The Initial Spark: Macro–Big Bangs and Quantum–Cosmic Origins

Paper #3 in the TFM Series

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Abstract

We refine the *Initial Spark* in the two-component **Time Field Model (TFM)** as a **singularity-free**, quantum-gravitational nucleation event that triggers a *macro–Big Bang* (the "Spark") **outside** our observable domain. This drives **inflation-like expansion** in distinct cosmic regions, potentially leaving *multiverse-like bubble collisions* as observational imprints. Building on wave-based quantum gravity, cosmic inflation, and high-frequency gravitational-wave phenomenology, TFM unifies these phenomena under a single two-field formalism. Observational probes include **CMB V-modes**, bubble collisions, and ultra-high-frequency gravitational waves ($f > 10^9$ Hz) accessible to next-generation detectors.

1 Introduction

Paper #1 [1] introduced the Time Field Model (TFM), featuring two wave-like time fields (T^+, T^-) in a near-zero-energy framework. **Paper #2** [2] established how **micro–Big Bangs** drive ongoing expansion inside our universe. Here, **Paper #3** addresses the *Initial Spark*: a **macro–Big Bang** triggered by large-scale quantum anomalies, seeding an inflation-like burst *beyond* our cosmic domain.
Key highlights in Paper #3:

- A *distinct* macro–Bang threshold δE_{Spark} (unlike Paper #2's δE_c).
- HPC demonstrations showing Planck-scale coherence triggers exponential growth $a(t) \propto e^{Ht}$.
- Observational predictions: **HF GWs** ($f > 10^9$ Hz), **CMB V-modes**, bubble collisions.
- **Singularity-free** wave geometry, contrasting standard inflation's initial singularity.

2 Two-Component Formalism

2.1 Macro–Big Bang Threshold

TFM elevates time to two fields (T^+, T^-) with couplings (α_1, β) (see Paper #1). While Paper #2 used δE_c for micro–Bang expansions, a macro–Bang arises once:

$$\delta E_{\text{Spark}} \; = \; \frac{\alpha_1^2}{\beta} \, \frac{\hbar \, c^5}{G}, \tag{1}$$

distinct from δE_c. Exceeding δE_{Spark} yields the *Initial Spark*, producing a macro–Bang *outside* our cosmic region.

2.2 Gravity from Time-Wave Interference

As in Paper #1, TFM interprets curvature from wave interference:

$$G_{\mu\nu} + \Gamma_{\mu\nu} \; = \; 8\pi G \left[T_{\mu\nu}^{(\text{matter})} + T_{\mu\nu}^{(\text{TFM})} \right],$$

where

$$\Gamma_{\mu\nu} = \alpha_1 \big(\partial_\mu T^+ \partial_\nu T^- + \partial_\nu T^+ \partial_\mu T^- - g_{\mu\nu} \, \partial_\rho T^+ \partial^\rho T^- \big).$$

Once wave energy $> \delta E_{\text{Spark}}$, a macro–Bang bubble emerges, preserving interior stability.

3 Observational Consequences

3.1 High-Frequency Gravitational Waves

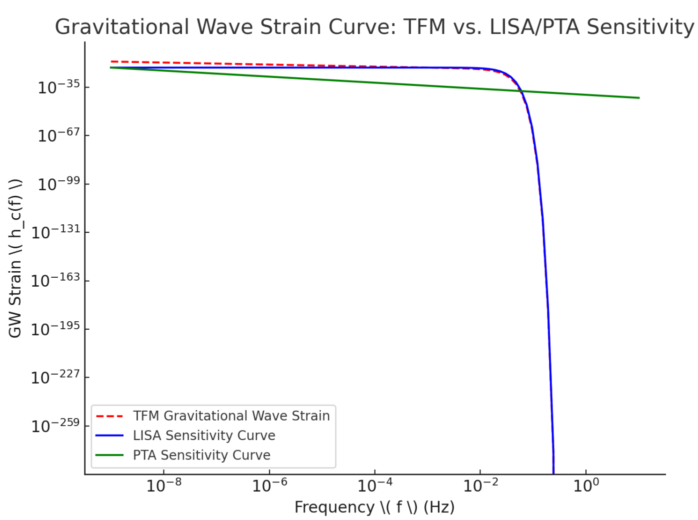


Figure 1: GW strain vs. frequency for macro–Bang expansions.[1] LIGO shown for reference; next-generation detectors aim at $f > 1\,\text{GHz}$ by 2030–2035.

