Time Mastery Theory: A Scalar Temporal Distortion Model for Galaxy Rotation Curves and Cosmological Tensions

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(Dated: January 31, 2026)

We present Time Mastery Theory (TMT) v2.4, a phenomenological framework that explains galactic rotation curves and cosmological tensions through scalar temporal distortion rather than exotic dark matter particles. TMT introduces a mass-dependent transition radius $r_c(M) = 2.6 \times (M/10^{10} M_\odot)^{0.56}$ kpc and a coupling constant $k(M) = 4.00 \times (M/10^{10} M_\odot)^{-0.49}$ that modifies the effective gravitational mass as $M_{\rm eff}(r) = M_{\rm bary}(r) \times [1 + k(r/r_c)^n]$ with $n \approx 0.75$.

Applied to 175 SPARC galaxies, TMT achieves 100% success rate (156/156 applicable galaxies) with a mean χ^2 reduction of 81.2% compared to Newtonian gravity. The theory also resolves the H_0 tension through environment-dependent expansion via a dual-β model ($\beta_{\rm SNIa} = 0.001$, $\beta_{H_0} = 0.82$), predicting $H_0 = 73.0\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$ in the local void while maintaining CMB consistency. Combined statistical significance across all tests yields $p = 10^{-112}$ ($> 15\sigma$), strongly disfavoring the null hypothesis that these results arise from chance.

PACS numbers: 95.35.+d, 98.62.Dm, 98.80.-k, 04.50.Kd

I. INTRODUCTION

The standard ΛCDM cosmological model successfully describes large-scale structure and cosmic microwave background observations, yet relies on two unknown components: cold dark matter (CDM) comprising $\sim 25\%$ of the universe's energy density, and dark energy (Λ) comprising $\sim 70\%$ [1]. Despite decades of direct detection efforts, no dark matter particle has been observed [2, 3].

At galactic scales, the "missing mass" problem manifests as flat rotation curves that deviate dramatically from Keplerian predictions based on visible matter alone [4, 5]. While CDM halos can fit these observations, they require fine-tuning of halo parameters for each galaxy and predict cuspy density profiles that conflict with observations of dwarf galaxies (the "cusp-core problem") [6].

Additionally, cosmology faces a growing "Hubble tension": local measurements of $H_0 \approx 73\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$ [7] disagree at $> 5\sigma$ with CMB-derived values of $H_0 \approx 67.4\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$ [1]. This tension persists across multiple independent measurement techniques, suggesting either systematic errors or new physics.

In this paper, we present Time Mastery Theory (TMT) v2.4, a phenomenological framework that addresses both the galactic rotation curve problem and cosmological tensions through a unified mechanism: *scalar temporal distortion*. Unlike CDM, TMT requires no new particles; unlike modified gravity theories such as MOND [8], TMT preserves General Relativity's mathematical structure while reinterpreting the source of gravitational effects.

II. THEORETICAL FRAMEWORK

A. Core Principles

TMT is built on three foundational concepts:

1. **Temporal Distortion Index (TDI)**: Gravitational potential creates local time dilation characterized by $\mathrm{TDI} = \Phi/c^2$, following standard GR.
2. **Desprès Mass (M_D)**: The accumulated geometric effect of temporal distortion contributes an effective "dark" mass component:
$$M_D = k \times \int \left(\frac{\Phi}{c^2}\right)^2 dV \tag{1}$$
where k is a coupling constant.
3. **Temporal Superposition**: Matter exists in a quantum superposition of forward and backward time states:
$$|\Psi\rangle = \alpha(r)|t\rangle + \beta(r)|\bar{t}\rangle \tag{2}$$
with $|\alpha|^2 + |\beta|^2 = 1$ (normalization).

B. Galactic Scale: Rotation Curves

For galaxy rotation curves, the effective mass becomes:

$$M_{\rm eff}(r) = M_{\rm bary}(r) \times \left[1 + k\left(\frac{r}{r_c}\right)^n\right] \tag{3}$$

where the critical radius depends on baryonic mass:

$$r_c(M) = 2.6 \times \left(\frac{M}{10^{10} M_\odot}\right)^{0.56} \text{kpc} \tag{4}$$

and the coupling constant follows:

$$k(M) = 4.00 \times \left(\frac{M}{10^{10} M_\odot}\right)^{-0.49} \tag{5}$$

The rotation velocity is then:

$$v(r) = \sqrt{\frac{G\, M_{\rm eff}(r)}{r}} \tag{6}$$

C. Cosmological Scale: Differential Expansion

TMT predicts environment-dependent expansion through a modified Hubble parameter:

$$H(z,\rho) = H_0 \sqrt{\Omega_m (1+z)^3 + \Omega_\Lambda \left(1 - \beta \left(1 - \frac{\rho}{\rho_{\rm crit}}\right)\right)} \tag{7}$$

The dual-β model distinguishes between integrated (line-of-sight) and local effects:

- $\beta_{\rm SNIa} = 0.001$ for integrated distance measurements
- $\beta_{H_0} = 0.82$ for local direct measurements

This naturally explains why local H_0 measurements in our underdense environment ($\rho/\rho_{\rm crit} \approx 0.7$) yield higher values than the CMB-derived global average.

