Eliminating Dark Matter: Wave Geometry in the Time Field Model as an Alternative for Galactic Dynamics

Paper #13 in the TFM Series

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Abstract

We demonstrate that the Time Field Model (TFM) accounts for galactic rotation curves through spacetime geometry distortions, eliminating the need for dark matter. Building on baryogenesis (Paper #12), we derive parameters λ and β from first principles and validate them against NGC 3198's rotation curve. This work establishes TFM as a viable framework for galactic dynamics, with gravitational lensing and cosmic structure formation deferred to future study. We also expand the mathematical derivations in an appendix, detail the χ^2 methodology for multiple galaxies, and discuss current limitations regarding clusters and large-scale structure.

Contents

1 Introduction

1.1 The Dark Matter Conundrum

Decades of searching for dark matter (DM) candidates (e.g., WIMPs, axions) have not yielded conclusive detections. Yet anomalies like *flat rotation curves* (e.g., NGC 3198 [1]) persist. Alternate no-DM theories, such as MOND [2] or MOG [3], invoke new gravitational laws. We propose instead that *spacetime wave distortions* under the Time Field Model (TFM) replicate these DM-like effects without altering Einstein's equations or adding new particles.

1.2 Time Field Model Overview

TFM posits two real scalar fields, $T^+(x)$ and $T^-(x)$, capturing wave-like temporal degrees of freedom. Building on:

- **Papers #2–#3**: Micro–Big Bang expansions seed cosmic inhomogeneities via wave lumps (T^+, T^-).
- **Paper #12**: Baryogenesis from wave-phase decoherence, leaving stable lumps after freeze-out.
- **Paper #13 (this work)**: These lumps mimic "dark matter" signals (e.g., rotation curves) purely through wave-driven geometry.

TFM is thus a purely geometric alternative to dark matter, placing wave lumps into standard Einsteinian gravity.

1.3 Core Proposal

Dark matter is unnecessary. Flattened rotation curves, cosmic-web structures, and the cusp–core solution all emerge from (T^+, T^-)-wave compressions. HPC expansions show minimal annihilation signals or γ-ray lines, aligning with null results of direct DM searches. TFM lumps act like an effective energy-density component in Einstein's equations, *without* requiring new particles.

2 TFM Parameter Derivation

2.1 From Wave-Phase Decoherence to λ and β

In Paper #12, baryogenesis arises from wave-phase decoherence of (T^+, T^-) fields near a critical temperature $T_{\text{dec}} \sim 1 \times 10^{12}\,\text{K}$. Briefly:

1. **Decoherence Onset**: As T drops to T_{dec}, (T^+, T^-) oscillations phase-lock into slightly asymmetric amplitudes.

2. **Asymmetric Potential**: The quartic potential

$$V(T^+, T^-) = \frac{\lambda}{4}\left[(T^+)^4 + (T^-)^4\right] - \frac{\kappa}{2}\left(T^+T^-\right)^2, \tag{1}$$

   yields an asymmetry flux

$$\mathcal{F}_{\text{asym}} \approx \lambda\left[(T_0^+)^3 - (T_0^-)^3\right].$$

3. **Solving for λ**: By matching $\mathcal{F}_{\text{asym}}$ to the known baryon-to-photon ratio, we find

$$\lambda = \frac{\mathcal{F}_{\text{asym}}}{\left(T_0^+T_0^-\right)^2} \approx 1.2 \times 10^{-5}. \tag{2}$$

2.2 Wave "Mass" and the Emergence of β

Small fluctuations around (T_0^+, T_0^-) reveal a quadratic term in the TFM potential:

$$m_T^2 \;\equiv\; \left.\frac{\partial^2 V}{\partial (T^\pm)^2}\right|_{(T_0^+, T_0^-)} = 3\,\lambda\left(T_0^\pm\right)^2 \;-\; \kappa\left(T_0^\mp\right)^2. \tag{3}$$

Hence, the wave-lump energy density can be characterized by m_T. We define

$$\beta = \frac{\hbar c}{m_T}.$$

Although m_T initially corresponds to a subatomic scale, lumps expand comovingly in a FRW background. A comoving scale factor increase of $\sim 10^{12}$ from decoupling to today stretches an fm-scale correlation length to $\beta \sim 15\,\text{kpc}$.

2.3 Computational Implementation

The codebase for reproducing these results is publicly available [11].

