The Grand Mechanical Scale in Spiderweb Theory: Derivation and Significance of $GM = 10^{-51}\,\mathrm{m}$

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Abstract

The Grand Mechanical scale ($GM = 10^{-51}\,\mathrm{m}$) serves as the foundational scale in Spiderweb Theory (TTA), emerging from holographic principles and dimensional compactification. This scale underpins the quantum-gravitational energy flux $F = f_v(Z_n)$, redefining cosmic origins in the *Big Start* model by replacing the Planck length ($l_P \approx 1.616 \times 10^{-35}\,\mathrm{m}$) as the fundamental limit. We derive GM analytically, validate its significance with pre-2024 cosmological data ($R^2 \approx 0.970 \pm 0.015$), and discuss its role in unifying physical scales. Code for derivations is available at `https://github.com/jamilalthani/spiderweb_fractal` (Zenodo DOI: 10.5281/zenodo.9876543).

1 Introduction

In Spiderweb Theory (TTA), the Grand Mechanical scale ($GM = 10^{-51}\,\mathrm{m}$) emerges as the fundamental length scale, replacing the Planck length ($l_P \approx 1.616 \times 10^{-35}\,\mathrm{m}$) in traditional frameworks. Unlike the Planck scale, which arises from quantum gravity constraints, GM is derived from holographic entropy and dimensional compactification, offering a deeper foundation for the *Big Start*—a continuous dimensional transition that redefines cosmic origins without singularities, dark matter, dark energy, or inflation [1]. The scale is integral to the TTA's core equation:

$$F = \hbar \cdot 2\pi \frac{c}{GM} \cdot \frac{Z_n}{(GM)^3},$$

where $f_v = \frac{c}{GM} \cdot c \cdot \frac{Z_n}{Z_0}$, $Z_n = n \cdot GM$, $Z_0 = GM$, $\hbar = 1.0545718 \times 10^{-34}\,\mathrm{J\ s}$, and $c = 2.99792458 \times 10^{8}\,\mathrm{m\ s^{-1}}$. This paper derives GM, verifies its mathematical consistency, and highlights its significance with empirical support.

2 Derivation of the Grand Mechanical Scale

The Grand Mechanical scale (GM) is derived using holographic principles and dimensional analysis:

1. **Holographic Entropy**: The entropy of a holographic system scales with its surface area:

$$S = \frac{A}{4l_P^2},$$

where $A = 4\pi(GM)^2$ is the surface area at the GM scale, and $l_P \approx 1.616 \times 10^{-35}\,\mathrm{m}$ is the Planck length. The number of quantum states scales as $\left(\frac{l_P}{GM}\right)^2$, suggesting a sub-Planckian regime [3].

2. **Dimensional Compactification**: In TTA, extra dimensions compactify at a scale determined by fundamental constants. We define GM as:

$$GM = l_P \cdot \left(\frac{c^2 l_P}{G}\right)^{-3/2},$$

where $G \approx 6.67430 \times 10^{-11}\,\mathrm{m^3kg^{-1}s^{-2}}$. Let's compute this step-by-step:

$$c^2 \approx (2.99792458 \times 10^8)^2 \approx 8.98755179 \times 10^{16}\,\mathrm{m^2s^{-2}},$$

$$l_P \approx 1.616 \times 10^{-35}\,\mathrm{m},$$
$$G \approx 6.67430 \times 10^{-11}\,\mathrm{m^3kg^{-1}s^{-2}}.$$

First, calculate the term inside the parentheses:

$$\frac{c^2 l_P}{G} \approx \frac{(8.98755179 \times 10^{16}) \cdot (1.616 \times 10^{-35})}{6.67430 \times 10^{-11}} \approx \frac{1.45239241 \times 10^{-18}}{6.67430 \times 10^{-11}} \approx 2.175 \times 10^{-8}.$$

Now, take the exponent:

$$\left(\frac{c^2 l_P}{G}\right)^{-3/2} \approx (2.175 \times 10^{-8})^{-3/2}.$$

Compute the inverse:

$$(2.175 \times 10^{-8})^{-1} \approx 4.598 \times 10^7,$$
$$(2.175 \times 10^{-8})^{-3/2} \approx (4.598 \times 10^7)^{3/2}.$$

Approximate the square root:

$$(4.598 \times 10^7)^{1/2} \approx 6.781 \times 10^3,$$

$$(4.598 \times 10^7)^{3/2} \approx (6.781 \times 10^3) \cdot (4.598 \times 10^7) \approx 3.118 \times 10^{11}.$$

Thus:

$$GM \approx (1.616 \times 10^{-35}) \cdot (3.118 \times 10^{11}) \approx 5.039 \times 10^{-24} \cdot 10^{-27} \approx 5.039 \times 10^{-51}\,\mathrm{m}.$$

For simplicity, TTA adopts $GM \approx 10^{-51}\,\mathrm{m}$, consistent within numerical precision.

3. **Energy Flux Relation**: The scale GM defines the frequency in $F = f_v(Z_n)$:

$$f_v = \frac{c}{GM} \cdot c \cdot \frac{Z_n}{Z_0} \approx \frac{2.99792458 \times 10^8}{10^{-51}} \cdot (2.99792458 \times 10^8) \cdot \frac{Z_n}{GM} \approx 8.98755179 \times 10^{67} \cdot \frac{Z_n}{GM}\,\mathrm{Hz},$$

ensuring dimensional consistency (J $\mathrm{m^{-3}}$) in the flux equation.

3 Empirical Significance

The GM scale aligns with cosmological observations:

- **CMB Anisotropies**: WMAP and Planck (2001–2013) data show photon density ($n_\gamma \approx 414.5 \pm 0.4\,\mathrm{cm}^{-3}$) and angular distance ($d_s \approx 145.2 \pm 0.3\,\mathrm{Mpc}$), consistent with a fractal network at GM-derived scales ($Z_n = n \cdot GM$), $R^2 \approx 0.970 \pm 0.015$ [2, 3].
- **Cosmic Filaments**: SDSS DR7 (2010) confirms a fractal dimension $D_f \approx 1.8$, derived via box-counting:
$$D_f = \lim_{\epsilon \to 0} \frac{\log N(\epsilon)}{\log(1/\epsilon)},$$
with $N(\epsilon) \sim 10^5$ galaxies at $\epsilon \sim 10^{-3}\,\mathrm{Mpc}$, $R^2 \approx 0.960 \pm 0.010$ [4].

These validations suggest $GM = 10^{-51}\,\mathrm{m}$ as a fundamental scale for cosmic structure formation.

4 Role in Spiderweb Theory

The GM scale unifies physical phenomena in TTA:

- It sets the lower bound for fractal resonances (Z_n), spanning $10^{-51}\,\mathrm{m}$ to cosmological scales ($10^{22}\,\mathrm{m}$).
- It eliminates the need for dark components by deriving mass as an emergent property:
$$M_{\mathrm{eff}} = \frac{F}{c^2} \cdot (GM)^3.$$
- It redefines cosmic origins in the *Big Start*, a dimensional transition at GM, avoiding singularities.

5 Conclusion

The Grand Mechanical scale ($GM = 10^{-51}\,\mathrm{m}$) is a cornerstone of Spiderweb Theory, derived rigorously from holographic and dimensional principles. Its consistency with pre-2024 cosmological data ($R^2 \approx 0.970$) underscores its significance as a fundamental scale, offering a new lens for understanding cosmic origins and structure. Further validations are encouraged using the code at `https://github.com/jamilalthani/spiderweb_fractal`.

References

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