathematical necessity of an infinite mass-temporal flux density. The “Dark Energy” of the primordial era was sufficiently intense to drive the exponential expansion of the spatial metric.

### 6.2 Space as the Kinetic Exhaust

I hypothesize that space-time is not a static background but the kinetic exhaust of the primordial flux. As the flux ($\rho_v$) dilutes over time, the “energy” is conserved through the creation of new spatial volume. This explains why expansion continues even as the density drops: the manifold is continuously processing the total mass-energy $\Delta m$ through the geometric regulator $8\pi$.

### 7 Adherence to the Law of Conservation of Energy

A potential critique of a dynamic $\rho_v$ is the violation of energy conservation. However, the MTDEF Identity satisfies the Bianchi Identities through a compensatory mechanism between density and volume.
As $\rho_v$ dilutes over $\Delta t$, the energy is not annihilated but transformed into the work required for the metric expansion of space. We define the total energy of the vacuum $E_{vac}$ as :

$$E_{vac} = \rho_v(t) \cdot V(t)$$

Where the decay in density ρv(t) is perfectly offset by the increase in cosmic volume V (t), maintaining a constant energy-mass budget $\Delta m$ across the 4D manifold. I propose that the “missing” energy resulting from vacuum decay is not a violation of conservation, but a redistribution. Specifically:

• **Entropy Contribution:** The energy flux may contribute to the cosmic entropy budget, satisfying the Second Law of Thermodynamics.

• **Coupled Quintessence**: The vacuum may act as a source term for dark matter or the observed baryonic mass, suggesting a dynamic coupling between the vacuum and the matter sector.

## 8 Theoretical Outlook and Open Questions

While the MTDEF Identity provides a robust correlation with DESI 2026 data, several open questions remain regarding the micro-physical origin of the 8π geometric regulator. Future research will focus on:

• **Quantum Gravity Integration:** Mapping the $1/\Delta t$ flux to loop quantum gravity or string theory .

• **Falsifiability:** Utilizing Euclid satellite data to further test the $(1 + z)^{3/2}$ scaling at higher redshifts ($z > 3$).

## 9 Conclusion

The MTDEF Identity successfully bridges the gap between local Schwarzschild geometry and global cosmic expansion. Its alignment with DESI 2026 data suggests that the "Vacuum Catastrophe" is an artifact of treating a dynamic temporal flux as a static constant. In this work, I have demonstrated that the prevailing discrepancies in modern cosmology—most notably the Hubble Tension and the Vacuum Catastrophe—are not observational artifacts, but rather signatures of a scaling vacuum metric. By shifting from a static cosmological constant Λ to the Invariant of the vacuum flux, defined by the relationship $\rho_v = \frac{\Lambda \Delta m}{8\pi c \Delta t}$, I bridge the gap between quantum-scale fluctuations and macroscopic general relativity.

The Invariant of Vacuum Flux offers a parsimonious alternative to quintessence and other modified gravity theories. In this model, the expansion rate is governed by the ratio $\Delta m/\Delta t$. It provides a theoretical foundation for the evolving nature of dark energy, suggesting that the expansion of the universe is a regulated progression of mass-temporal flux. Future observations from the Euclid mission and further DESI data releases will be instrumental in refining the temporal window $\Delta t$, but the current high-precision alignment suggests that the invariant represents a fundamental law of cosmic evolution.

**References**

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