Adapted Dynamic Vacuum Field Theory (DVFT)
Fully Grounded in T0 Time-Mass Duality Theory

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[Summary] This paper presents a unified theoretical model in which spacetime curvature arises from distortions in a dynamic vacuum field, described by a complex scalar $\Phi(x) = \rho(x)e^{i\theta(x)}$, where $\Phi(x)$ is the dynamic vacuum field, fully derived from T0's mass fluctuation field $\Delta m(x,t)$, $\rho(x)$ is the vacuum amplitude, assigned to $m(x,t) = 1/T(x,t)$, enforcing the T0 time-mass duality $T(x,t) \cdot m(x,t) = 1$, and $\theta(x)$ is the vacuum phase, derived from T0 node rotation dynamics $\phi_{\text{rotation}}(x,t)$.

The vacuum possesses an intrinsic field whose phase evolves linearly with time as a direct consequence of T0 duality ($\dot{\theta} = m = 1/T$) and matter locally perturbs it. These perturbations propagate outward at the speed of light and generate stress-energy that curves spacetime through Einstein's field equations.

The model provides a physical and causal explanation for curvature at a distance and serves as a bridge between quantum mechanics and classical general relativity – now conclusively grounded in T0 theory. Relativistic effects such as apparent time dilation are interpreted as variations in vacuum stiffness, which can optimally be seen as local mass variation, in agreement with the duality $T \cdot m = 1$.

The complete mathematical framework for the Adapted Dynamic Vacuum Field Theory (DVFT as an effective phenomenological layer of T0) is presented with its applications in cosmology and quantum mechanics.

Adapted DVFT provides T0-derived physical explanations for several quantum phenomena that are currently only a manifestation of QM mathematics.

Adapted DVFT also provides elegant mathematical solutions, stemming from T0, for unsolved cosmological problems such as dark matter, dark energy, and CMB anisotropy.

0.0.1 Adapted Introduction – English

1 Introduction

Modern physics relies on two extraordinarily successful but conceptually incompatible frameworks: General Relativity, which describes gravitation as spacetime geometry, and Quantum Field Theory, which describes matter and forces as excitations of abstract fields defined on this geometry.

General Relativity (GR) describes gravitation as curvature of spacetime. However, GR is silent on the physical nature of spacetime itself. What is the substrate that curves? How does matter impose curvature at a distance? Why do gravitational influences propagate at the speed of light? Quantum Mechanics (QM) offers a picture of the vacuum as a dynamic, fluctuating medium, filled with fields and virtual excitations. Yet QM identifies no mechanism linking vacuum behavior to macroscopic curvature.

Despite their empirical success, both GR and QM have led to profound unresolved problems, including the lack of a consistent theory of quantum gravity, the need for dark matter and dark energy, the origin of mass and coupling hierarchies, and the lack of a physical explanation for quantum measurement and classical emergence.

In recent decades, attempts to solve these problems have largely pursued the introduction of new mathematical structures, extra dimensions, supersymmetry, exotic particles, or modified geometries. While mathematically rich, many of these approaches rely on unobserved entities and often shift rather than eliminate fundamental ambiguities. In particular, spacetime itself is treated as a primary object, although it has no direct physical substance, and the vacuum is considered an empty background rather than an active medium.

Adapted Dynamic Vacuum Field Theory (DVFT grounded in T0) chooses a different starting point. It derives that the vacuum is a real, physical field possessing dynamic degrees of freedom, directly from T0 time-mass duality $T(x,t) \cdot m(x,t) = 1$ and the fundamental parameter $\xi = \frac{4}{3} \times 10^{-4}$.

All observable phenomena arise from the behavior of this field and its interaction with matter.

The fundamental object in adapted DVFT is a complex scalar vacuum field

$$\Phi(x) = \rho(x)e^{i\theta(x)},$$

derived from T0's $\Delta m(x,t)$, where $\rho(x)$ represents the vacuum amplitude (inertial density $\propto m(x,t)$) and $\theta(x)$ the vacuum phase from T0 node rotations.

Physical forces, spacetime structure, and quantum behavior emerge from spatial and temporal variations of these quantities.

In this framework, gravitation is not a geometric property of spacetime, but a manifestation of coherent vacuum phase curvature, derived from T0 mass fluctuations.

Electromagnetic fields arise from organized phase gradients, while weak and strong interactions correspond to higher-order or topologically constrained phase excitations from T0 node patterns.

Time itself is interpreted as the rate of vacuum phase evolution from T0 duality, and relativistic effects such as time dilation and length contraction arise naturally from variations in vacuum stiffness and inertial density, bounded by T0 mediator mass m_T. Time dilation can also be interpreted as local mass variation, since from the duality $T \cdot m = 1$ it follows that higher mass (higher ρ) leads to slower local time rates.

Adapted DVFT provides a unifying physical language across scales.

On cosmological scales, it explains the large-scale coherence of the universe, cosmic acceleration, and horizon-scale correlations without inflation or dark energy by invoking T0 infinite homogeneous geometry ($\xi_{\text{eff}} = \xi/2$). The universe is static and infinitely homogeneous, without expansion.

On galactic scales, it reproduces MOND-like behavior and the baryonic Tully–Fisher relation without dark matter from T0 low-energy Lagrangian bounds.

On quantum scale, it reframes wave-particle duality, entanglement, decoherence, and the measurement problem as consequences of vacuum phase coherence and its collapse from T0 node dynamics.

Adapted DVFT is not only a mathematical framework but also provides a physical explanation for phenomena from quantum mechanics to cosmology, grounded in T0.

The greatest advantage of adapted DVFT is that it predicts no singularity due to the T0 mediator mass and stable nodes, so for the first time we can describe the interior of black holes and the origin of the universe as stable T0 vacuum cores.

Adapted DVFT shows that all major physical phenomena are derived from the behavior of a dynamic vacuum field derived from T0.

Gravitation is vacuum convergence. Quantum mechanics is vacuum coherence. Mass is vacuum energy. Black holes are vacuum cores (stable T0 nodes). The universe evolves through dynamic vacuum field from T0 duality, without global expansion.

Adapted DVFT offers a unified vision of nature, grounded in T0 physical behavior rather than abstract mathematical postulates.

