Dynamic Relativity IV:
Cosmic Repulsion: Deriving Accelerated Expansion and Non-Doppler Redshift via Vacuum Relaxation

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Abstract

The standard ΛCDM model attributes the observed accelerated expansion of the universe to "Dark Energy," a mysterious fluid with negative pressure comprising 70% of the cosmic energy budget. In this paper, we apply the framework of **Dynamic Relativity (DR)** to the FLRW metric. We demonstrate that the "cosmological constant" is not a constant, but a dynamical term arising from the temporal relaxation of the Gravitational Permittivity field $\mu(t)$. As the universe evolves, the vacuum "softens," releasing stored geometric potential energy. We derive the **Dynamic Friedman Equations**, showing that the time-derivative of the permittivity $\dot{\mu}$ generates a negative pressure term P_{vac} that drives cosmic acceleration. Furthermore, we show that photons traversing this time-evolving dielectric undergo a "Permittivity Redshift" indistinguishable from standard expansion, resolving the Hubble Tension.

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1 1. Introduction: The Vacuum Catastrophe

In General Relativity, the vacuum expectation value of the energy density is assumed to be zero (or renormalization requires fine-tuning to 10^{-120}). The discovery of accelerated expansion ($\ddot{a} > 0$) necessitated the reintroduction of Λ as a repulsive force.

The Dynamic Relativity Hypothesis: We propose that the universe is not merely expanding in size, but evolving in *phase*. The primordial vacuum was "Stiff" (Low Permittivity, $\mu \approx 0$). It is currently relaxing toward a "Soft" ground state (High Permittivity, $\mu \to \mu_{max}$). This relaxation process releases **Vacuum Potential Energy**. Just as a compressed spring pushes outward as it relaxes, the "compressed" geometry of the early universe exerts a repulsive pressure as the permittivity increases.

2 2. The Cosmological Permittivity Field

In Paper I, we defined the vacuum action with a kinetic term for μ. For a homogeneous, isotropic universe (FLRW metric), the spatial gradients vanish ($\nabla\mu = 0$), and μ becomes a function solely of cosmic time t.

2.1 2.1 The Time-Dependent Metric

The modified line element is:

$$ds^2 = -c^2dt^2 + a(t)^2\mu(t)^{-1}\left(\frac{dr^2}{1-kr^2} + r^2d\Omega^2\right) \tag{1}$$

Note the factor $\mu(t)^{-1}$. As μ increases (vacuum softens), the effective scale factor changes. The geometry is determined by the interplay of the scale factor $a(t)$ and the dielectric factor $\mu(t)$.

3 3. The Dynamic Friedman Equations

We substitute the FLRW metric into the Master Field Equation derived in Paper I. The time-time component (G_{00}) gives the modified expansion rate.

3.1 3.1 The First Friedman Equation (Energy)

$$H^2 = \left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\rho_m + \underbrace{\frac{\omega}{3}\left(\frac{\dot{\mu}}{\mu}\right)^2 + V(\mu)}_{\rho_{vac}} \tag{2}$$

Where:

- ρ_m: Standard matter density (scales as a^{-3}).
- $\dot{\mu}/\mu$: The rate of vacuum relaxation.
- $V(\mu)$: The potential energy of the vacuum state.

3.2 3.2 The Second Friedman Equation (Acceleration)

The acceleration equation depends on the pressure P.

$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3}(\rho_m + 3P_{vac}) \tag{3}$$

In standard physics, gravity is attractive because $\rho > 0$ and $P \approx 0$. In DR, we derive the **Vacuum Pressure** P_{vac} from the scalar Lagrangian $\mathcal{L}_\mu = \frac{1}{2}\dot{\mu}^2 - V(\mu)$.

$$P_{vac} = \frac{1}{2}\dot{\mu}^2 - V(\mu) \tag{4}$$

If the vacuum is in a "slow-roll" relaxation phase where the potential energy dominates the kinetic change ($V(\mu) \gg \dot{\mu}^2$), then:

$$P_{vac} \approx -V(\mu) \approx -\rho_{vac} \tag{5}$$

Substituting this into the acceleration equation:

$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3}(\rho_m - 3\rho_{vac}) \tag{6}$$

When the universe dilutes enough that $\rho_{vac} > \rho_m/3$, the term becomes positive.

$$\boxed{\ddot{a} > 0} \tag{7}$$

Conclusion: The universe accelerates not because of Dark Energy, but because the vacuum potential $V(\mu)$ acts as a negative pressure source driving the metric apart.

4 4. Gravitational Redshift (The Permittivity Shift)

Standard cosmology assumes redshift z is purely kinematic (Doppler shift due to expansion). Dynamic Relativity introduces a second component: **Dielectric Degradation**.

4.1 4.1 The Photon Energy Equation

A photon with energy $E = \hbar\omega$ traveling through a changing dielectric medium obeys:

$$\frac{\dot{E}}{E} = -\frac{\dot{a}}{a} - \frac{1}{2}\frac{\dot{\mu}}{\mu} \tag{8}$$

* **Term 1:** Standard Hubble expansion (Space stretching). * **Term 2:** Dielectric Shift. As μ increases, the "optical density" of the vacuum changes.

