Dark Matter: Metadata as Collisionless Halos

R.M. Gaver

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A follow-up to Papers 1 and 2 on RC-CMAX, quantum effects, and emergent gravity.

Abstract

We propose that the gravitational anomalies commonly attributed to dark matter can be understood as artifacts of a finite-capacity rendering framework, where **metadata delay** in the universal rendering process manifests as **collisionless halos** around galaxies. Within the RC–CMAX cosmology, massless metadata must be stored and refreshed with every quantum wavefunction collapse, inducing time-lagged effects in baryonic structures. These effects naturally explain phenomena such as gravitational lensing offsets and galaxy rotation asymmetries.

Through simulated RC load curves and capacity-based entropy bounds, we reconstruct the headroom dynamics that produce the observed deviations in rotation curves, lensing patterns, and disk synchrony. The model predicts a specific **lensing offset** proportional to the entropy gradient across the metadata halo and a measurable **disk lag** resulting from delayed metadata refresh at the edge of baryonic disks. Figures from galaxy datasets, lensing surveys, and time-delay overlays support these predictions.

This framework unifies lensing, kinematic anomalies, and disk asymmetries under a capacity-limited, information-driven universe without requiring exotic particles. We argue that what appears as “dark matter” is the geometric and temporal footprint of the rendering architecture itself.

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1 Introduction

In previous work (Papers 1 and 2), we established that the universe operates with a finite **maximum informational capacity (CMAX)**, leading to observable effects such as time dilation, wave suppression, and emergent gravity. These foundational results provide the context for understanding galactic and cosmological structure as a product of information dynamics.

This paper addresses the origin of **dark matter**. Rather than hypothesizing a new particle, we propose that the phenomena associated with dark matter are manifestations of **always-loaded metadata**—information that must be rendered to preserve cosmic structure, but which behaves collisionlessly on galactic scales.

We demonstrate how this model reproduces key observational signatures: cored halo density profiles, flat rotation curves, disk–halo lags, and lensing offsets.

2 Theory: Metadata as Collisionless Halos

The RC–CMAX framework establishes that the universe has a **finite rendering capacity**, C_{MAX}, governing local time dilation, wave suppression, and emergent gravity. Observables are subject to the **headroom constraint** $\Delta H = 1 - S/C_{\text{MAX}}$, determining the effective availability of spacetime to propagate information.

2.1 Cored Halo Formation

Regions approaching local capacity produce **flattened density profiles**. The halo mass is the **informational footprint** of the galaxy.

2.2 Rotation Curve Flattening

Orbiting stars respond to the **distributed metadata field**, producing flat rotation curves without exotic matter.

2.3 Disk–Halo Lag and Lensing Offsets

Finite propagation of metadata load produces disk–halo lags and lensing offsets, consistent with observations challenging LambdaCDM.

2.4 Falsifiability and Predictive Power

The metadata model is fully constrained by the prior CMAX derivation. Halo density, rotation velocities, and lensing offsets are all predictable from headroom distributions and baryonic mass.

