

Generative Unified Field Theory: Modeling Cosmic Acceleration

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Note on v2. This is a corrected re-release of an exploratory paper first posted in October 2025, at the very beginning of the author’s research program. v1 contained presentation errors and overstated what its numerical section demonstrates; v2 fixes the equations, states honestly what is postulated and what is derived, and preserves the original ideas unchanged in spirit. It is kept as a historical record: every research program starts with exploration, and exploration is not expected to be right at the start.

Abstract

We propose a generative unified field theory extending Zhang’s framework, in which real space is generated and driven by a constant virtual (imaginary) space with a feedback mechanism. Applied to cosmic acceleration, the framework accommodates the observed expansion history: a constant virtual-space background contributes an effective cosmological constant, and with its one free parameter set to the observed value ($\Omega_v \simeq 0.7$), its expansion history tracks the standard Λ CDM history (Planck parameters) to within $\sim 0.6\%$ in comoving distance over $z = 0$ –4. We state explicitly that this is a consistency check, not a first-principles derivation of Ω_Λ : the value is matched to observation, while the framework’s contribution is to provide a generative physical picture—a constant virtual background with feedback—for what the standard model parametrizes as Λ . The sequel to this exploratory work, in which the virtual-space idea matured into a data-inversion program, is summarized at the end of this paper.

1 Introduction

Unified field theories aim to reconcile gravity, electromagnetism, and quantum mechanics. Zhang’s Unified Field Theory posits that the universe consists solely of objects and space, with space undergoing light-speed cylindrical spiral divergence around objects. This motion follows a right-handed helical path with constant speed modulus c (light speed), composed of a linear component $v_z = c \cos \theta$ and a rotational component $v_\perp = c \sin \theta$, where θ is the spiral angle. Time is redefined as the observer’s perception of this spatial motion, leading to the space-time relation $r^2 = c^2 t^2$, and forces are unified via momentum changes [1]. The framework as originally formulated lacks an explicit mechanism that sustains the motion and connects it to quantum phenomena. We extend it by introducing a constant virtual space as a generative source that drives real space, stabilized by a feedback loop. The feedback concept is philosophically inspired by the dynamic-balance thinking of Traditional Chinese Medicine; we cite this as motivation, not as a physical mechanism. This paper applies the extended framework to cosmic acceleration, the observed quickening of the universe’s expansion attributed to dark energy ($\sim 68\%$ of the cosmic energy density) [2, 3, 4].

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2 Model

We summarize Zhang’s core picture for readers unfamiliar with it: the universe comprises objects and space, and the space around any object performs a cylindrical right-handed spiral divergence at vector light speed $\vec{c}$ (constant modulus c , variable direction). The trajectory is $\vec{r}(t) = (v_z t, R \cos(\omega t), R \sin(\omega t))$ with $\omega = c/R$, so that the total speed is c . Imaginary components appear in the wave solutions as mathematical tools.

We extend this picture by doubling the space. Write a complex field

$$\vec{s}(\vec{x}, t) = \vec{r}(\vec{x}, t) + i \vec{\phi}(\vec{x}, t), \quad (1)$$

where $\vec{r} \in \mathbb{R}^3$ is real (observable) space and $\vec{\phi}$ is the virtual-space field. The central postulate of this paper is:

The virtual field has a constant homogeneous background amplitude $\vec{\phi} = \vec{\phi}_0$ with $|\vec{\phi}_0| = \phi_0$ (dimensionless, normalized to $\phi_0 = 1$), and real space is generated and sustained by this background through a feedback loop.

The field obeys a wave equation with a feedback coupling,

$$\frac{\partial^2 \vec{s}}{\partial t^2} = c^2 \nabla^2 \vec{s} + i\lambda (\vec{r} \cdot \nabla \vec{\phi}), \quad (2)$$

with a feedback law that maintains the background,

$$\frac{d\vec{\phi}}{dt} = \kappa \delta \vec{r}, \quad (3)$$

where $\delta \vec{r}$ is the deviation of real space from its background-driven configuration and λ, κ are coupling constants. For the constant background, $\nabla \vec{\phi} \approx 0$, and Eq. (2) reduces to the ordinary wave equation; the feedback term’s role is to keep $\vec{\phi} = \vec{\phi}_0$ stationary against perturbations, i.e., it is a *stationarity condition*, not a dynamical derivation of the background’s value.

The cosmological consequence follows from the postulate, not from the wave equation: a constant virtual background contributes a constant energy density ρ_v to the Friedmann equation,

$$H^2(z) = \frac{8\pi G}{3} [\rho_m(z) + \rho_v], \quad (4)$$

with $\rho_m(z) = \rho_{m,0}(1+z)^3$. Formally we may parameterize

$$\rho_v = \frac{\lambda \kappa \phi_0^2 c^2}{8\pi G} \frac{1}{L^2} \iff \Omega_v \equiv \frac{\rho_v}{\rho_{\text{crit},0}}, \quad (5)$$

where L is a length scale absorbed into the normalization. We are explicit: in v1 the constants were set to $\lambda = 1.0$, $\kappa = 1.0$, $\phi_0 = 1.0$ and described as “fitted from simulations.” That description was incorrect. These are *normalization choices*; only the combination that sets $\Omega_v \simeq 0.7$ is constrained, and it is constrained *by the data*, not derived from the theory. Equation (5) is therefore a parameterization showing how virtual-space quantities combine into the macroscopic Ω_v , not a prediction of its value.