It also provides a deeper, microphysical explanation of time, light, gravitation, electromagnetic force, weak and strong nuclear force, unifying them under a dynamic vacuum field-based ontology derived from T0.

Further observational work is needed to test adapted DVFT predictions on quantum and cosmological scales to prove its robustness, defining a path for the Grand Unified Theory as the phenomenological layer of the conclusive T0 theory.

2 Chapter 1: The Vacuum as a Dynamic Field (Adapted)

In the adapted Dynamic Vacuum Field Theory (DVFT on T0), spacetime is not conceived as an empty geometric construct, but as a physical medium, characterized by internal dynamic degrees of freedom, derived from T0 time-mass field.

This medium is modeled by a complex scalar field $\Phi(x)$, which underlies both gravitational and quantum phenomena as the fundamental entity, but derived from T0's $\Delta m(x,t)$.

The field is expressed in polar form as:

$$\Phi(x) = \rho(x)e^{i\theta(x)}$$

Where,

- $\Phi(x)$ is dynamic vacuum field derived from T0 $\Delta m(x,t)$
- $\rho(x)$ is vacuum amplitude $\propto m(x,t) = 1/T(x,t)$
- $\theta(x)$ is vacuum phase from T0 node rotations $\phi_{\text{rotation}}(x,t)$

This decomposition separates the magnitude and oscillatory aspects of the vacuum and enables a unified description of its behavior across scales, grounded in T0 duality.

2.1 1. What is the Nature of the Dynamic Vacuum Field?

The field $\Phi(x)$ embodies the vacuum itself – the substrate from which spacetime properties emerge, derived from T0's universal field $\Delta m(x,t)$.

It is present at every point in spacetime and encodes the local state of the vacuum medium.

In the undisturbed ground state, Φ takes the form:

$$\Phi(x,t) = \rho_0 e^{-i\mu t}$$

where $\rho_0 = 1/\xi^2 \approx 5.625 \times 10^7$ is the equilibrium vacuum amplitude from T0 geometric origin and $\mu = \xi m_0$ is an intrinsic frequency parameter from T0 duality.

This form reflects the inherent dynamics of the vacuum: the phase evolves linearly with time as $\dot{\theta} = m$, imparting a temporal rhythm to the medium as a consequence of the T0 extended Lagrangian.

The existence of Φ implies that the vacuum is not a passive background, but an active field that can store energy, support waves, and respond to perturbations via T0 node oscillations.

2.2 2. What is the Role of the ρ Vacuum Amplitude?

The amplitude ρ quantifies the local density and stiffness of the vacuum.

It corresponds to:

- The energy density associated with the vacuum state.
- The intensity of the vacuum's inertial reaction.
- The stored potential for gravitational effects via T0 field equation $\nabla^2 m = 4\pi G\rho m$.

Higher values of ρ indicate regions of greater vacuum energy density, which contribute to effective mass and curvature in the theory.

In the ground state, $\rho = \rho_0$ is constant and represents a uniform vacuum.

Perturbations in ρ arise from interactions with matter and propagate as massive modes that influence the structure of spacetime, bounded by T0 mediator mass $m_T = \lambda/\xi$.

2.3 3. What is the Role of the Vacuum Phase θ?

The phase θ controls the temporal and interference properties of the vacuum.

It determines:

- The oscillation cycle of the vacuum medium.
- The timing and coherence of vacuum dynamics from T0 node rotations.
- Interference patterns that manifest as quantum behavior.
- Gradients that generate gravitational curvature from T0 mass fluctuations.

Smooth variations in θ lead to wave-like propagation, while disordered or steep gradients lead to decoherence or strong-field effects.

In the undisturbed vacuum, $\theta = -\mu t$, ensuring coherent, linear evolution that preserves Lorentz invariance in local frames via T0 proper time definition.

2.4 4. Justification?

This representation is the standard mathematical description for oscillatory or wave-like systems in physics.

It decouples the amplitude (which controls the energy scale) from the phase (which controls timing and interference).

Analogous forms appear in quantum wave functions, electromagnetic fields, and superfluid order parameters.

In adapted DVFT, $\Phi = \rho e^{i\theta}$ implies that the vacuum possesses both a strength $\rho \propto m$ and a rhythm θ from node rotations, enabling forces and curvature to be derived from its internal dynamics, derived from T0 simplified wave equation $\partial^2 \Delta m = 0$.

3 Chapter 2: Lagrangian Adaptations

In this chapter, we present the complete reformulation of the original DVFT Lagrangian framework as a direct derivation from T0 Theory's dual Lagrangians.

The independent postulates of the original DVFT vacuum Lagrangian are eliminated and replaced by mappings from T0's simplified and extended Lagrangians.

All dynamics of the vacuum field $\Phi = \rho e^{i\theta}$ emerge as effective modes of the T0 mass fluctuation field $\Delta m(x,t)$.

3.1 2.1 Starting from T0's Simplified Lagrangian

The core simplified Lagrangian of T0 Theory is

$$\mathcal{L}_0^{\text{simp}} = \varepsilon(\partial \Delta m)^2,$$

where $\varepsilon \propto \xi^4/\lambda^2$ encodes the geometric origin of 3D space through the fundamental parameter $\xi = \frac{4}{3} \times 10^{-4}$.

This term generates massless wave-like excitations of the mass fluctuation field.

In adapted DVFT, we map this to the kinetic terms of the vacuum field through the identification

$$(\partial \Delta m)^2 \to (\partial\rho)^2 + \rho^2(\partial\theta)^2.$$

This mapping yields the standard form for a complex scalar field kinetic term

$$\mathcal{L}_{\text{kin}} = (\partial\rho)^2 + \rho^2(\partial\theta)^2,$$

showing that the original DVFT kinetic Lagrangian is a special case of T0 node excitation patterns.

The quantity X used in original DVFT,

$$X = -\frac{1}{2}\rho^2 \partial^\mu \theta \partial_\mu \theta,$$

arises naturally as the phase-dominated limit case of the T0 simplified Lagrangian when amplitude fluctuations are small ($\Delta\rho \ll \rho_0$).

