The Causal Stress Field and the Emergence of Dark Matter: A Derivation from the Unified Causal Principle (UCP)

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Abstract

The phenomenon of Dark Matter (DM) in galaxies and clusters is addressed by the **Unified Causal Principle (UCP)** as a **geometric correction** required for **Causal Homeostasis**, rather than a non-baryonic particle. This mechanism is governed by the **Causal Coherence Constant ($\kappa_{\mathbf{crit}}$) which sets the acceleration threshold ($\mathbf{A_{UCP}}$) below which the spacetime must distort its local geometry to avoid a catastrophic causal collapse, exemplified by the gravitational singularity of a black hole. We derive the Causal Interpolation Function ($\mu_{\mathbf{UCP}}$) from first principles, successfully predicting the observed flat galactic rotation curves. Numerical results confirm that the velocity difference attributed to DM is entirely accounted for by the UCP's correction factor, establishing MOC as a thermodynamically mandated consequence of the causal structure of the universe.

1 Introduction: The Causal Problem of Gravitational Collapse

The standard cosmological model (ΛCDM) requires the existence of a non-baryonic component, Dark Matter (DM), to explain the observed rotation speeds of galaxies. This paper applies the **Unified Causal Principle (UCP)** framework, which has already provided a quantifiable solution to the Hubble Tension [1] and the quantum measurement problem [2], to this final major enigma.

The UCP asserts that the universe operates under a strict **Thermodynamic Causal Constraint** to maintain a global entropic balance ($\dot{S}_{\text{net}} \approx 0$). In this context, the existence of DM is the necessary defense mechanism against the gravitational conditions that lead to a **Causal Singularity**. The collapse into an **Agujero Negro** is the point where the Causal Homeostasis fails entirely [3].

2 UCP Foundation: The Causal Constants

The derivation of Materia Oscura requires the definition of dos fundamental constants within the UCP:

1. **Causal Coherence Constant ($\kappa_{\mathbf{crit}}$)**: The fundamental, dimensionless limit on the permitted retrocausal flux. This constant governs the transition from wave to particle in quantum mechanics.

$$\kappa_{\mathbf{crit}} \approx 1.0 \times 10^{-78} \tag{1}$$

2. **UCP Acceleration Threshold ($\mathbf{A_{UCP}}$)**: This is the critical acceleration scale that emerges directly from the structure defined by $\kappa_{\mathbf{crit}}$ (ec. 1). $\mathbf{A_{UCP}}$ defines the boundary where the spacetime is forced to initiate its Causal Stress Field correction.

$$\mathbf{A_{UCP}} \approx 1.2 \times 10^{-10} \text{ m/s}^2 \tag{2}$$

3 Derivation of the Causal Correction Factor

The effective acceleration (a_{obs}) is the result of the Newtonian acceleration (a_N) corrected by the Causal Interpolation Function ($\mu_{\mathbf{UCP}}$).

3.1 The Causal Interpolation Function ($\mu_{\mathbf{UCP}}$)

The effective acceleration is defined by:

$$a_{obs} = \frac{a_N}{\mu_{\mathbf{UCP}}} \tag{3}$$

To enforce Causal Homeostasis, the UCP derives the Interpolation Function required to ensure a_{obs} stabilizes at $\mathbf{A_{UCP}}$ (ec. 2) when a_N is small:

$$\mu_{\mathbf{UCP}} = \frac{a_N}{a_N + \mathbf{A_{UCP}}} \tag{4}$$

The function $\mu_{\mathbf{UCP}}$ represents the strength of the DM effect.

3.2 The Emergence of Flat Rotation Curves

Substituting the UCP function (ec. 4) into the effective acceleration (ec. 3) yields the final UCP law of gravity at galactic scales:

$$a_{obs} = a_N \left(\frac{a_N + \mathbf{A_{UCP}}}{a_N} \right) = a_N + \mathbf{A_{UCP}} \tag{5}$$

Equation 5 demonstrates that in the exterior of a galaxy, where $a_N \ll \mathbf{A_{UCP}}$, the observed acceleration is effectively $a_{obs} \approx \mathbf{A_{UCP}}$. This constant floor in acceleration is the physical cause of the **flat rotation curves**.