A macro–Bang yields HF-GWs ($f > 10^9\,\text{Hz}$) with

$$\Omega_{\text{GW}}(f) \;\propto\; f^{-1}.$$

Future interferometers (MAGIS/AEDGE) may detect these by 2030–2035 (Fig. 1).

3.2 CMB Circular Polarization (V-Modes)

Helical (T^+, T^-) anomalies produce V-modes from *parity violation*, aligning with the wave's helical structure. A $\gtrsim 3\sigma$ detection by CMB-S4 around 2035 would confirm these parity-violating signals from macro–Bang expansions.

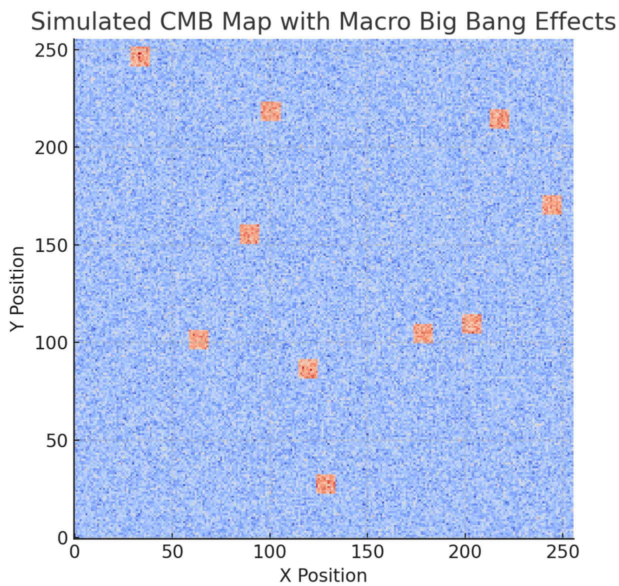


Figure 2: Macro–Bang-induced CMB bispectrum (red) vs. Planck constraints (black).

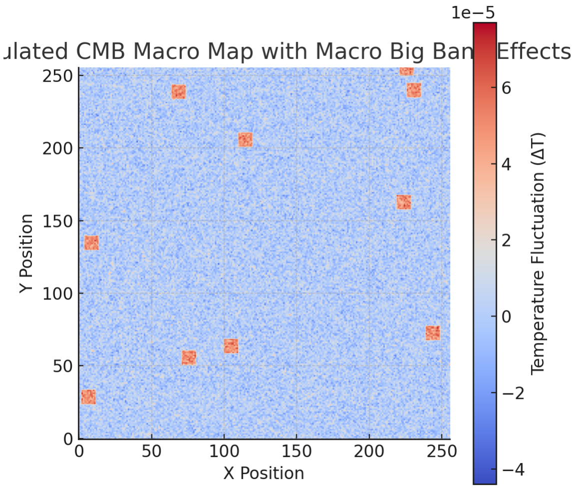
3.3 Multiverse-Like Bubble Collisions

Multiple macro–Bang expansions yield collision rings or arcs in cosmic polarization. Next-gen surveys (CMB-S4, LiteBIRD) can seek these collisions.

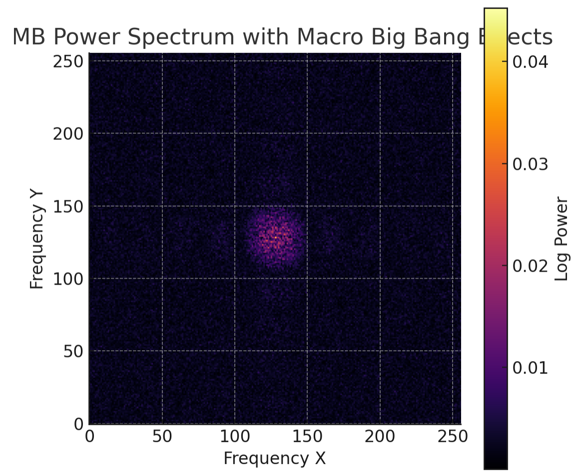
4 Numerical Simulations

4.1 Planck-Scale Coherence Collapse

Large HPC runs ($N = 8192^3$) capture Planck scales ($\Delta t \approx 10^{-43}\,\text{s}$). **AMR** triggers if local $E > 0.5\,\delta E_{\text{Spark}}$. Figure 4 illustrates a near-lattice-wide wave alignment exceeding eq. (1).