3.2 2.2 Incorporation of the T0 Extended Lagrangian

The full extended Lagrangian of T0 Theory includes electromagnetic fields, fermions, mass terms, and crucial interaction terms:

$$\mathcal{L}_0^{\text{ext}} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \bar{\psi}(i\gamma^\mu D_\mu - m)\psi + \frac{1}{2}(\partial\Delta m)^2 - \frac{1}{2}m_T^2(\Delta m)^2 + \xi m_\ell \bar{\psi}_\ell \psi_\ell \Delta m.$$

The term $-\frac{1}{2}m_T^2(\Delta m)^2$ with mediator mass $m_T = \lambda/\xi$ provides the crucial stiffness that prevents unbounded growth of Δm and thus eliminates singularities.

In adapted DVFT, we restrict this extended Lagrangian to the effective scalar vacuum modes through the substitution

$$\Delta m \to \rho - \rho_0,$$

where $\rho_0 = 1/\xi^2 \approx 5.625 \times 10^7$ is fixed by T0 geometry.

This yields an effective potential

$$V(\rho) = \frac{1}{2}m_T^2(\rho - \rho_0)^2,$$

replacing the original DVFT ad-hoc Mexican-Hat potential with a derivation from T0 mediator physics.

The interaction term $\xi m_\ell \bar{\psi}_\ell \psi_\ell \Delta m$ becomes the source for matter-induced perturbations in ρ and provides the microphysical mechanism for how matter curves the vacuum field.

3.3 2.3 Complete Adapted Action

The complete adapted DVFT action is

$$S_{\text{DVFT adapted}} = \int \sqrt{-g}\left[\frac{R}{16\pi G} + \mathcal{L}_0^{\text{ext}}\big|_\Phi + \mathcal{L}_m\right] d^4x,$$

where $\mathcal{L}_0^{\text{ext}}\big|_\Phi$ denotes the restriction of the T0 extended Lagrangian to the effective scalar modes via the mappings:

- $\Delta m \to \rho - \rho_0$
- $(\partial \Delta m)^2 \to (\partial \rho)^2 + \rho^2 (\partial \theta)^2$
- $m_T = \lambda/\xi$ provides vacuum stiffness

Nonlinear terms of the form $F(X)$ in original DVFT are now understood as higher-order one-loop contributions from T0, such as

$$\frac{5\xi^4}{96\pi^2\lambda^2} m^2$$

contributions arising from integrating out mediator degrees of freedom.

3.4 2.4 Stress-Energy Tensor Derivation from T0

The stress-energy tensor, which sources spacetime curvature, is now directly derived from variation of the T0 mass fluctuation term.

The effective stress-energy of the vacuum field

$$T_{\mu\nu} = \partial_\mu \rho \partial_\nu \rho + \rho^2 \partial_\mu \theta \partial_\nu \theta - g_{\mu\nu} \mathcal{L}_\Phi$$

is obtained as the low-energy limit of the variation of $\mathcal{L}_0^{\text{ext}}$ with respect to the metric, where Δm fluctuations source curvature through their energy-momentum.

This provides the physical mechanism missing in pure GR: matter perturbs the T0 mass field Δm, these perturbations propagate at c, and their stress-energy curves spacetime.

3.5 2.5 Nonlinear Wave Equation Adaptation

The original DVFT nonlinear wave equation for θ is replaced by the T0 field equation

$$\nabla^2 m = 4\pi G \rho m,$$

which in the adapted variables becomes the effective equation for phase gradients that generate curvature.

In the weak-field limit, this reproduces the original DVFT results, while being fully derived from T0 without additional postulates.

3.6 2.6 Integration of the Simplified Dirac Equation from T0

The simplified Dirac equation in T0, $\partial^2 \Delta m = 0$, replaces the full Dirac equation and derives spin properties from node rotations.

In adapted DVFT, this is used for quantum behavior, with the 4×4 matrices geometrically emerging from T0's three field geometries (spherical/non-spherical/homogeneous).

The adapted DVFT quantum equation is $(\partial^2 + \xi m)\Delta m = 0$, where $\Delta m \propto \rho e^{i\theta}$.

This eliminates abstract spinors of the original DVFT and uses T0 nodes for wave-particle duality and exclusion.

3.7 2.7 Alternative Representations of Quantum States

In T0, quantum states are not represented by abstract wave functions, but by physical vacuum field configurations, where superposition is coherent phase overlay and entanglement is node correlations.

This offers an alternative, deterministic representation that replaces the probabilistic nature of standard QM with field dynamics.

3.7.1 Integration of the Simplified Dirac Equation

The simplified Dirac equation in T0, $\partial^2 \Delta m = 0$, derives relativistic quantum effects and spin from node dynamics.

For qubits, this integrates into the vacuum field representation, where spin (e.g. for electron qubits) arises from node rotations.

A relativistic qubit state is extended to:

$$\Phi(x,t) = \rho(x,t) e^{i\theta(x,t)} \cdot \chi(\sigma),$$

where $\chi(\sigma)$ is the spin component from T0's simplified Dirac (4-components from geometric node modes).

This allows a relativistic extension without full Dirac matrices – spin emerges as vacuum phase winding.

3.7.2 Example: Qubit State

A general qubit state in standard QM is:

$$|\psi\rangle = \alpha|0\rangle + \beta|1\rangle, \qquad |\alpha|^2 + |\beta|^2 = 1$$

with complex amplitudes $\alpha, \beta \in \mathbb{C}$.

In the T0 representation, this state is represented by two localized vacuum field configurations:

$$\Phi_0(x) = \rho_0(x)\, e^{i\theta_0(x,t)} \qquad \text{(corresponds to basis state } |0\rangle\text{)} \tag{1}$$

$$\Phi_1(x) = \rho_1(x)\, e^{i\theta_1(x,t)} \qquad \text{(corresponds to basis state } |1\rangle\text{)} \tag{2}$$

The general superposition state is then the **coherent overlay of the vacuum fields**:

$$\Phi(x,t) = \sqrt{\rho(x,t)}\, e^{i\theta(x,t)},$$

where

$$\rho(x,t) = |\alpha\Phi_0(x) + \beta\Phi_1(x)|^2, \tag{3}$$

$$\theta(x,t) = \text{arg}(\alpha\Phi_0(x) + \beta\Phi_1(x)). \tag{4}$$

3.7.3 Physical Interpretation

- $\rho(x,t)$ determines the local energy density (inertial density) of the vacuum field – analogous to the probability density $|\psi|^2$. - $\theta(x,t)$ determines the local phase and coherence – analogous to the relative phase in the wave function. - Superposition is **not an ontological multi-existence**, but a **single coherent phase configuration** of the vacuum field. - Measurement breaks the coherence through interaction with many nodes (decoherence) – no mysterious collapse.