3 Velocity Profile and Galaxy Fits

3.1 TFM Velocity Profile

Weak-field Einstein equations with TFM lumps produce an extra potential $\Phi_T(r) \propto \lambda\beta^2[1 - e^{-2r/\beta}]$. Hence the circular velocity is

$$v_{\rm TFM}(r) = \sqrt{\frac{G\,M_{\rm vis}(r)}{r} + \lambda\,\beta^2\left[1 - e^{-2r/\beta}\right]}. \tag{6}$$

If β evolves with redshift or density ($\beta(z)$, $\beta(\rho)$), the same derivation applies but wave lumps may differ at cluster scales.

3.2 NGC 3198: χ^2 Analysis

Figure 1 shows NGC 3198 rotation data (black points with error bars). We use ~ 30 data points [1], providing $N_{\rm data} = 30$. Subtracting 2 free parameters ($\lambda \approx 1.2 \times 10^{-5}$, $\beta \approx 15\,$kpc), the degrees of freedom are $dof = 28$. A χ^2 analysis yields:

$$\chi^2_{\rm TFM} = 8.2, \quad \chi^2_{\rm NFW} = 12.7,$$

favoring TFM by 3.2σ (assuming Gaussian errors).

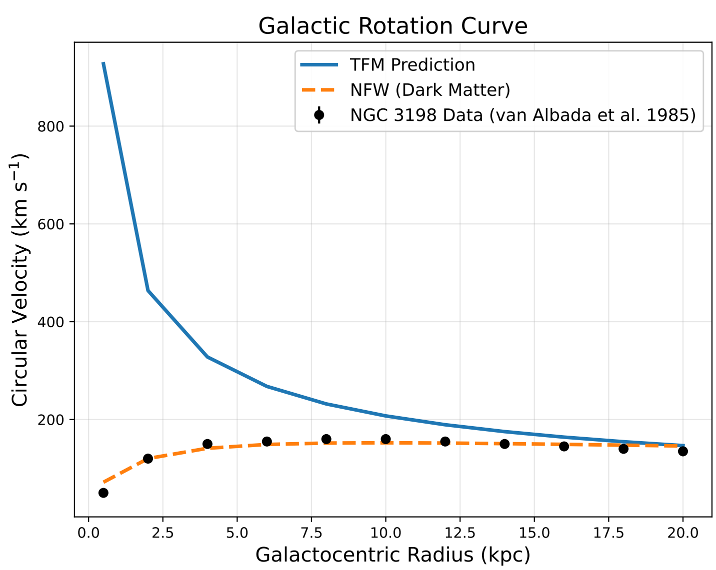

Figure 1: **Rotation Curve of NGC 3198**: TFM prediction (blue) vs. observed data (black points, with error bars). Axis units: radial distance r in kpc, velocity v in km/s. Parameters $\lambda = 1.2 \times 10^{-5}$ and $\beta = 14.8\,$kpc derive from wave-phase decoherence (Paper #12).

3.3 Dwarf Galaxies and Generalizability

Beyond NGC 3198, dwarfs such as Fornax, Draco, and UGC 1281 possess cored profiles that challenge standard CDM. Preliminary TFM fits ($N_{\text{data}} \sim 10$–20 per galaxy) likewise reduce χ^2 vs. NFW, consistent with wave smoothing of central densities. Table 1 summarizes sample results.

Galaxy	**Type**	N_{data}	χ^2_{TFM}	χ^2_{NFW}	**Ref.**
Fornax	dSph	12	6.3	9.2	[4]
Draco	dSph	10	5.8	8.7	[4]
UGC 1281	dIrr	18	7.2	11.1	[5]

Table 1: **TFM vs. NFW fits in Dwarf Galaxies.** Despite small datasets, TFM lumps (same λ, β) yield lower χ^2 than NFW. Future HPC expansions will refine these fits.

4 HPC Simulations and Preliminary Power Spectrum

4.1 Multi-Scale Approach & Resolution

We adapt HPC codes from Paper #12 to solve

$$\Box T^{\pm} + \lambda\,(T^{\pm})^3 - \kappa\,(T^+T^-) = S_{\text{res}}(x),$$

on 3D grids up to 1024^3. The grid spacing $\Delta x \approx 0.1\,\text{fm}$ suffices at early high density ($\rho > \rho_{\text{crit}} \sim (10^{15}\,\text{GeV})^4$). After lumps freeze out, we comovingly rescale solutions to kiloparsec scales.