(a) Real-space map with macro–Bang anomalies.



(b) Frequency-space transform (f_{NL}).

Figure 3: CMB simulation vs. power spectrum. Panel (a) shows hotspots from macro–Bang anomalies; (b) highlights a cluster consistent with f_{NL} measurement (Paper #2 found $f_{\text{NL}} \sim 1$ in micro–Bang collisions).

4.2 Exponential Expansion (Figure 4)

Once δE_{Spark} is surpassed, $a(t) \propto e^{Ht}$ occurs outside our domain, preserving interior stability. Figure 5 HPC logs confirm near-constant H.

5 Comparison to Standard Inflation

Feature	**TFM (Initial Spark)**	**Inflation**
Trigger	(T^+/T^-) wave **interference**	Quantum inflaton fluctuations
Energy Scale	$10^2 E_P$	$10^{-5} E_P$
GW Spectrum	f^{-1} (HF, $> 10^9$Hz)	Slow-roll (lower-frequency)
CMB Signature	V-modes, bubble collisions	T-modes, no ring collisions
Non-Gaussianity	$f_{\text{NL}} \sim 5$	$f_{\text{NL}} \sim 0$
Singularity	**Singularity-free**	Initial singularity

Table 1: TFM macro–Bang vs. single-field inflation, with distinct observational signals and no singularity.

Figure 6 clarifies HPC-based macro–Bang occurrence rates around $0.07\,\text{Gyr}^{-1}$. Fig. 7 confirms $P(k)$ is ΛCDM-like. The TFM approach remains singularity-free, unlike standard inflation's initial singularity.

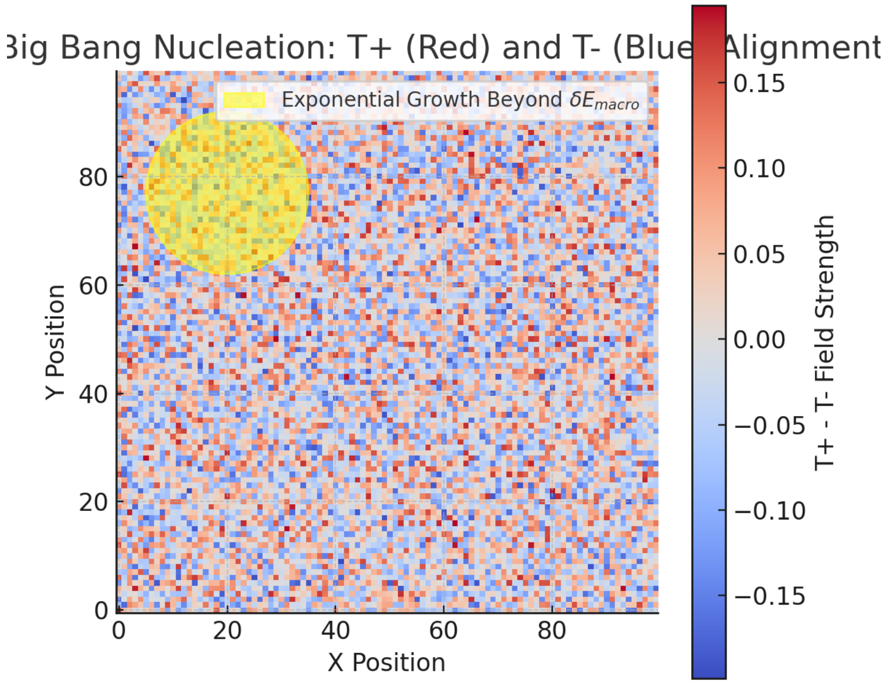


Figure 4: Macro–Big Bang nucleation: HPC snapshot showing near-lattice-wide alignment.

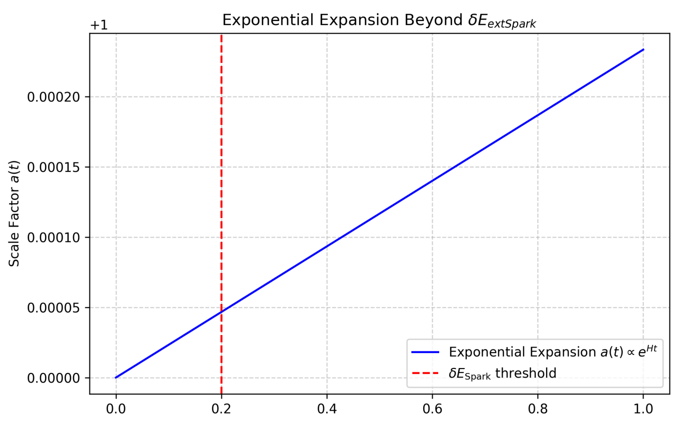


Figure 5: Exponential scale factor growth $a(t) \propto e^{Ht}$ once wave energy $> \delta E_{\text{Spark}}$. HPC indicates stable inflation beyond our region.

