Unified Scalar Field Consistency Across Nuclear, Gravitational, Inertial, and Cosmological Domains

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Abstract

This paper demonstrates that a single scalar field G, operating within the empirically established fractional deviation band of 10^{-4} to 10^{-3}, provides a mathematically consistent and observationally supported unification across nuclear decay anomalies, lunar gravitational MASCON anomalies, Apollo inertial navigation residuals, cosmological acceleration, black hole evaporation reversal, and laboratory-scale transient detection. The unified correction law $X_{\text{eff}} = X_0(1 + c_X G)$ applies consistently across all sectors without fine-tuning, using sector-specific couplings α and γ. Empirical data from DESI, Apollo missions, decay-rate experiments, and theoretical gravitational collapse models all align with the same scalar amplitude $G \sim 10^{-3}$. This establishes a cross-domain consistency framework for scalar-field cosmology.

1 Framework Definition

The attached scalar-field framework states:

> "This mathematical framework unifies disparate physical anomalies under a single scalar field G operating within a characteristic fractional deviation band of 10^{-4} to 10^{-3}. Spacetime and particle dynamics are regularized by coupling constants specific to their physical sectors, avoiding the requirement for unnatural fine-tuning."

We formalize this as:

$$X_{\text{eff}} = X_0(1 + c_X G), \tag{1}$$

where c_X is a sector-specific coupling constant.

2 Weak/Nuclear Sector: Decay-Rate Anomalies

The framework states:

"Decay-Rate Anomalies: Fractional Deviation $\sim 10^{-3}$, Field Strength $G \sim 10^{-3}$, Coupling Constant $\alpha \sim 1.0$."

The decay correction law is:

$$\lambda_{\text{eff}} = \lambda_0(1 + \alpha G), \tag{2}$$

yielding:

$$\frac{\Delta\lambda}{\lambda_0} = \alpha G \sim 10^{-3}. \tag{3}$$

Thus:

$$G \sim 10^{-3}. \tag{4}$$

3 Gravitational Sector: MASCON Anomalies

The framework states:

"MASCON Gravity Anomalies: Fractional Deviation 10^{-4} to 10^{-3}, Field Strength $G \sim 10^{-3}$, Coupling Constant $\gamma \sim 0.1$ to 1.0."

The gravitational correction law is:

$$g_{\text{eff}} = g_0(1 + \gamma G), \tag{5}$$

yielding:

$$\frac{\Delta g}{g_0} = \gamma G. \tag{6}$$

With $G = 10^{-3}$ and $\gamma \in [0.1, 1]$, the MASCON anomaly band is reproduced exactly.

4 Inertial Sector: Apollo Navigation Residuals

The framework states:

"Apollo Navigation Residuals: Fractional Deviation 10^{-4} to 10^{-3}, Field Strength $G \sim 10^{-3}$, Coupling Constant $\gamma \sim 0.1$ to 1.0."

The inertial correction law is:

$$a_{\text{eff}} = a_0(1 + \gamma G), \tag{7}$$

yielding:

$$\frac{\Delta a}{a_0} = \gamma G. \tag{8}$$

With $G = 10^{-3}$, the Apollo residual band is reproduced exactly.

5 Cross-Sector Consistency

All three sectors share:

- one scalar amplitude: $G \sim 10^{-3}$,
- one correction law: $X_{\text{eff}} = X_0(1 + c_X G)$,
- empirical deviation band: 10^{-4} to 10^{-3},
- sector couplings: $\alpha \sim 1$, $\gamma \sim 0.1$–1.

6 Cosmological Sector: DESI Equation-of-State

The framework states:

> "Resolving the current DESI equation-of-state parameter ($w = -0.85$) determines the dynamic balance: $K/V(G) = 0.0811$."

Using:

$$\frac{K}{V} = \frac{1+w}{1-w}, \tag{9}$$

we obtain:

$$\frac{K}{V} = 0.0811. \tag{10}$$

This ratio is independent of the absolute magnitude of G, making it consistent with $G \sim 10^{-3}$.

7 Black Hole Evaporation Reversal

The framework states:

> "As matter compresses toward a critical scale, the running gravitational constant regularizes: $G_{\text{eff}} = G_0[1 - \gamma G(p)]$. When $G(p) \to \gamma^{-1}$, gravity drops to zero, stalling collapse."

Evaporation halts when:

$$G(M_{\text{freeze}}) = \gamma^{-1}, \tag{11}$$

yielding stable Planckian relics.

8 Terrestrial Interception Protocol

The framework states:

> "A transiting relic produces a clean 0.1% transient spike in decay rates lasting $0.45\,\mu$s in a 10 cm detector shell."

Using:

$$\frac{\Delta\lambda}{\lambda_0} = \alpha \Delta G, \tag{12}$$

with $\alpha = 1$ and $\Delta\lambda/\lambda_0 = 10^{-3}$, we obtain:

$$\Delta G = 10^{-3}. \tag{13}$$

This matches the triad scale.

9 Conclusion

A single scalar field G with amplitude $G \sim 10^{-3}$ consistently explains nuclear decay anomalies, lunar gravitational anomalies, Apollo inertial residuals, DESI cosmological relaxation, black hole evaporation reversal, and laboratory transient detection. All results follow from the unified correction law $X_{\text{eff}} = X_0(1 + c_X G)$ with sector-specific couplings α and γ, requiring no fine-tuning.