Matter Activation and the Planck Threshold: Quantizing Emergence in a Six-Dimensional Spacetime

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Abstract

Building upon prior work modeling curvature memory and coherence-driven emergence in a six-dimensional spacetime framework, we introduce a physically grounded activation threshold for the emergence function $\tau_3(x)$. We identify the Planck power limit $P_{\text{Planck}} \approx 3.63 \times 10^{52}\,\text{W}$ as the critical coherence energy E_{crit} required to activate observable geometric transitions. This reinterpretation aligns the model with quantum gravitational constraints and provides a natural quantization mechanism for localized emergence events. We refine the τ_3 activation function accordingly and discuss implications for black hole memory, early-universe phase structure, and potential gravitational observables.

1 Introduction

Note: The recognition of the Planck power limit as a potential threshold for quantum-to-classical transition was recently popularized in public discourse by a 2024 article in *The Sustainability Times* [9]. This article helped crystallize the idea that the Planck power is not merely a dimensional artifact, but may have real physical meaning at the boundary of classical spacetime structure. This popular insight inspired deeper mathematical exploration within the present work.

In previous papers [1, 2, 3, 4, 5], we developed a model in which a scalar field $\tau_2(x^\mu, \theta, \phi, t)$, defined across a compactified 2-sphere, stores localized coherence energy that can induce geometric transitions in 4D spacetime. The emergence function $\tau_3(x)$ mediates this activation and was originally modeled as a sigmoid or dynamic scalar field governed by local energy thresholds. However, the critical activation energy E_{crit} remained a free parameter.

Here we identify E_{crit} with the **Planck power** limit, the maximum physically meaningful power scale derivable from fundamental constants:

$$P_{\text{Planck}} = \frac{c^5}{G} \approx 3.63 \times 10^{52}\,\text{W}$$

This threshold represents the **upper bound of classical spacetime description**, beyond which quantum gravitational effects dominate. First discussed in early dimensional

analysis by Planck (1899) [6], this limit has since been adopted in quantum gravity literature as the dividing line between semi-classical regimes and fully nonlocal quantum domains [7, 8].

2 Emergence Function with Planck Power Threshold

We redefine the emergence function $\tau_3(x)$ as:

$$\tau_3(x) = \frac{1}{1 + \exp\left[-\beta\left(E_{\tau_2}(x) - P_{\text{Planck}}\right)\right]}$$

Here:

- $E_{\tau_2}(x)$ is the localized coherence energy derived from the compactified 2-sphere,
- β determines the sharpness of the emergence threshold,
- P_{Planck} acts as a universal quantization scale.

This definition enforces **discrete activation**: emergence only occurs when τ_2's coherence energy accumulates to the Planck power threshold, enabling phase-transition-like curvature release.

3 Physical Interpretation and Implications

3.1 Coherence Storage and Quantized Emergence

The τ_2 field now operates as a **geometric memory system**, accumulating structured energy that remains latent until emergence conditions are met. Below the Planck threshold, spacetime remains unaffected. At the threshold, $\tau_3(x)$ activates, inducing geometric reconfiguration.

3.2 Discrete Geometric Transitions

This power-based gating mechanism transforms τ_3 into a true **semi-classical emergence operator**, akin to a phase transition in condensed matter. Geometric transitions become localized, quantized events rather than continuous evolution.

3.3 Bridge to Quantum Gravity

This reframing connects the model to foundational themes in quantum gravity:

- **Black hole memory**: Information may be encoded in τ_2 fields and released via threshold-based τ_3 activation
- **Early universe inflation**: Local domains surpassing Planck power could seed emergent structure
- **Gravitational wave spikes**: Ringdown events exceeding Planck limits may display nonlinear modulations traceable to $\tau_3(x)$ emergence fronts

4 Observational Signatures

This formulation predicts several potential observables:

- **Time-varying gravitational redshift** localized to coherent systems
- **Quantized ringdown phase shifts** during high-power gravitational wave events
- **Curvature-induced phase flips** in quantum systems exposed to localized geometric anomalies

While each of these remains speculative, they offer concrete targets for simulation and possible observational refinement.

5 Conclusion

Anchoring E_{crit} in the Planck power limit transforms the emergence mechanism from a tunable function to a physically justified quantization rule. This integration unifies the six-dimensional coherence model with established thresholds in gravitational physics and opens a structured path toward experimental falsifiability.

References

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