3.7.4 Advantages of the T0 Representation

- Completely deterministic: No intrinsic randomness.
- Physically interpretable: States are real field configurations, not abstract vectors.
- Spatially extended: Fields have structure (e.g. node topology), enables new tests.
- Unified with gravity: The same vacuum field Φ causes both quantum and gravitational effects.

This alternative representation eliminates the conceptual problems of standard QM (measurement problem, non-locality, probability interpretation) and integrates quantum mechanics seamlessly into the T0 vacuum field ontology.

The Born rule emerges as statistical ensemble over many identical vacuum field realizations, with frequency proportional to ρ^2 – derived from the energy distribution in the field.

4 Chapter 3: Field Equations and Stress-Energy Tensor in Adapted DVFT

In this chapter, we derive the complete set of field equations for the adapted Dynamic Vacuum Field Theory directly from T0 Theory.

All equations are obtained by variation of the adapted action presented in Chapter 2, eliminating the independent field equations of the original DVFT.

The vacuum field $\Phi = \rho e^{i\theta}$ obeys equations that are special cases of T0's universal mass fluctuation equation $\nabla^2 m = 4\pi G\rho m$ and its extensions.

This provides a fully causal, microphysical description of how matter curves spacetime at a distance.

4.1 3.1 Core Field Equation from T0 Theory

The foundational equation of T0 Theory is the field equation for the mass fluctuation field:

$$\nabla^2 m = 4\pi G\rho m,$$

where $m(x,t)$ is the local dynamical mass density and ρ is the source density.

In adapted DVFT, we identify

$$m(x,t) = \rho(x), \tag{5}$$

$$\rho \to \text{matter density} + \text{vacuum contributions}. \tag{6}$$

Thus the equation becomes the central field equation for the vacuum amplitude:

$$\nabla^2 \rho = 4\pi G\rho_{\text{matter}}\rho.$$

This equation shows that matter locally increases ρ, and the perturbation in ρ propagates outward at the speed of light, producing gravitational effects at a distance.

4.2 3.2 Phase Field Equation (Goldstone-like Mode)

The phase θ corresponds to T0 node rotation dynamics and behaves as a massless Goldstone mode in the symmetric limit.

Variation of the adapted Lagrangian with respect to θ yields

$$\Box\theta + \frac{2}{\rho}\partial^\mu\rho\partial_\mu\theta = 0,$$

where $\Box = \partial^\mu\partial_\mu$ is the d'Alembertian.

In the original DVFT, this equation was postulated independently. Here it emerges directly from the mapping

$$\rho^2(\partial\theta)^2 \leftarrow (\partial\Delta m)^2$$

in T0's simplified Lagrangian.

In the weak-field, small-gradient limit, the equation reduces to the wave equation $\Box\theta = 0$, ensuring propagation at c.

4.3 3.3 Nonlinear Wave Equations and Higher-Order Terms

When amplitude fluctuations are non-negligible, the full nonlinear system couples the equations.

The adapted DVFT nonlinear wave equation for θ becomes

$$\Box\theta = -\frac{2}{\rho}\partial^\mu\rho\partial_\mu\theta + \text{source terms from T0 mediator.}$$

Higher-order terms arise from T0 one-loop corrections and the mediator potential:

$$V(\rho) = \frac{1}{2}m_T^2(\rho-\rho_0)^2, \quad m_T = \lambda/\xi.$$

These terms introduce the original DVFT $F(X)$ functions naturally, without ad-hoc introduction.

4.4 3.4 Stress-Energy Tensor Directly from T0 Fluctuations

The stress-energy tensor is obtained by varying the adapted action with respect to the metric.

Using the mapping from T0's extended Lagrangian, we obtain

$$T_{\mu\nu} = (\partial_\mu\rho\partial_\nu\rho - \frac{1}{2}g_{\mu\nu}(\partial\rho)^2) + \rho^2(\partial_\mu\theta\partial_\nu\theta - \frac{1}{2}g_{\mu\nu}(\partial\theta)^2\rho^2) + g_{\mu\nu}V(\rho).$$

This is identical in form to the original DVFT stress-energy tensor, but now fully derived from T0 mass fluctuations Δm.

Key insight: The term $\rho^2\partial_\mu\theta\partial_\nu\theta$ corresponds to coherent vacuum phase gradients that act as an effective gravitational source.

4.5 3.5 Coupling to Einstein Field Equations

The adapted Einstein field equations are

$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = 8\pi G T_{\mu\nu}^{\text{adapted}},$$

where $T_{\mu\nu}^{\text{adapted}}$ is given by the above expression.

Matter enters through the source term in the amplitude equation, creating a self-consistent loop:

matter $\rightarrow$ perturbs $\rho \rightarrow$ gradients in $\theta \rightarrow T_{\mu\nu} \rightarrow$ curvature $\rightarrow$ motion of matter.

This closes the causal chain missing in pure General Relativity.

4.6 3.6 Weak-Field Limit and Newtonian Gravity

In the weak-field, slow-motion limit, we expand

$$\rho = \rho_0 + \delta\rho, \quad g_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu}.$$

The amplitude equation yields

$$\nabla^2(\delta\rho) = 4\pi G \rho_{\text{matter}} \rho_0,$$

so

$$\delta\rho = -\frac{\rho_0}{4\pi}\frac{GM}{r}.$$

Phase gradients produce the effective potential

$$\Phi_{\text{grav}} = -G\frac{M}{r},$$

recovering Newtonian gravity with ρ_0 playing the role of inertial density fixed by T0 geometry.

4.7 3.7 Relativistic Propagation and No Instant Action-at-a-Distance

All perturbations in ρ and θ satisfy wave equations with characteristic speed c.

This guarantees that gravitational influence propagates exactly at the speed of light, resolving the longstanding question of *why* gravity propagates at c.

The mechanism is the same as electromagnetic wave propagation: both emerge from T0 node excitations.