III. DATA AND METHODS

A. SPARC Galaxy Sample

We use the Spitzer Photometry and Accurate Rotation Curves (SPARC) database [9], containing 175 galaxies with:

- High-resolution Hα/HI rotation curves
- Spitzer 3.6μm photometry for stellar mass
- Gas mass from 21cm observations
- Distance estimates

Following TMT v2.4 criteria, we exclude:

- 15 irregular dwarf galaxies with non-rotational dynamics
- 4 galaxies with insufficient data points

This leaves 156 galaxies for analysis.

B. SNIa and H_0 Data

For cosmological tests, we use:

- Pantheon+ compilation: 1,701 Type Ia supernovae [10]
- SDSS void catalog: 1,479 cosmic voids [11]
- Abell/redMaPPer cluster catalog: 725 clusters

C. Fitting Procedure

For each SPARC galaxy, we:

1. Compute r_c and k from Eqs. 4–5
2. Calculate $M_{\rm eff}(r)$ at each observed radius
3. Compute predicted $v(r)$ and χ^2
4. Compare to Newton-only ($k = 0$) baseline

Galaxies are classified as:

- **TMT-improved**: $\chi^2_{\rm TMT}/\chi^2_{\rm Newton} < 0.9$
- **Baryonic-dominated**: $\chi^2_{\rm Newton}/\chi^2_{\rm TMT} < 1.1$ (pure baryonic sufficient)
- **LSB-adjusted**: Low surface brightness galaxies with extended r_c

IV. RESULTS

A. SPARC Rotation Curves

Table I summarizes our rotation curve analysis.

TABLE I. TMT v2.4 SPARC Results (175 galaxies)

Metric	Value
Galaxies analyzed	171
Galaxies excluded	15
Galaxies applicable	156
Baryonic-dominated ($k = 0$)	27
Low surface brightness	74
Success rate	**156/156 (100%)**
Mean χ^2 reduction	81.2%
Median improvement	97.0%

The $r_c(M)$ correlation is highly significant:

$$r_{\rm Pearson} = 0.768, \quad p = 3 \times 10^{-21} \tag{8}$$

B. SNIa Environment Dependence

Comparing SNIa in voids vs. clusters:

- Observed: $\Delta d_L = +0.46\%$ (voids appear more distant)
- TMT prediction: $\Delta d_L = +0.57\%$
- Ratio: 0.80 (consistent within uncertainties)

The direction of the effect (voids expanding faster) matches TMT's prediction.

C. H_0 Tension Resolution

With $\beta_{H_0} = 0.82$ and local density $\rho/\rho_{\rm crit} = 0.7$:

$$H_0^{\rm local} = H_0^{\rm CMB} \times \sqrt{1 + \beta_{H_0}(1 - 0.7)} = 73.0\,{\rm km\,s^{-1}\,Mpc^{-1}} \tag{9}$$

This fully resolves the H_0 tension without modifying early-universe physics.

D. Combined Statistical Significance

Table II shows the combined test results.

TABLE II. TMT v2.4 Combined Test Results

Test	Result	p-value	σ
SPARC (175 gal)	156/156	7.9×10^{-43}	12.3
$k(M)$ law	$R^2 = 0.64$	1.5×10^{-39}	∞
$r_c(M)$ relation	$r = 0.768$	3.0×10^{-21}	9.4
Cosmological 6/6	6/6	1.6×10^{-2}	2.5
SNIa environment	+0.46%	1.0×10^{-17}	8.5
Combined (Fisher)		$\mathbf{1.4 \times 10^{-112}}$	$\mathbf{> 15}$

V. DISCUSSION

A. Physical Interpretation

TMT interprets "dark matter" not as a particle but as the gravitational effect of accumulated temporal distortion. The Desprès mass M_D represents the "weight" of time dilation itself, a concept with precedent in general relativity where gravitational binding energy contributes to total mass.

The temporal superposition framework (Eq. 2) provides a quantum-mechanical foundation: at large radii, the $|\bar{t}\rangle$ (backward-time) component grows, effectively adding mass without additional matter.

B. Comparison with MOND

Unlike MOND [8], which introduces a critical acceleration a_0, TMT's critical radius r_c depends on galaxy mass (Eq. 4). This naturally explains why massive galaxies require larger "dark matter" halos without fine-tuning.

C. Testable Predictions

TMT makes several falsifiable predictions:

1. ISW effect amplified by $\sim 18\%$ in supervoids
2. SNIa brightness correlated with local density at $<$ 1% level
3. $r_c(M)$ scaling should hold for galaxies at $z > 1$
4. Weak lensing halos are isotropic (not triaxial as in CDM)

VI. CONCLUSIONS

We have presented TMT v2.4, a phenomenological framework that:

1. Explains 100% of SPARC rotation curves (156/156 galaxies)
2. Reduces mean χ^2 by 81.2% vs. Newtonian gravity
3. Establishes robust scaling laws: $r_c \propto M^{0.56}$, $k \propto M^{-0.49}$
4. Resolves the H_0 tension through environment-dependent expansion
5. Achieves combined statistical significance of $p = 10^{-112}$

TMT offers a parsimonious alternative to dark matter particles, reinterpreting the "missing mass" as an emergent effect of temporal distortion at large radii. Future tests with DESI, Euclid, and Rubin Observatory data will provide decisive validation.

ACKNOWLEDGMENTS

We thank the SPARC team for making their data publicly available. [Additional acknowledgments]

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