With Ω_v thus set, Eq. (4) becomes

$$H_{\text{model}}(z) = H_0 \sqrt{\Omega_m (1+z)^3 + \Omega_v}, \quad (6)$$

with $H_0 = 67.4 \text{ km s}^{-1} \text{ Mpc}^{-1}$, $\Omega_m = 0.315$, $\Omega_v = 0.7$. We emphasize the logical status: Eq. (6) has the same functional form as the standard Λ CDM expansion history with Ω_Λ renamed to Ω_v . Any agreement with data is therefore a *consistency check*—the framework can host the observed expansion history—and not an independent prediction.

3 Consistency check: cosmic acceleration

3.1 Data

We use three standard datasets: Type Ia supernovae (Pantheon+, 1701 light curves [3, 4]), the cosmic microwave background (Planck 2020, $\Omega_\Lambda = 0.6847 \pm 0.0073$ [2]), and baryon acoustic oscillations (DESI 2024). The comoving distance is

$$d_c(z) = \int_0^z \frac{c dz'}{H(z')}, \quad (7)$$

and the supernova distance modulus is $\mu(z) = 5 \log_{10}(d_L/10 \text{ pc})$ with $d_L = (1+z)d_c$.

3.2 Result

Evaluating Eq. (6) by numerical integration (SciPy `quad`) over $z = 0\text{--}4$ gives comoving distances (Mpc), compared with the standard Λ CDM history at the Planck parameters ($H_0 = 67.4$, $\Omega_m = 0.315$, $\Omega_\Lambda = 0.685$):

Λ CDM reference: 0.0, 1951.4, 3401.3, 4482.1, 5312.1, 5970.0, 6506.1, 6952.9, 7332.5.

Model, Eq. (6) ($\Omega_v = 0.7$): 0.0, 1940.0, 3385.2, 4464.1, 5293.2, 5950.6, 6486.5, 6933.2, 7312.7.

The mean relative deviation is 0.37% (maximum 0.58%), corresponding to distance-modulus differences below 0.013 mag, well inside the Pantheon+ uncertainties. (v1’s printed table did not survive recomputation: its “observed” column deviates by $\sim 10\%$ from the Λ CDM values for the parameters it cites, and its “model” column was not a genuine integration output. The table above replaces it with verified integrations.) As stressed above, this closeness is expected by construction: it confirms that a constant virtual-space background is *compatible* with the observed expansion history. It does not derive $\Omega_v \simeq 0.7$; that number is an input fixed by the same observations.

3.3 What would make this a prediction

The framework becomes predictive where it goes beyond reparameterization. Two directions are identified: (i) the feedback law, Eq. (3), implies a specific dynamics for perturbations of the virtual background, which could leave imprints distinct from a strict cosmological constant (e.g., in the growth of structure or in phase shifts in interferometric tests); (ii) applying the same generative idea at galactic scales leads to spatially varying virtual-space couplings, which is the subject of the sequel work summarized in §5.

4 Discussion

The v1 paper presented the numerical agreement as the model’s validation and left the impression that $\Omega_\Lambda \simeq 0.68$ had been derived. v2 corrects this: the derivation was circular, and the honest claim is compatibility, not prediction. What survives—and what motivated keeping this paper as a historical record—is the *conceptual* move: treating virtual (imaginary) space not as a mathematical convenience but as a generative physical background with its own dynamics and feedback. That move, first tried here on cosmic acceleration, later matured into a quantitative program in which the virtual-space coupling is *inverted from data* rather than postulated, as described next.

5 Sequel: from postulated background to inverted coupling

The ideas explored above did not stop at this paper. In subsequent work, the virtual-space concept was developed into *information dynamics*, a framework in which a generalized Ginzburg–

Landau equation governs an order-parameter field and a real scalar coupling $K(x)$ mediates the projection of virtual information onto real phenomena. Crucially, the direction of inference was reversed: instead of postulating the virtual-space coupling and checking consistency, the coupling $K(r)$ was *inverted directly from SPARC galaxy rotation curves*. Across 126 galaxies, the inverted coupling takes a universal Lorentzian form, and the framework unifies dark matter (localized virtual vortices) with dark energy (the homogeneous virtual background) as two scales of one projection. That work is published as:

Kai Huang, *Dark Matter Halos as Virtual Vortices: Inverting a Universal Coupling from SPARC Rotation Curves and Unifying Dark Matter with Dark Energy*, Zenodo (2026). <https://doi.org/10.5281/zenodo.23440073>

The present paper is thus the exploratory beginning—a postulated constant background checked for consistency—and the Zenodo paper is its sequel: the same virtual space, now measured rather than assumed.

6 Conclusion

This paper proposed a generative extension of Zhang’s unified field theory and applied it to cosmic acceleration. v2 has corrected the presentation errors of v1 and stated the logical status of each step honestly. The framework accommodates the observed expansion history with a single data-matched parameter; deriving that parameter’s value, and testing the feedback dynamics beyond the background level, remain open. The research program that grew out of this beginning is documented in the sequel cited above.

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References

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