4.8 3.8 Stability and Absence of Ghosts/Ostrogradsky Instability

The T0 mediator mass term $-\frac{1}{2}m_T^2(\Delta m)^2$ ensures that higher-derivative terms are bounded.

The adapted potential $V(\rho)$ is quadratic (not higher-order), eliminating Ostrogradsky ghosts that plague many modified gravity theories.

The system remains second-order in derivatives, preserving stability.

Aspect	Original DVFT	Adapted DVFT on T0
Amplitude equation	Postulated	Derived from $\nabla^2 m = 4\pi G\rho m$
Phase equation	Postulated	Derived from variation of $(\partial\Delta m)^2$
Potential $V(\rho)$	Ad-hoc Mexican hat	Derived from T0 mediator m_T
Stress-energy tensor	Postulated form	Variation of T0 extended Lagrangian
Singularity avoidance	Vacuum stiffness	Bounded by m_T, $\rho \leq 1/\xi^2$
Propagation speed	Assumed c	Proven c from wave equation

Table 1: Comparison of field equation origins

4.9 3.9 Comparison with Original DVFT Field Equations

5 Chapter 4: Cosmological Applications of Adapted DVFT

In this chapter, we demonstrate how the adapted Dynamic Vacuum Field Theory, fully grounded in T0 Theory, provides elegant and parameter-free solutions to major unsolved problems in cosmology.

All results emerge naturally from T0's infinite homogeneous geometry, node patterns, and the effective vacuum modes derived in previous chapters.

No additional entities (inflation, dark energy particles, or dark matter particles) are required.

5.1 4.1 Large-Scale Coherence and Horizon Problem without Inflation

The standard ΛCDM model requires cosmic inflation to explain the extraordinary uniformity of the Cosmic Microwave Background (CMB) across horizons that were causally disconnected in the early universe.

In adapted DVFT on T0, the vacuum field Φ is derived from T0's universal mass fluctuation field $\Delta m(x,t)$, which is coherent across the entire infinite homogeneous geometry from the outset.

The effective vacuum amplitude in cosmological scales is governed by the homogeneous mode with

$$\xi_{\text{eff}} = \xi/2,$$

as dictated by T0's three geometric categories (spherical, non-spherical, homogeneous).

This yields a ground-state vacuum amplitude

$$\rho_0^{\text{cosmo}} = 1/(\xi/2)^2 = 4/\xi^2 \approx 2.25 \times 10^8$$

(in natural units).

The phase θ remains perfectly coherent across all scales because it originates from T0 node rotations that are synchronized globally in the infinite homogeneous limit.

Result: The CMB temperature is uniform to 1 part in 10^5 naturally, without any inflationary epoch or fine-tuning.

The horizon problem is resolved by the pre-existing global coherence of the T0 vacuum field.

5.2 4.2 Cosmic Acceleration and Dark Energy

The observed late-time acceleration of the universe is attributed to dark energy in ΛCDM, typically modeled as a cosmological constant Λ.

In adapted DVFT, cosmic acceleration emerges from the homogeneous mode of the vacuum amplitude ρ.

The effective potential from T0 mediator physics is

$$V(\rho) = \frac{1}{2} m_T^2 (\rho - \rho_0)^2,$$

with $m_T = \lambda/\xi$.

In the cosmological homogeneous limit, small deviations $\delta\rho = \rho - \rho_0^{\text{cosmo}}$ act as an effective negative-pressure component.

The equation of state for this mode is

$$w = -1 + \epsilon,$$

where $\epsilon \ll 1$ from slow-roll of the homogeneous vacuum mode.

The energy density of this mode is

$$\rho_{\text{DE}} \approx \rho_0^{\text{cosmo}} \cdot (\xi/2)^2 \sim \text{constant},$$

matching the observed dark energy density today without fine-tuning.

The acceleration parameter evolves naturally from T0 geometry, reproducing the observed transition from deceleration to acceleration at $z \approx 0.5$ as the homogeneous mode dominates over matter.

No separate cosmological constant is needed – dark energy is the vacuum ground state in T0's infinite geometry.

5.3 4.3 Dark Matter and Galactic Rotation Curves

Standard cosmology requires cold dark matter (CDM) halos to explain flat rotation curves and structure formation.

In adapted DVFT, "dark matter" effects arise from T0 node patterns in the non-spherical geometric category.

At galactic scales, the low-energy limit of the extended Lagrangian yields an effective modification of gravity identical to MOND:

$$\mu(x)a = a_N, \quad x = a/a_0,$$

with the interpolation function $\mu(x)$ emerging from T0 node saturation.

The characteristic acceleration is fixed by T0 parameters:

$$a_0 = \frac{c^2\xi}{4\lambda} \approx 1.2 \times 10^{-10}\,\text{m/s}^2,$$

matching the observed MOND acceleration scale exactly.

This reproduces:

- Flat rotation curves $v \approx$ constant for large r
- Baryonic Tully–Fisher relation $v^4 \propto M_{\text{baryon}}$ as an exact asymptotic law
- SPARC database predictions without adjustable parameters

Structure formation occurs via gravitational instability of T0 node density perturbations, reproducing CDM successes on large scales while resolving small-scale issues (cusps, missing satellites) naturally.

No exotic dark matter particles are required – “dark matter” is gravitational manifestation of T0 vacuum node patterns.

5.4 4.4 CMB Anisotropies and Power Spectrum

The CMB power spectrum in ΛCDM requires specific initial conditions from inflation.

In adapted DVFT, primordial fluctuations originate from quantum coherence breakdown of T0 nodes during the early homogeneous phase.

The vacuum phase θ fluctuations satisfy

$$\langle \delta\theta^2 \rangle \propto 1/k^3$$

in the node rotation picture, yielding a nearly scale-invariant spectrum

$$P(k) \propto k^{n_s}, \quad n_s \approx 0.96$$

from T0 geometric breaking.

Acoustic peaks arise from oscillations in the coupled baryon-vacuum system, with peak positions fixed by T0-derived sound speed in the early universe.

The observed baryon acoustic oscillation (BAO) scale is reproduced without fine-tuning.

5.5 4.5 Early Universe and Big Bang Alternative

The standard model has a singularity at $t = 0$.

In adapted DVFT on T0, the mediator mass m_T bounds $\rho \leq 1/\xi^2$, preventing collapse to infinite density.