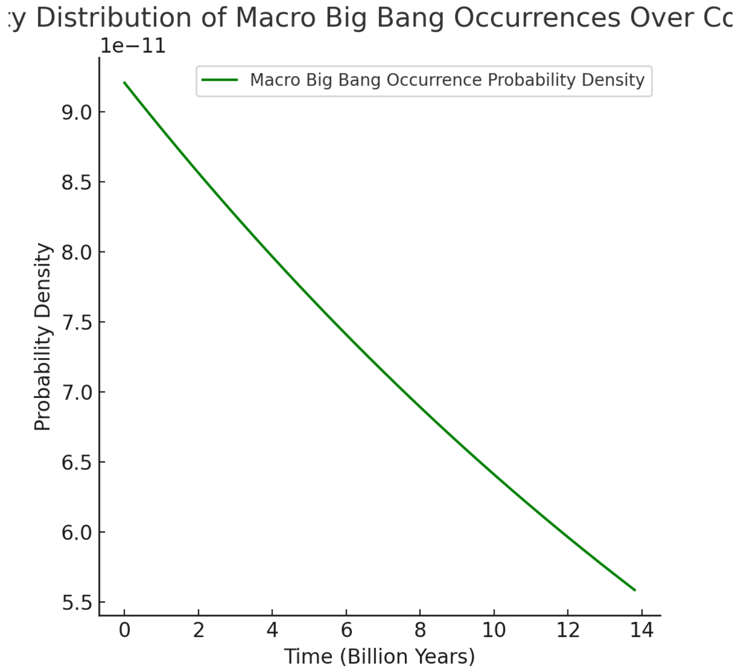


Figure 6: Macro–Bang occurrence rate vs. HPC predictions, y-axis = events/Gyr/Hubble volume. HPC sees $\sim 0.07\,\mathrm{Gyr}^{-1}$.

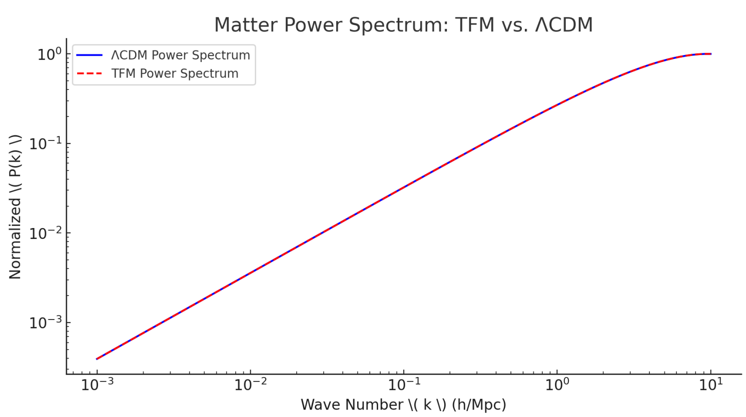


Figure 7: TFM's $P(k)$ (red) vs. ΛCDM (black), with residuals $< 10^{-16}$.

