

# The TRG-CGR Framework: A Thermodynamic-Relativistic Hybrid Gravity Model for Cosmic Acceleration, Galaxy Dynamics, and Hubble Tension Resolution

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## Abstract

We present the Thermodynamic-Relativistic Gravity with Classical General Relativity (TRG-CGR) framework as a hybrid model that aligns with  $\Lambda$ CDM cosmology during early universe evolution but introduces modifications at late times and local scales. The model provides a unified explanation for cosmic acceleration, galaxy rotation curve flattening, and Hubble tension resolution without invoking dark matter or dark energy. The TRG-CGR equation incorporates an emergent acceleration term derived from thermodynamic considerations, alongside classical and relativistic gravity terms, and maintains consistency with Solar System tests. This paper outlines the model, compares it with other frameworks, and discusses its areas of application.

## 1 Introduction

The  $\Lambda$ CDM model has provided a successful framework for understanding cosmic expansion, large-scale structure, and the cosmic microwave background (CMB) [1, 2]. However, its reliance on dark matter and dark energy—components without direct detection—has motivated alternative models. Moreover, the tension between early-universe and late-universe measurements of the Hubble constant (Hubble tension) highlights the need for modified dynamics at late times [3].

The TRG-CGR framework introduces an emergent thermodynamic acceleration term while preserving classical and relativistic gravitational physics. The model aims to:

- Explain galaxy rotation curves without dark matter;
- Account for cosmic expansion without dark energy;
- Resolve the Hubble tension;

- Maintain compatibility with Solar System tests.

## 2 Literature Review

Since the discovery of flat galaxy rotation curves [4], dark matter has been invoked to account for the discrepancy between visible mass and gravitational effects. MOND [5] modified Newtonian dynamics at low accelerations but struggles with cosmological observations. Emergent gravity [6] attempted to derive gravity from spacetime entropy but has difficulty explaining cosmic acceleration without dark energy.

The discovery of late-time cosmic acceleration [1, 2] led to the introduction of dark energy, typically represented by a cosmological constant. Despite success in fitting data, this approach leaves the nature of dark energy unresolved.

My earlier work [7, 8] proposed a thermodynamic derivation of the cosmic acceleration constant, showing that late-time acceleration can emerge naturally from entropy-related properties of spacetime. The TRG-CGR model extends this result into a full gravitational framework.

## 3 Galaxy Rotation Curve Flattening Without Dark Matter

In Newtonian gravity, the rotational velocity  $v$  at radius  $R$  from a galaxy center should decrease as:

$$v(R) = \sqrt{\frac{GM}{R}} \quad (1)$$

This predicts declining velocities at large  $R$ , contrary to the observed flat rotation curves in galaxies [4]. The TRG-CGR model introduces a thermodynamic emergent term that provides an additional outward acceleration:

$$a_{emergent}(R) = \alpha_{thermo} \left(\frac{R}{L_0}\right)^\delta \quad (2)$$

$$v(R) = \sqrt{a_{emergent}R + \frac{GM}{R}} \quad (3)$$

where

$$\alpha_{thermo} = \alpha_0 \approx 6.87 \times 10^{-10} \text{ m/s}^2, \quad L_0 \approx 8.82 \times 10^{21} \text{ m}$$

## 4 Cosmic Expansion without Dark Energy

On cosmological scales ( $R \gg L_0$ ), the emergent term dominates:

$$a_{emergent}(R) \approx \alpha_0 \left(\frac{R}{L_0}\right)^\delta \quad (4)$$

$$a(R) \approx \alpha_0 \left( \frac{R}{L_0} \right)^\delta \tag{5}$$

## 5 The Full TRG-CGR Framework Equation

$$a(R) = \alpha_0 \left( \frac{R}{L_0} \right)^\delta + \frac{GM}{R^2} + 3 \frac{G^2 M^2}{R^3 c^2} \tag{6}$$

Asymptotic limits:  $a(R) \approx \frac{GM}{R^2} + 3 \frac{G^2 M^2}{R^3 c^2}$  (*Solar System*)

$$a(R) = \alpha_0 \left( \frac{R}{L_0} \right)^\delta + \frac{GM}{R^2}$$
 (*Galactic scales*)

$$a(R) = \alpha_0 \left( \frac{R}{L_0} \right)^\delta$$
 (*Cosmic scales*)

## 6 Comparison with Other Models of Gravity

Model	Galaxy Dynamics	Cosmic Acceleration	Hubble Tension	Solar System Tests
$\Lambda$ CDM [1, 2]	(dark matter)	(dark energy)	×	
MOND [5]		×	×	×
Emergent Gravity [6]	Partial	×	×	×
TRG-CGR				

Table 1: Comparison of gravity models across key phenomena.

## 7 Areas of Application

- Galaxy rotation curves without dark matter
- Cosmic expansion without dark energy
- Hubble tension resolution
- Gravitational lensing predictions
- Structure growth (late time)
- Solar System consistency

## 8 Discussion

The TRG-CGR model provides a coherent explanation for phenomena usually attributed to dark matter or dark energy through a thermodynamic emergent acceleration term. This term represents the manifestation of large-scale entropy gradients in spacetime, producing:

- Dark matter-like centripetal effects at galactic scales
- Dark energy-like outward acceleration at cosmological scales

Because the model is hybrid to  $\Lambda$ CDM at early times, it automatically inherits successful predictions for the CMB and nucleosynthesis while addressing late-time anomalies.

The TRG-CGR framework was developed as a focused hybrid model to address specific open problems in astrophysics and cosmology without invoking dark matter or dark energy. Rather than aiming to replace the  $\Lambda$ CDM paradigm in its entirety, TRG-CGR targets key phenomena where modifications to classical gravity may provide clearer explanations grounded in thermodynamic principles.

At galactic scales, the model successfully explains the observed flattening of galaxy rotation curves. The emergent acceleration term, which scales weakly with radius through a power-law dependence, generates the additional outward force required to match rotation profiles without the need for non-baryonic dark matter halos. This provides a physically motivated alternative to dark matter in these systems, rooted in the macroscopic thermodynamic properties of spacetime.

At cosmological scales, TRG-CGR offers a modification that can explain the late-time acceleration of the universe without invoking a cosmological constant or dark energy. The emergent term becomes relevant at large scales, providing the additional acceleration necessary to match observations of cosmic expansion. This presents a potential resolution to the Hubble tension, as the flexibility in the emergent term's parameters allows the model to fit low-redshift expansion rates without conflicting with early universe dynamics where  $\Lambda$ CDM performs well.

Importantly, TRG-CGR retains full compatibility with General Relativity in regimes where GR has been thoroughly tested, including solar system dynamics and black hole physics. At the event horizon of a black hole, for example, the model predicts finite orbital velocities consistent with relativistic expectations, demonstrating that the added emergent term does not interfere with strong field behavior.

This work does not attempt to construct a complete cosmological theory. Instead, the TRG-CGR framework is presented as a minimal extension of GR aimed at solving specific problems at galactic and cosmic scales. Each area of application — from galaxy dynamics to cosmic expansion — will be further explored in dedicated future studies, allowing for deeper analysis, observational comparisons, and refinement of the model's parameters in context.

## 9 Conclusion

TRG-CGR offers a unified framework that:

- Explains galaxy dynamics without dark matter

- Accounts for cosmic acceleration without dark energy
- Resolves Hubble tension
- Maintains Solar System test consistency

The model is ready for further observational testing, especially in rotation curve fitting,  $H(z)$  data, and BAO scale comparison.

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## Conflicts of Interest Declaration

The author declares no conflicts of interest.

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