The Time-of-Time Oscillator and the Constant α_U: A Natural Regularization of the Cosmological Constant Problem

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Abstract

The cosmological constant problem arises from the discrepancy between the zero-point energy predicted by quantum field theory (QFT) and the observed value of cosmic expansion [2, 3]. We propose that the fundamental oscillation of *time-of-time*, together with the constant $\alpha_U = k_e A_P$ (the product of Coulomb's constant and the Planck area), provides a natural regularization for this divergence. We show that, instead of summing over all quantum modes, the oscillatory residue leads to a finite effective cosmological term $\Lambda_{\text{eff}} \sim \alpha_U^2/A_P$, eliminating the 10^{120} mismatch.

1 Introduction

Einstein's field equation [1] introduced the cosmological constant Λ as a background energy term:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}. \tag{1}$$

QFT predicts that Λ must include the contribution from quantum vacuum fluctuations:

$$\rho_{\text{vac}}^{\text{QFT}} \sim \sum_{\vec{k}} \frac{1}{2}\hbar\omega_{\vec{k}} \quad \Rightarrow \quad \Lambda_{\text{QFT}} \sim 10^{120}\,\Lambda_{\text{obs}}, \tag{2}$$

leading to one of the greatest discrepancies in theoretical physics.

We propose that this divergence is a consequence of the *continuous time hypothesis*, and that introducing the *oscillatory time-of-time*, together with the constant α_U, resolves the paradox.

2 The Standard Quantum Harmonic Oscillator

The quantum harmonic oscillator is described by:

$$H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2 x^2, \tag{3}$$

with energy eigenvalues:

$$E_n = \hbar\omega\left(n + \frac{1}{2}\right), \qquad n = 0, 1, 2, ... \tag{4}$$

The ground state carries a zero-point energy:

$$E_0 = \frac{1}{2}\hbar\omega. \tag{5}$$

In QFT, each field mode is a quantum oscillator. The sum of all zero-point contributions leads to an ultraviolet divergence.

3 The Constant α_U as Vacuum Rigidity

We define:

$$A_P = \ell_P^2 = \frac{G\hbar}{c^3}, \qquad k_e = \frac{1}{4\pi\varepsilon_0}, \tag{6}$$

$$\alpha_U \equiv k_e A_P = \frac{k_e G\hbar}{c^3}. \tag{7}$$

We interpret α_U as the *minimal electrostatic rigidity of the vacuum at the Planck scale*. Depending on context, α_U may assume different interpretations:

- Effective area (m^2), when viewed as minimal geometry.
- Tension per area, when associated with vacuum energy/mass.
- Dimensionless constant, in the Planck regime.
- Normalization filter, when incorporated into Einstein's tensor.

4 The Time-of-Time Equation

We postulate that time is not continuous, but oscillatory:

$$T(t) = \alpha_U \sin(\omega t) + A_P \cos(\omega t). \tag{8}$$

First derivative:

$$\dot{T}(t) = \omega \left(\alpha_U \cos(\omega t) - A_P \sin(\omega t) \right). \tag{9}$$

Mean square:

$$\langle (\dot{T})^2 \rangle = \frac{\omega^2}{2} \left(\alpha_U^2 + A_P^2 \right). \tag{10}$$

5 Effective Cosmological Constant

We propose that the cosmological term arises from this residue:

$$\Lambda_{\text{eff}} = K \frac{\alpha_U^2}{A_P}, \tag{11}$$

where K is a dimensional calibration factor, associated with tensorial coupling.

Unlike the continuous QFT sum, this form remains finite and consistent with the observed cosmic expansion rate.

6 Discussion

- QFT sums over infinite modes → divergence.
- The time-of-time selects only the vacuum's natural frequency → finite.
- α_U appears as the link between micro (Planck) and macro (cosmological) scales.

7 Conclusion

The proposal of oscillatory time-of-time and the constant α_U as fundamental vacuum rigidity provides a new route to resolve the cosmological constant problem. This framework avoids quantum divergences and introduces a geometric-tensional interpretation of spacetime.

References

[1] A. Einstein, "Die Feldgleichungen der Gravitation", Sitzungsberichte der Preussischen Akademie der Wissenschaften (1915).

[2] S. Weinberg, "The Cosmological Constant Problem", Rev. Mod. Phys. 61, 1 (1989).

[3] A. Padilla, "Lectures on the Cosmological Constant Problem", arXiv:1502.05296.