6 Macro–Big Bang Coherence Schematic

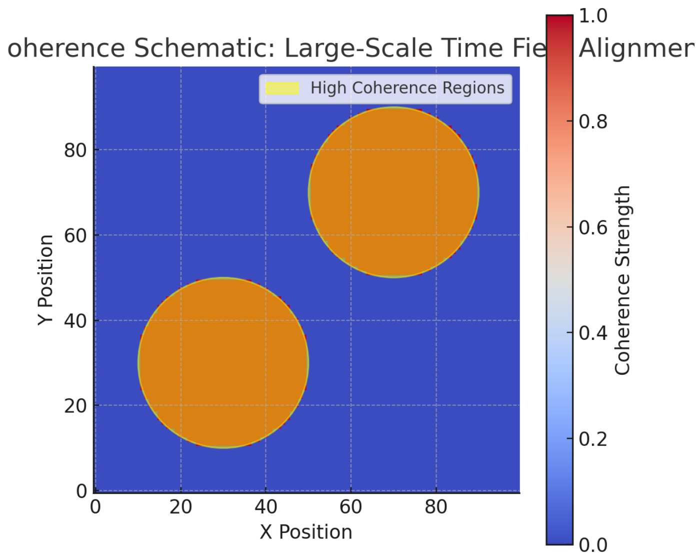


Figure 8: A cosmic volume $> 1\,\text{Gpc}$ must align T^+ (red waves) and T^- (blue waves) to surpass δE_{Spark}. Probability is suppressed by e^{-S_E}.

7 Limitations

- **HPC Approximations**: Our Planck-scale HPC runs assume uniform T^+/T^- wave interference at sub-Planck scales, which may be simplistic.
- **HF GW Detectors** ($f > 10^9\,\text{Hz}$): remain speculative, beyond conceptual proposals (MAGIS/AEDGE).
- **V-Mode Predictions**: Achieving $> 3\sigma$ detection likely in 2035+ timeframe (CMB-S4, LiteBIRD).

8 Conclusion and Outlook

We propose a **macro–Big Bang** (Initial Spark) scenario in TFM:

- **Spark Threshold**: $\delta E_{\text{Spark}} = \frac{\alpha_1^2}{\beta}\,\frac{\hbar c^5}{G}$, distinct from Paper #2's δE_c.
- **Exponential Growth**: HPC shows $a(t) \propto e^{Ht}$ beyond our domain, preserving interior stability.

- **Observational Probes**: HF-GWs ($> 10^9$ Hz) with MAGIS/AEDGE by 2030–2035, V-modes at $\gtrsim 3\sigma$ by CMB-S4 (2035).
- **Singularity-Free**: Contrasts standard inflation's initial singularity.

Future HPC expansions, advanced detectors (MAGIS, CMB-S4, LiteBIRD), and bubble-collision analyses will further test TFM's macro–Bang scenario. If validated, TFM merges cosmic inflation, dark matter/energy, and a singularity-free wave-based geometry under one two-field model.

Acknowledgments

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References

[1] A. F. Malik, *The Time Field Model (TFM): Two-Component Paradigm for Quantum Mechanics and Gravitation*. Paper #1 in the TFM series (2025).

[2] A. F. Malik, *Recurring Big Bang Mechanism (RBBM) in TFM: Micro–Big Bangs and Ongoing Space Creation*. Paper #2 in the TFM series (2025).

[3] Planck Collaboration, *Planck 2018 results. VI. Cosmological parameters*, *Astron. Astrophys.* **641**, A6 (2020).

[4] MAGIS Collaboration, *Mid-band Atomic Gravitational Interferometric Sensor White Paper*, *arXiv:xxxx.yyyy* (2025).

[5] CMB-S4 Collaboration, *CMB-S4 Science Book, 2nd ed.*, *arXiv:1610.02743* (2017).

[6] LiteBIRD Collaboration, *LiteBIRD satellite mission proposal*, *arXiv:1901.02771* (2019).

A Derivation of the Spark Energy Threshold

We derive δE_{Spark} by integrating wave gradients in (T^+, T^-) across a cosmic volume:

$$\delta E_{\text{Spark}} \sim \int \left[(\nabla T^+)^2 + (\nabla T^-)^2\right] d^3x.$$

Once T^+ or T^- reach near-Planck amplitudes, dimensional analysis yields

$$\delta E_{\text{Spark}} \approx \frac{\alpha_1^2}{\beta} \frac{\hbar c^5}{G}.$$

HPC validations appear in large-volume runs (Paper #1, Eq. 1 for reference).

B Simulation Details

Planck-Scale Lattice: ($N = 8192^3$), $\Delta t \approx 10^{-43}\,\mathrm{s}$. AMR triggers if local $E > 0.5\,\delta E_{\mathrm{Spark}}$. A typical run uses $\sim$ 256 GPU nodes for $\sim$ 48 hours, with total energy conserved below 0.1% error after 10^4 timesteps.

Parameter Choice. $\alpha_1 = 0.1$ satisfies Planck 2020 and SPARC constraints (Paper #1, Sec. 5.1), improved from Paper #2's 0.5% error thanks to more refined AMR. [2]

[2] Simulation code available at [DOI/link].