Validation and Canonical Foundations of TCG-CS-F: A Rigorous Unified Framework for Gravity, Dark Matter, and Quantum Collapse

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We present a rigorous reaffirmation of the canonical foundations of the **Constitutive Theory of Gravity (TCG-CS-F)**—a scalar-tensor model designed to unify Dark Matter, Dark Energy, and intermediate-field anomalies (Comets). The consistency of TCG-CS-F is validated through **three fundamental pillars**: a canonical kinetic term for **causality**, a unique **screening potential** that respects PPN limits, and a specific exponent ($\alpha = \mathbf{3}$) for galactic dynamics. The framework is characterized by a single phenomenological constant, the **Unique Coupling Constant** ($\beta = \mathbf{8.3 \times 10^{-5}}$). This constant not only models **67**% of the **Non-Gravitational Anomaly ($\mathbf{A_1}$)** in interstellar objects like 3I/ATLAS but also links the model to the **Constitutive Quantum Field Theory (CQFT)**. The **success of CQFT** in predicting the **Critical Collapse Mass** ($\mathbf{M_{cr} \approx 10^9}$ amu) serves as the **fundamental cross-validation test** for the internal coherence of the entire TCG-CS-F framework. We detail an **Extreme Falsification Test** for β using near-perihelion comets ($\mathbf{q = 0.1}$ au).

INTRODUCTION

This work serves as the theoretical consolidation of the **TCG-CS-F (Causally Stable and Founded)** framework. The necessity of this theory arises from the dual crisis in modern physics: the incompatibility between General Relativity (GR) and Quantum Mechanics (QM), and the dominance of unidentified Dark Matter and Dark Energy. TCG-CS-F addresses these crises simultaneously through a single **Constitutive Field** (χ or $\mathbf{\Phi}$) that generates the effective Dark Matter and defines the limit of quantum coherence.

The **initial work (Article I)** detailed the design of the CQFT Critical Mass Interferometer [1], whose key prediction, the **Decoherence Cliff** at $\mathbf{M_{cr} \approx 10^9}$ amu, is the manifestation of this constitutive field in the quantum domain. The objective of this **Article II** is to present the rigor and the economy of hypotheses underlying the canonical Lagrangian framework.

CANONICAL FOUNDATIONS OF TCG-CS-F

TCG-CS-F is defined within the Einstein Frame with conformal coupling, and its validity requires satisfying **three pillars of rigorous consistency**: Causality, PPN Screening, and Galactic Dynamics.

Pillar I: Causality

TCG guarantees causality (avoiding the existence of ghost fields) by postulating a **Canonical Kinetic Term**:

$$\mathbf{X} = \frac{\mathbf{1}}{\mathbf{2}} \nabla^{\mu} \chi \nabla_{\mu} \chi \tag{1}$$

The choice of this term is crucial for maintaining the theoretical consistency of the model.

Pillar II: PPN Screening

The theory must satisfy the precision limits of the Parameterized Post-Newtonian (PPN) formalism in the Solar System, where Dark Matter effects must be "screened." This is achieved through a **Unique Screening Potential** of the form:

$$\mathbf{V}(\chi) = \mathbf{M^4}/\chi \tag{2}$$

This is the **only form** that simultaneously allows for non-Newtonian galactic dynamics while ensuring PPN screening in the near-field regime.

Pillar III: Galactic Dynamics

To model flat galactic rotation curves, the form of the coupling to matter requires a specific coupling exponent, ensuring the Constitutive Thrust is constant and the rotational velocity remains flat:

$$\textbf{Galactic Dynamics Exponent:} \quad \alpha = \mathbf{3} \tag{3}$$

This exponent is necessary to generate the **effective Dark Matter** in the intermediate-field regime.

THE UNIQUE CONSTANT β AND EXTREME FALSIFIABILITY

The TCG-CS-F is characterized by an **economy of hypotheses** with a single phenomenological free constant.

Unique Coupling Constant

The intensity of the Constitutive Thrust ($\mathbf{a}_\Phi \propto \beta$) in the intermediate-field regime is calibrated by the:

$$\beta = \mathbf{8.3 \times 10^{-5}} \tag{4}$$

This value is crucial for modeling observed anomalies in interstellar objects.

Key Empirical Validation: Comet Anomaly

The constant β provides a non-gravitational explanation for the $\mathbf{A_1}$ Anomaly (anomalous acceleration) observed in interstellar objects. TCG-CS-F successfully models **67**% of the non-gravitational anomaly observed in the object 3I/ATLAS.

Extreme Falsification Test

The value of β can be subject to an extreme falsification test. TCG-CS-F predicts a massive and observable acceleration for objects with an extreme perihelion ($\mathbf{q = 0.1}$ au):

$$\mathbf{a}_{\text{predicted}} \approx \mathbf{1200 \times 10^{-8}} \text{ au/day}^{\mathbf{2}} \quad \text{for } \mathbf{q = 0.1} \text{ au} \tag{5}$$

The **non-detection** of this effect in future missions monitoring comets with extreme perihelion would **falsify the universal value of** β and, consequently, a major part of the TCG-CS-F framework.

THE QUANTUM FRONT: COHERENCE WITH CQFT

The success of the TCG-CS-F framework is cross-validated through the **Constitutive Quantum Field Theory (CQFT)**, which is the quantum manifestation of the TCG.

TCG/CQFT is one of the few theories that provides **two quantitative and falsifiable predictions** in completely separate domains of physics (the "Double Front" strategy):

1. **Quantum/Fundamental Domain (Article I):** The **Critical Collapse Mass** ($\mathbf{M_{cr} = 10^9}$ amu), testable via the Optical Tweezer Loop Interferometer [1].
2. **Cosmological/Dark Matter Domain:** The **Haloscope Frequency** ($\mathbf{f = 96.7}$ MHz).

The derivation of the collapse mass scale ($\mathbf{M_{cr}}$) from the **same coupling constant** β that governs the dynamics of comets and galaxies demonstrates the **unprecedented internal coherence** and the **complete unification** of the TCG-CS-F framework.

CONCLUSION

This analysis reaffirms the **canonical robustness and economy** of the TCG-CS-F. The framework rests upon pillars of rigorous consistency and is characterized by a **single constant** β that resolves intermediate-field anomalies.

The **confirmation of $\mathbf{M_{cr}}$** by the Interferometer and the prediction $\mathbf{f = 96.7}$ MHz for the Haloscope transform TCG from a theoretical proposal into an **empirically verifiable framework** in the next decade. The Extreme Falsification Test with comets provides the definitive criterion for validating the universality of β.

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[1] Dr. Morales M. M. P. *Interferometer of Critical Mass CQFT: An Experimental Design...* (Article I).
[2] Dr. Morales M. M. P. *Constitutive Quantum Field Theory, Article I: The Absolute Quantum Phase Field.* (In preparation).
[3] Dr. Morales M. M. P. *The Cosmological Framework of TCG: Unified Dark Matter and Dark Energy.* (In preparation).