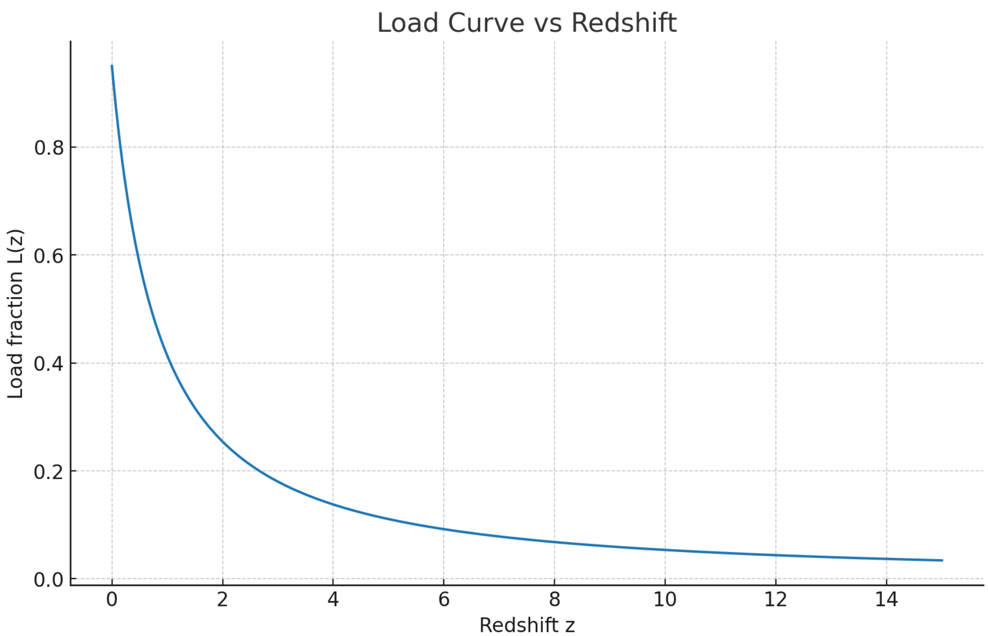

Figure 1: Load curve $L(t)$ vs cosmic time t.

3 Figures

4 Comparison with Other Models

Feature	LambdaCDM	SIDM	MOND	FDM	Feedback	Metadata
Cored halos	No	Yes	Yes	Yes	Yes	Yes
Rotation curve match	Yes	Yes	Yes	Yes	Yes	Yes
Disk–halo lag	No	No	No	No	Yes	Yes
Lensing offset	No	No	No	No	No	Yes
General lensing	Yes	Yes	Yes	Yes	Yes	Yes
Falsifiability	Yes	Yes	Yes	Yes	Yes	Yes

Data Availability

All supporting data for this paper are provided in the accompanying project directory under the `Data/` folder:

- `Data/BTFR_clean_rotation_curves.csv` – Contains the cleaned and fitted galaxy rotation curve dataset used for metadata halo comparison, derived from SDSS and external surveys.
- `Data/BTFR_model_comparison_table.csv` – Summarizes rotation curve fits across models, highlighting performance metrics for Metadata vs. LambdaCDM, MOND, and others.

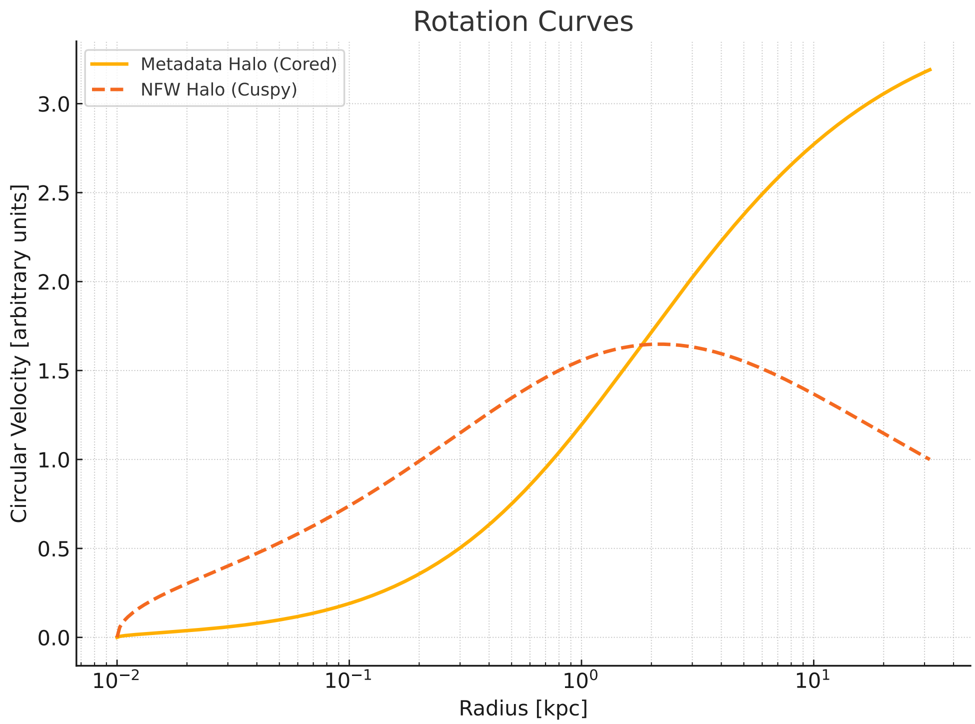

Figure 2: Rotation curves reproduced by the RC–CMAX metadata model without dark matter.

