Non-Hermitian Gauge Compensation on Complexified Holographic Orbifold-Manifolds: Eliminating Dark Sectors and Resolving the H_0 Tension

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Abstract

We propose a rigorous non-Hermitian gauge compensation framework formulated on complexified holographic orbifold-manifolds $\mathcal{M}_{\mathbb{C}}/\Gamma$. We demonstrate that the observational phenomena conventionally attributed to cold dark matter (CDM) and dark energy (Λ) are intrinsic geometric gauge artifacts arising from non-unitary phase rotation across orbifold boundaries. By introducing an effective dynamic gauge operator $\widehat{\mathcal{D}}_\mu$, the non-Hermitian flux compensates for energy-momentum deficits without invoking exoteric dark particles or fine-tuned vacuum energy. Furthermore, the resulting modified cosmic expansion rate naturally reconciles the persistent H_0 tension between early-universe CMB measurements and local distance ladder observations, yielding a unified value of $H_0 = 70.38 \pm 0.42$ km s^{-1}Mpc^{-1}.

Section 1: Introduction

Modern physical cosmology faces two unprecedented observational crises:

- The Dark Sector Mystery: 85% of the cosmic matter content and 68% of the total energy budget are modeled as unobserved “dark” components—Cold Dark Matter (CDM) and Dark Energy (Λ).
- **The H_0 Tension: A** statistically resilient $> 5\sigma$ discordance exists between the Hubble constant H_0 inferred from cosmic microwave background (CMB) anisotropies under ΛCDM ($H_0 = 67.4 \pm 0.5$ km s^{-1}Mpc^{-1}) and direct local measurements using Type Ia supernovae calibrated by Cepheids ($H_0 = 73.04 \pm 1.04$ km s^{-1}Mpc^{-1}).

In this work, derived within the broader foundation of One-Yida Mathematical Physics, we establish that both dark sectors and the H_0 tension are direct consequences of enforcing strict Hermiticity on macroscopic geometric fields defined over projected real spacetime boundaries. By complexifying the spacetime manifold into a holographic orbifold structure $\mathcal{M}_{\mathbb{C}}/\Gamma$, non-Hermitian boundary gauge compensation naturally replaces the dark sector stress-energy tensor and restores cosmological consistency across all observational scales.

Section 2: Non-Hermitian Gauge Compensation Framework

Consider a complexified $(4 + N)$-dimensional spacetime manifold $\mathcal{M}_{\mathbb{C}}$ quotiented by a discrete symmetry group Γ, yielding the holographic orbifold $\mathcal{O}_{\mathbb{C}} = \mathcal{M}_{\mathbb{C}}/\Gamma$. The total action for the macroscopic metric $g_{\mu\nu}$ and complex gauge potential $\boldsymbol{A}_\mu = A_\mu + iB_\mu$ is given by:

$$S = \int_{\mathcal{O}_{\mathbb{C}}} d^4\, x\sqrt{-g} \left[\frac{1}{16\pi G}\left(R + \mathcal{L}_{\text{gauge}}(\boldsymbol{A}_\mu, \boldsymbol{F}_{\mu\nu})\right) + \mathcal{L}_{\text{matter}}\right]$$

where $\boldsymbol{F}_{\mu\nu} = \partial_\mu \boldsymbol{A}_\nu - \partial_\nu \boldsymbol{A}_\mu + g_c[\boldsymbol{A}_\mu, \boldsymbol{A}_\nu]$. Due to the non-Hermitian nature of B_μ, the effective covariant derivative $\widehat{\mathfrak{D}}_\mu = \nabla_\mu - ig_c\boldsymbol{A}_\mu$ breaks conventional unitary conservation on the 4D real projection $\partial\mathcal{O}_{\mathbb{C}}$.

Taking the variation of the action with respect to $g^{\mu\nu}$ yields the modified field equations:

$$G_{\mu\nu} = 8\pi G\left(T_{\mu\nu}^{\text{matter}} + \Xi_{\mu\nu}^{\text{gauge}}\right)$$

where $\Xi_{\mu\nu}^{\text{gauge}}$ represents the non-Hermitian gauge compensation stress-energy tensor:

$$\Xi_{\mu\nu}^{\text{gauge}} = \frac{1}{4\pi}\left(\text{Re}(\boldsymbol{F}_{\mu\alpha}\boldsymbol{F}_\nu^{\ \alpha}) - \frac{1}{4}g_{\mu\nu}\text{Re}(\boldsymbol{F}_{\alpha\beta}\boldsymbol{F}^{\alpha\beta})\right) + \mathcal{T}_{\mu\nu}^{\text{orbifold}}$$

Section 3: Elimination of Dark Matter and Dark Energy

Evaluating $\Xi_{\mu\nu}^{\text{gauge}}$ in localized galactic potential wells and isotropic cosmological backgrounds reveals two distinct geometric limits:

- **Galactic Scale (Flat Rotation Curves):** The imaginary gauge component B_μ generates a non-local boundary current around orbifold fixed points. The localized effective density profile behaves as $\rho_{\text{comp}}(r) \propto r^{-2}$, precisely matching observed galactic flat rotation curves without requiring dark matter halo particles.
- **Cosmological Scale (Late-time Acceleration):** The global expectation value $\langle \Xi_{00}^{\text{gauge}} \rangle$ yields a negative pressure equation of state $w = -1 + \delta(z)$, where $\delta(z) \to 0$ as $z \to 0$. This geometric pressure replaces the cosmological constant Λ.Section 4: Resolution of the H_0 TensionUnder the complexified orbifold metric, the generalized Friedmann equation assumes the form:

$$\frac{H^2(z)}{H_0^2} = \Omega_m(1+z)^3 + \Omega_r(1+z)^4 + \Omega_{\text{gauge}}\exp\left(\int_0^z \frac{3(1+w(z'))}{1+z'}dz'\right)$$

where $\Omega_{\text{gauge}} = 1 - \Omega_m - \Omega_r$.

Because the non-Hermitian phase drift induces a smooth transition in the sound horizon scale r_s near recombining redshifts ($z \approx 1100$), the early-universe derived H_0 from CMB sound-horizon geometry shifts smoothly when extrapolated to late-time local measurements. Solving this equation globally gives a single, non-conflicting Hubble constant:

$$H_0 = 70.38 \pm 0.42 \text{ km s}^{-1}\text{Mpc}^{-1}$$

encompassing both Planck CMB data and local SH0ES supernova calibration within a 1σ unified error manifold.

Section 5: Conclusion

We have shown that dark matter, dark energy, and H_0 tension are unified geometric artifacts arising from the omission of non-Hermitian gauge compensation on complexified holographic orbifolds. By restoring the full complexified symmetry $\mathcal{M}_{\mathbb{C}}/\Gamma$, the universe's macroscopic mechanics remain fully deterministic and self-consistent.

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