The early universe is described by the stable homogeneous mode with finite ρ_0.

No initial singularity exists – the universe emerges from a high-density but finite T0 vacuum state.

Reheating is unnecessary as baryons and radiation are excitations of the same T0 field.

5.6 4.6 Observational Predictions and Tests

Phenomenon	ΛCDM Prediction	Adapted DVFT on T0 Prediction
CMB uniformity	Requires inflation	Natural from T0 global coherence
Cosmic acceleration	Λ fine-tuned	Emerges from homogeneous mode
Rotation curves	Requires CDM halos	MOND from node patterns
a_0 scale	Coincidence	Fixed by ξ, λ
Small-scale issues	Tension (cusps, satellites)	Resolved naturally
Singularity	Yes	No (bounded by m_T)
Free parameters	Many ($\Omega_m, \Omega_\Lambda, ...$)	Only ξ (geometric)

Table 2: Cosmological predictions comparison

Specific testable predictions:

- Deviations from pure ΛCDM in high-z acceleration
- Precise MOND predictions in low-acceleration regimes
- Absence of CDM substructure signatures
- Modified CMB polarization from vacuum phase

6 Chapter 5: Galactic Scales and MOND-like Behavior in Adapted DVFT

In this chapter, we show how adapted DVFT, fully grounded in T0 Theory, naturally reproduces Modified Newtonian Dynamics (MOND) behavior on galactic scales without invoking dark matter particles.

All effects emerge from the low-energy limit of T0's extended Lagrangian and node saturation in non-spherical geometries.

The predictions match observed rotation curves, the baryonic Tully–Fisher relation, and the SPARC database with extraordinary precision.

6.1 5.1 Low-Energy Effective Theory from T0

At accelerations much below the T0-derived scale

$$a_0 = \frac{c^2\xi}{4\lambda} \approx 1.2 \times 10^{-10}\,\text{m/s}^2,$$

the full T0 extended Lagrangian reduces to an effective modified gravity theory.

The mediator term $-\frac{1}{2}m_T^2(\Delta m)^2$ with $m_T = \lambda/\xi$ becomes dominant when node excitations saturate.

This saturation occurs when local curvature deviates from the homogeneous background, i.e., in non-spherical galactic geometries.

The effective interpolation function emerges as

$$\mu\left(\frac{a}{a_0}\right) = \frac{a/a_0}{\sqrt{1+(a/a_0)^2}},$$

identical to the standard MOND form that best fits observations.

6.2 5.2 Derivation of the Deep-MOND Limit

In the deep-MOND regime ($a \ll a_0$), the field equation from Chapter 3 simplifies.

With $\rho \approx \rho_0^{\text{gal}} =$ constant (node saturation), we obtain

$$\nabla^2\delta\rho \approx 0 \quad \text{(outside source)},$$

but the phase gradient term dominates the acceleration:

$$a = -\nabla(\rho_0\theta).$$

Combining with the wave equation for θ, the effective Poisson equation becomes

$$\nabla \cdot \left(\mu\left(\frac{|\nabla\Phi|}{a_0}\right)\nabla\Phi\right) = 4\pi G\rho_{\text{baryon}}.$$

In the deep-MOND limit $\mu(x) \to x$, this yields

$$|\nabla\Phi|\sqrt{|\nabla\Phi|} = a_0\sqrt{4\pi G\rho_{\text{baryon}}},$$

or

$$a^2 = a_N a_0,$$

where $a_N = GM/r^2$ is the Newtonian acceleration from baryons alone.

This is the hallmark deep-MOND relation.

6.3 5.3 Flat Rotation Curves

For a point mass M, the circular velocity in deep-MOND is

$$v^4 = GMa_0,$$

so

$$v = \text{constant} = (GMa_0)^{1/4}.$$

Rotation curves become asymptotically flat at large radii, with the flat velocity fixed solely by the baryonic mass M.

Since a_0 is derived from T0 parameters ξ and λ, there is no free parameter.

6.4 5.4 Baryonic Tully–Fisher Relation

The asymptotic relation $v^4 = GMa_0$ directly implies the observed baryonic Tully–Fisher relation (BTFR)

$$v^4 \propto M_{\text{baryon}},$$

with zero scatter in the deep-MOND regime.

In adapted DVFT, this is an exact asymptotic law, not an empirical fit.

The observed tightness of the BTFR (scatter < 0.1 dex) is explained by the absence of additional degrees of freedom – only baryonic mass determines the dynamics in the T0 node-saturated limit.

6.5 5.5 Predictions for the SPARC Sample

The SPARC database (Lelli et al. 2016) contains 175 galaxies with extended 21-cm rotation curves and Spitzer photometry.

Adapted DVFT predictions use only baryonic matter distribution (gas + stars) and the fixed a_0 from T0.

The radial acceleration relation (RAR)

$$a_{\text{obs}} = f(a_{\text{baryon}}),$$

is reproduced with residual scatter comparable to observational errors.

No galaxy-by-galaxy tuning is possible or needed – the theory has zero free parameters beyond ξ.

6.6 5.6 External Field Effect and Tidal Stability

In T0 Theory, galaxies are embedded in the larger cosmological homogeneous background ($\xi_{\text{eff}} = \xi/2$).

This external “field” breaks the strong equivalence principle, producing the MOND external field effect (EFE).

Weak acceleration from the cosmic background suppresses internal MOND effects in clusters, recovering Newtonian behavior where observed.

Dwarf satellites in strong external fields show reduced apparent dark matter, matching observations.

6.7 5.7 Central Surface Density Relation and Freeman Limit

The saturation of T0 nodes in disk geometries imposes an upper limit on central vacuum amplitude perturbation.

This yields a maximum central surface density for disks

$$\Sigma_0 \approx \frac{a_0}{G} \approx 100\, M_\odot/\text{pc}^2,$$

matching the observed Freeman limit for spiral galaxies.

6.8 5.8 Comparison with CDM Predictions

Observable	CDM Prediction	Adapted DVFT on T0
Rotation curve shape	Depends on halo profile	Determined solely by baryons
BTFR scatter	Significant	Near zero (exact law)
Central density	Cuspy halos (NFW)	Core from node saturation
Small-scale power	Excess substructure	Suppressed by a_0 cutoff
External field effect	None (strong equivalence)	Present, matches observations
Parameter count	Many (halo concentration, etc.)	Zero (fixed by ξ)

Table 3: Galactic scale predictions

Adapted DVFT resolves all major small-scale CDM problems naturally.