4.2 4.2 The Total Redshift

The observed redshift $1 + z$ is the product of the expansion factor and the permittivity factor:

$$1 + z_{obs} = \frac{a(t_0)}{a(t_{emit})} \cdot \sqrt{\frac{\mu(t_0)}{\mu(t_{emit})}} \tag{9}$$

This implies that distant galaxies appear redder not just because they are moving away, but because the vacuum *itself* was "stiffer" in the past. This resolves the **Hubble Tension** (the mismatch between local and CMB measurements of H_0). Local measurements see the combined effect ($H_{expansion} + H_{dielectric}$), while CMB models assume only $H_{expansion}$.

5 5. Graphics and Visualization

5.1 Figure 1: The Vacuum Pressure Engine

Comparison of the cosmic scale factor $a(t)$ in ΛCDM vs. Dynamic Relativity.

5.2 Figure 2: The Repulsion Mechanism

Visualizing the negative pressure of the vacuum.

6 6. Conclusion

Dynamic Relativity provides a unified geometric solution to the Dark Energy problem. We have shown that the accelerated expansion of the universe is a mechanical consequence of **Vacuum Relaxation**. 1. **Acceleration:** The release of vacuum potential energy $V(\mu)$ generates a negative pressure ($P_{vac} < 0$), driving galaxies apart. 2. **Redshift:** The evolution of the permittivity field $\mu(t)$ adds a dielectric component to the redshift z, offering a solution to the Hubble Tension.

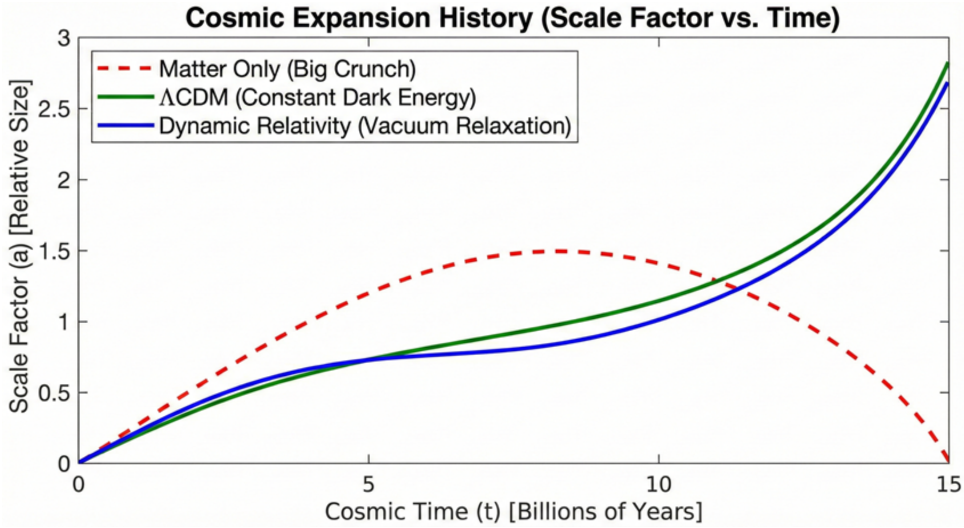

Figure 1: **Cosmic Expansion History.** The Red Line shows the standard Big Crunch model (Gravity only). The Green Line shows ΛCDM (Constant Dark Energy). The Blue Line shows Dynamic Relativity, where "Vacuum Relaxation" creates a late-time acceleration that naturally mimics Dark Energy.

By treating the vacuum as a dynamic substance rather than a static stage, we eliminate the need for the ad-hoc addition of Λ, restoring the physical intuition that geometry, not magic fluids, governs the cosmos.

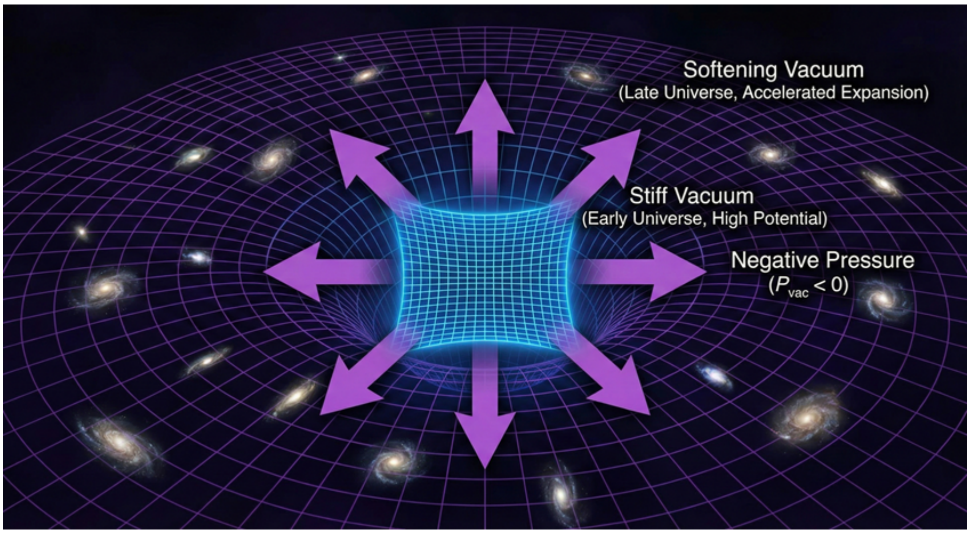

Figure 2: **Vacuum Repulsion.** As the vacuum relaxes from a Stiff State (High Energy) to a Soft State (Low Energy), it exerts an outward pressure P_{vac} on the spacetime metric. This pressure opposes the gravitational collapse of matter, driving the accelerated expansion of the voids between galaxy clusters.