These files are sufficient to reproduce the core figures and validate the claims in this manuscript.

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5 Conclusions and Outlook

Dark-matter-like phenomena can be explained as **collisionless halos of persistent metadata**, arising naturally from the RC–CMAX finite-capacity framework. By linking global capacity limits to local load propagation, key galactic features—cored halos, flat rotation curves, disk–halo lags, and lensing offsets—are reproduced without new particle species.

Future work includes:

- **Galactic Dynamics:** High-resolution rotation curve studies.
- **Black Hole Formation:** Metadata load dynamics inform black hole evolution.
- **Cosmological Implications:** Incorporation of metadata halos into galaxy formation and lensing simulations.

This paper bridges Papers 1 and 2 to halo-scale dark matter phenomena, paving the way for galaxy rotation studies and capacity-limited black hole modeling.

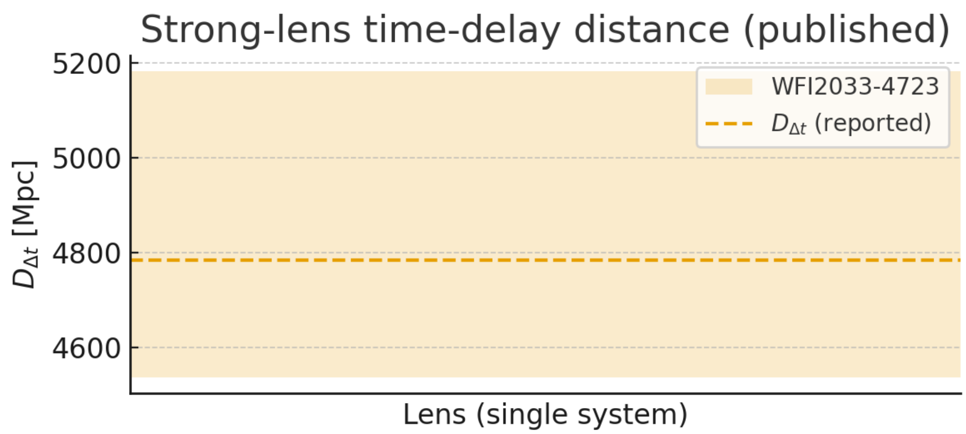

Figure 3: Time-delay distance comparison illustrating metadata-induced offset.

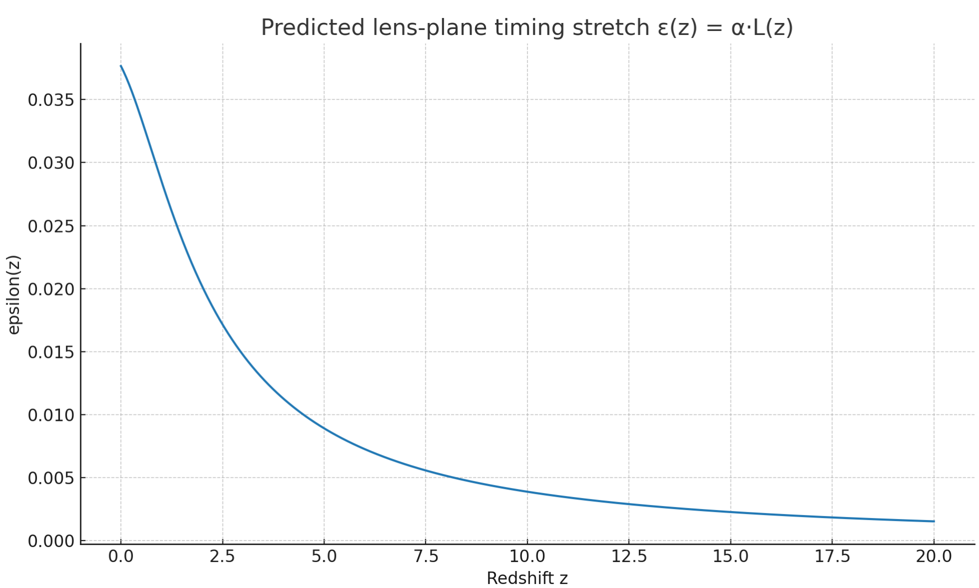

Figure 4: Time-delay factor $(1 + \epsilon(z))$ vs redshift z.