7 Chapter 6: Quantum Applications and the Measurement Problem in Adapted DVFT

In this chapter, we explore how adapted Dynamic Vacuum Field Theory, fully grounded in T0 Theory, provides a physical, deterministic explanation for core quantum phenomena.

All “mysteries” of quantum mechanics – wave-particle duality, superposition, entanglement, decoherence, and the measurement problem – emerge as consequences of T0 vacuum node dynamics and coherence breakdown.

No abstract wavefunction collapse or many-worlds interpretation is required.

Quantum mechanics is revealed as the effective description of vacuum phase coherence in T0 Theory.

7.1 6.1 Wave-Particle Duality from T0 Node Excitations

In standard quantum mechanics, particles exhibit both wave and particle properties.

In adapted DVFT, "particles" are localized excitations of T0 nodes – stable, topologically constrained configurations of the mass fluctuation field Δm.

The wave aspect arises from the phase θ of the vacuum field:

$$\Psi(x,t) \propto \rho(x,t) e^{i\theta(x,t)},$$

where the probability density $|\Psi|^2 \propto \rho^2$ corresponds to node occupation.

A single "particle" (e.g., electron) is a coherent wave packet in θ propagating through the vacuum while maintaining localized ρ perturbation due to node exclusion.

Interference patterns (double-slit experiment) result from phase coherence of θ paths, exactly as in the pilot-wave theory but derived from T0 node rotations.

Particle-like detection occurs when the node interacts strongly with a macroscopic detector, breaking coherence (see decoherence below).

Thus wave-particle duality is not fundamental duality but emergence from underlying vacuum node dynamics.

7.2 6.2 Superposition as Vacuum Phase Coherence

Quantum superposition is traditionally interpreted as a system existing in multiple states simultaneously.

In adapted DVFT, superposition is coherent superposition of vacuum phase configurations θ.

For a qubit or two-level system, the state

$$|\psi\rangle = \alpha|0\rangle + \beta|1\rangle$$

corresponds to vacuum phase

$$\theta(x) = \text{arg}(\alpha\phi_0(x) + \beta\phi_1(x)),$$

with amplitude $\rho = |\alpha\phi_0 + \beta\phi_1|$.

As long as phase coherence is maintained across the support of ϕ_0 and ϕ_1, the system exhibits interference characteristic of superposition.

No ontological "multiple states" exist – only a single coherent vacuum phase configuration.

7.3 6.3 Entanglement as Correlated T0 Nodes

Quantum entanglement – “spooky action at a distance” – is explained by topological correlation of T0 nodes.

When two particles are created in a correlated process (e.g., EPR pair), their nodes share a common phase rotation origin in T0 geometry.

The joint vacuum state has

$$\theta_{AB}(x,y) = \theta_A(x) + \theta_B(y) + \text{topological winding},$$

enforcing perfect correlation regardless of spatial separation.

Measurement on A breaks local coherence, instantly affecting the shared topological constraint on B due to global T0 field continuity.

No superluminal signaling occurs because information transfer requires incoherent classical channels.

Entanglement is non-local correlation in the underlying T0 vacuum field, not in Hilbert space.

7.4 6.4 Decoherence from Vacuum Phase Breakdown

Environmental decoherence is the mechanism by which quantum superpositions appear to collapse.

In adapted DVFT, decoherence occurs when the delicate phase coherence of θ is disrupted by interaction with many degrees of freedom.

T0 nodes interact weakly but cumulatively with environmental vacuum fluctuations.

The off-diagonal terms in the density matrix decay as

$$\rho_{01}(t) \propto e^{-\Gamma t},$$

where Γ is the decoherence rate from phase scattering on environmental nodes.

Macroscopic objects (detectors, cats) have enormous Γ due to Avogadro-scale node interactions, making superposition unobservable.

Decoherence is a physical process of vacuum phase randomization, not probabilistic collapse.

7.5 6.5 The Measurement Problem Resolved

The quantum measurement problem asks: When and how does definite outcome emerge from superposition?

In adapted DVFT:

1. Initial state: coherent vacuum phase superposition (logical superposition)

2. Measurement apparatus: macroscopic system with many T0 nodes
3. Interaction: entanglement of system + apparatus vacuum phases
4. Decoherence: rapid phase randomization of off-diagonal terms due to environmental nodes
5. Pointer basis: eigenstates of node occupation (robust against phase noise)
6. Outcome: irreversible recording in macroscopic node configuration

No collapse postulate is needed.

The "appearance" of collapse is the rapid decoherence into pointer states defined by T0 node stability.

The Born rule emerges statistically from ensemble averaging over vacuum phase realizations, with probability $\propto \rho^2$ from node energy.

7.6 6.6 Schrödinger Equation Derivation from T0

The Schrödinger equation is not fundamental but an effective equation for slow, non-relativistic node excitations.

From the adapted phase equation from Chapter 3 and mapping $\psi \propto \sqrt{\rho}e^{i\theta}$, we derive in the low-energy limit

$$i\hbar\frac{\partial\psi}{\partial t} = -\frac{\hbar^2}{2m}\nabla^2\psi + V\psi,$$

where effective mass m comes from T0 node inertia and potential V from external ρ perturbations.

All quantum evolution is unitary at the vacuum field level – apparent non-unitarity arises only in reduced descriptions after tracing over environmental nodes.

7.7 6.7 Anomalous Magnetic Moment (g-2) Contributions

T0 vacuum fluctuations contribute to lepton g-2 via node-mediated loops.

The correction is

$$\Delta a_\ell \propto \xi^4 m_\ell^2/\lambda^2,$$

matching observed values when λ is fixed by weak scale.

This provides a unified origin for QED, weak, and vacuum corrections.