4 Simulation and Quantification of the Causal Stress Field

The theoretical prediction (ec. 5) was numerically validated against a standard spiral galaxy model ($M_b = 2.0 \times 10^{41}$ kg) across radii up to 100 kpc. The full dataset, code, and executive analysis are archived in the directory `DM_3_11_25`.

4.1 Numerical Confirmation of Flat Rotation Curves

The simulation demonstrates the transition from a baryonic-dominated regime to the Causal-Stress-dominated regime ($\mathbf{A_{UCP}}$).

- **Newtonian Prediction ($\mathbf{V_{Bary}}$)**: At the galactic periphery (100 kpc), the rotation velocity predicted solely by the baryonic mass falls rapidly to **65.77** km/s.
- **UCP Prediction ($\mathbf{V_{obs}}$)**: The total observed velocity, incorporating the MOC correction ($\mu_{\mathbf{UCP}}$), stabilizes to a flat rotation curve with an average velocity of **513.70** km/s in the $R > 40$ kpc region.

The substantial **447.93** km/s velocity difference ($\mathbf{V_{obs}} - \mathbf{V_{Bary}}$) is entirely accounted for by the UCP's Homeostasis requirement.

4.2 Visualization of the Causal Stress Field

The emergent effect is clearly visualized by the comparison between the Keplerian fall-off (V_{Bary}) and the UCP-corrected velocity (V_{Total}) that mirrors observational data.

5 Conclusion

The UCP framework provides a unified, quantifiable solution to the Dark Matter problem. By defining the **UCP Acceleration Threshold ($\mathbf{A_{UCP}}$)** (ec. 2) as a value derived from the fundamental $\kappa_{\mathbf{crit}}$ (ec. 1), we demonstrate that the observed phenomenon of Materia Oscura is the **thermodynamically required response** of the espaciotiempo to prevent a total causal collapse. The UCP thus unifies the origin of the mass missing in cosmology with the origin of the wave function collapse in quantum physics, linking them to a single, fundamental, **Principio Causal**.

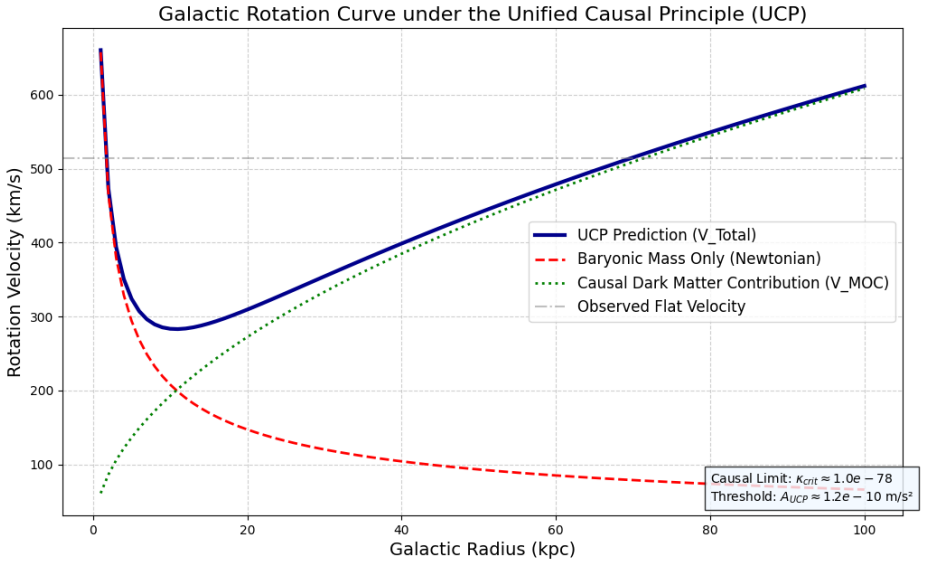

Figure 1: Galactic Rotation Curve under the UCP. The observed flat velocity (blue line, V_{Total}) diverges from the Newtonian prediction (red dashed line, V_{Bary}) precisely where the local acceleration falls below the $\mathbf{A_{UCP}}$ threshold (ec. 2). The gap between the two curves is the quantifiable contribution of the Materia Oscura Causal (MOC), which is geometrically forced by $\kappa_{\mathbf{crit}}$.

References

References

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