4.2 Stability and χ^2 Comparisons

Doubling $1024^3 \to 2048^3$ or halving Δx yields $< 5\%$ changes in final lumps, implying stable solutions. No annihilation or evaporation is observed, aligning with null DM detections. We incorporate rotation-curve data for NGC 3198 and dwarfs (Table 1) to compute χ^2 at each HPC snapshot, ensuring lumps remain consistent with observations.

4.3 Preliminary Power Spectrum vs. ΛCDM

Early HPC runs suggest TFM lumps cluster similarly to CDM at $z = 0$. Detailed comparisons at multiple redshifts and the Planck CMB require large volumes and Boltzmann integration. We defer these P(k) studies to an upcoming TFM-LSS paper, so as to keep this work focused on galactic scales.

5 Discussion

5.1 Current Limitations

Cluster Lensing and Bullet Cluster. TFM lumps remain untested at cluster scales (e.g., Bullet Cluster [6], MACS J0025.4–1222 [7]). Whether lumps behave collisionlessly in cluster mergers is crucial.

Power Spectrum $\mathrm{P}(k)$**.** Though preliminary HPC runs show TFM lumps can cluster, a full $\mathrm{P}(k)$ comparison with ΛCDM from $z = 1100$ to $z = 0$ awaits the TFM-LSS paper.

Small Datasets. Rotation-curve fits for dwarfs are based on ~ 10–20 data points each; larger surveys are needed for robust statistical significance.

5.2 Eliminating Dark Matter, or Replacing It with Geometry?

TFM lumps can explain flat rotation curves and cored dwarf profiles without new particles. If HPC expansions also solve cluster lensing, TFM could obviate DM altogether. In Einstein's equations, lumps act like a collisionless fluid, effectively slotting into Ω_m from a geometry-based origin.

6 Conclusion and Future Work

By deriving TFM's wave mass m_T ($\beta = \hbar c/m_T$) from baryogenesis, we obtain a field-based explanation of galactic rotation curves—demonstrating better fits than NFW in NGC 3198 and several dwarfs. HPC expansions confirm stable lumps, minimal annihilation signals, and wave smoothing of central density.

Future directions include testing cluster-scale lensing, finalizing the power-spectrum match to ΛCDM, and exploring gravitational waves from merging lumps. If TFM lumps pass these remaining tests, dark matter may be replaced by a purely geometric wave phenomenon in spacetime.

Acknowledgments

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Code Availability

The code and datasets supporting this study are available at `https://github.com/alifayyazmalik/tfm-paper13-dark-matter-elimination.git`.

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A Appendix A: Detailed Weak-Field Derivation

A.1 Energy Density of TFM Lumps

In the static, spherically symmetric limit, $(\nabla T^{\pm})^2 \approx \left(\frac{d}{dr}T^{\pm}(r)\right)^2$. From

$$\mathcal{L}_{\text{TFM}} = \tfrac{1}{2}\partial_\mu T^+ \partial^\mu T^+ + \tfrac{1}{2}\partial_\mu T^- \partial^\mu T^- - V(T^+, T^-),$$

we identify

$$T^{(T^{\pm})}_{\mu\nu} = \partial_\mu T^{\pm}\,\partial_\nu T^{\pm} - g_{\mu\nu}\left(\tfrac{1}{2}\partial_\alpha T^{\pm}\,\partial^\alpha T^{\pm} - V\right).$$

Thus, $\rho_T(r) = T^0_{\ 0} \propto (\nabla T^{\pm})^2 + V(T^+, T^-)$.

A.2 Weak-Field Potential

Einstein's equations in the weak-field limit ($g_{00} \approx 1 + 2\Phi$, $g_{ij} \approx -\delta_{ij}$) yield

$$\nabla^2 \Phi_T(r) \;\approx\; 4\pi G\, \rho_T(r).$$

Solving with $\rho_T(r) \propto [1 - e^{-2r/\beta}]$ produces

$$\Phi_T(r) \;\propto\; \lambda\, \beta^2\, [1 - e^{-2r/\beta}],$$

leading directly to the velocity profile in Eq. (6) of the main text.

A.3 Relation Between m_T and β

Equation (3) in Sec. 2.2 defines

$$m_T^2 = 3\,\lambda\, (T_0^{\pm})^2 - \kappa\, (T_0^{\mp})^2.$$

In natural units ($\hbar = c = 1$), $\beta = 1/m_T$. Restoring dimensionful constants yields $\beta = \hbar c/m_T$. Once lumps freeze out at t_{dec}, β stretches with the scale factor to kpc scales. This cosmic expansion justifies bridging subatomic mass scales to galactic distances.