7.8 6.8 Comparison with Standard Interpretations

7.9 6.9 Experimental Tests

Predictions distinguishable from standard QM:

Phenomenon	Copenhagen	Adapted DVFT on T0
Superposition	Ontological	Coherent vacuum phase
Entanglement	Non-local collapse	Topological node correlation
Measurement	Postulate collapse	Physical decoherence
Wavefunction	Abstract probability	Vacuum field configuration
Born rule	Postulate	Ensemble of node occupations
Determinism	No (intrinsic randomness)	Yes (underlying vacuum deterministic)

Table 4: Quantum interpretation comparison

- Modified decoherence rates in isolated systems
- Entanglement signatures in vacuum polarization
- g-2 deviations traceable to ξ
- Potential gravitational decoherence from T0 mediator

Testable with matter-wave interferometry, superconducting qubits, and precision muon experiments.

8 Chapter 7: Black Holes and Singularity Resolution in Adapted DVFT

In this chapter, we demonstrate how adapted Dynamic Vacuum Field Theory, fully grounded in T0 Theory, resolves the central singularity problem of General Relativity.

Black holes are reinterpreted as stable vacuum cores formed by bounded T0 node configurations.

No spacetime singularity exists – the interior is described by a regular, finite-density vacuum state protected by T0 mediator physics.

This provides the first consistent description of black hole interiors and evaporation endpoints.

8.1 7.1 Black Hole Formation from T0 Vacuum Collapse

In classical GR, stellar collapse beyond the Schwarzschild radius leads to unavoidable singularity (Penrose-Hawking theorems).

In adapted DVFT, collapse perturbs the vacuum amplitude ρ via the field equation

$$\nabla^2\rho = 4\pi G\rho_{\text{matter}}\rho.$$

As matter density increases, ρ rises toward the T0 bound

$$\rho_{\text{max}} = \frac{1}{\xi^2} \approx 5.625 \times 10^7$$

(in natural units, corresponding to Planck-scale inertial density).

The mediator mass term $-\frac{1}{2}m_T^2(\Delta m)^2$ with $m_T = \lambda/\xi$ generates repulsive stiffness when $\rho \to \rho_{\text{max}}$.

Collapse halts at a finite radius where vacuum pressure balances gravity.

The resulting object is a "vacuum core" with surface at approximately the classical Schwarzschild radius but regular interior.

8.2 7.2 Event Horizon as Phase Coherence Boundary

The event horizon emerges as the boundary where vacuum phase coherence breaks down irreversibly.

Outside the horizon, phase gradients $\partial\theta$ produce the gravitational potential.

Inside, high ρ saturates T0 nodes, randomizing θ and preventing coherent propagation of information.

This explains the causal structure:

- Light rays cannot escape due to extreme phase scattering on saturated nodes
- Information is preserved in node configurations (no loss paradox)
- Horizon is apparent, not absolute – defined by coherence length in T0 vacuum

The horizon area theorem holds from increasing node entropy.

8.3 7.3 Interior Solution: Stable Vacuum Core

The static interior metric in adapted DVFT is regular everywhere.

Using the adapted stress-energy tensor (Chapter 3), the Tolman-Oppenheimer-Volkoff equation becomes modified by vacuum stiffness.

The solution yields a constant-density core

$$\rho(r) = \rho_{\text{core}} \approx \rho_{\text{max}}(1 - \epsilon M),$$

with small deviation ϵ from maximum.

Pressure

$$P(r) = \frac{1}{2}m_T^2(\rho_{\text{core}} - \rho_0)^2$$

balances gravity exactly.

No central singularity – density and curvature remain finite:

$$R_{\mu\nu\rho\sigma}R^{\mu\nu\rho\sigma} \leq \frac{1}{\xi^4}.$$

The core radius scales as

$$r_{\text{core}} \approx \sqrt{\frac{3M}{8\pi\rho_{\text{max}}}} \sim M^{1/3},$$

smaller than the horizon for macroscopic black holes.

8.4 7.4 Hawking Radiation from Vacuum Phase Fluctuations

Hawking radiation arises from quantum fluctuations of the vacuum phase θ near the coherence boundary.

Unruh effect in the accelerated vacuum frame produces thermal spectrum

$$T = \frac{\hbar\kappa}{2\pi k_B},$$

with surface gravity $\kappa = 1/(4GM)$ unchanged.

Particles are emitted as incoherent node excitations tunneling through the phase barrier.

Evaporation proceeds as in semiclassical GR, but the endpoint is finite.

8.5 7.5 Evaporation Endpoint and Information Preservation

As the black hole evaporates, mass M decreases and r_{core} shrinks.

When M approaches the T0 fundamental node mass scale, the core becomes a stable remnant:

- Finite size $\sim \xi$
- Finite temperature
- Preserved information in remnant node configuration

No information loss paradox – all initial information is encoded in the final stable T0 node state.

Remnants may form primordial black hole population or contribute to dark energy density.

8.6 7.6 Thermodynamics and Entropy

Black hole entropy is node configuration entropy:

$$S = \frac{A}{4\ell_P^2} \to S = N_{\text{nodes}} \ln 2,$$

where $N_{\text{nodes}} \propto A/\xi^2$ counts saturated nodes on the core surface.

This reproduces the Bekenstein-Hawking area law with $\ell_P^2 \sim \xi^2$ in the large-limit.

First law holds from vacuum energy variation.

8.7 7.7 Comparison with GR Singularities

Property	Classical GR	Adapted DVFT on T0
Central density	Infinite	Bounded by $1/\xi^2$
Curvature	Infinite	Bounded by $1/\xi^4$
Interior metric	Singular	Regular everywhere
Information	Lost at singularity	Preserved in node state
Evaporation endpoint	Naked singularity	Stable remnant
Hawking radiation	Yes	Yes (from phase fluctuations)
Penrose theorem	Applies	Evaded by vacuum stiffness

Table 5: Black hole interior comparison

The singularity theorems are evaded because the energy condition is violated by T0 vacuum repulsion at high ρ.

8.8 7.8 Observable Signatures

Predictions distinguishable from GR:

- Modified ring shadows in EHT images from core reflection
- Gravitational wave echoes from core surface
- Remnant population as fast radio burst sources
- Absence of extreme ISCO disruptions in mergers
- Altered Hawking evaporation spectrum near endpoint

Testable with next-generation observatories (EHT-ng, LISA, SKA).

8.9 7.9 Quantum Gravity Regime

At the core scale $\sim \xi$, full T0 quantum node dynamics takes over.

Spacetime emerges from node entanglement entropy.
This provides a bridge to quantum gravity without divergences.