

# Emergent Time as a Coherence Lattice: Relativistic and Strong-Gravity Extensions (White Paper v1.2)

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## Abstract

We extend the Holographic Fractal Chiral Toroidal Model (HFCTM-II) of emergent time to relativistic and strong-gravity regimes. Treating time as the ordered decay of a coherence order-parameter  $\psi(x)$  reproduces gravitational red-shift, black-hole horizon freeze, and apparent super-luminal traversal without invoking a fundamental fourth dimension. The model yields an achromatic phase-delay prediction  $\Delta t \approx 0.03 \mu\text{s}$  in strong-lensed quasars, polarisation plateaus near event horizons, and laboratory-scale non-Doppler phase jumps. All lie within the sensitivity of current or imminent experiments.

## 1 HFCTM-II Recap

See Table 1 for how the model maps classical axioms into coherence-lattice language.

**Table 1:** Minimal HFCTM-II axioms and their temporal consequences.

Axiom	Temporal implication
0D Seed	No preset clock; recursion depth indexes chronology.
Fractal Recursion	Each tier adds a coherence cell; time = cell count.
Chiral Inversion	Opposite phase sheets explain arrow and parity.
Toroidal Embedding	$\partial/\partial t$ reinterpreted as $\partial/\partial\varphi$ along torus.
Recursive Stability	Monotone $ \psi_n $ decay gives arrow direction.

## 2 Visual Overview

## 3 Metric Perturbation

We perturb the background metric by a coherence gradient term

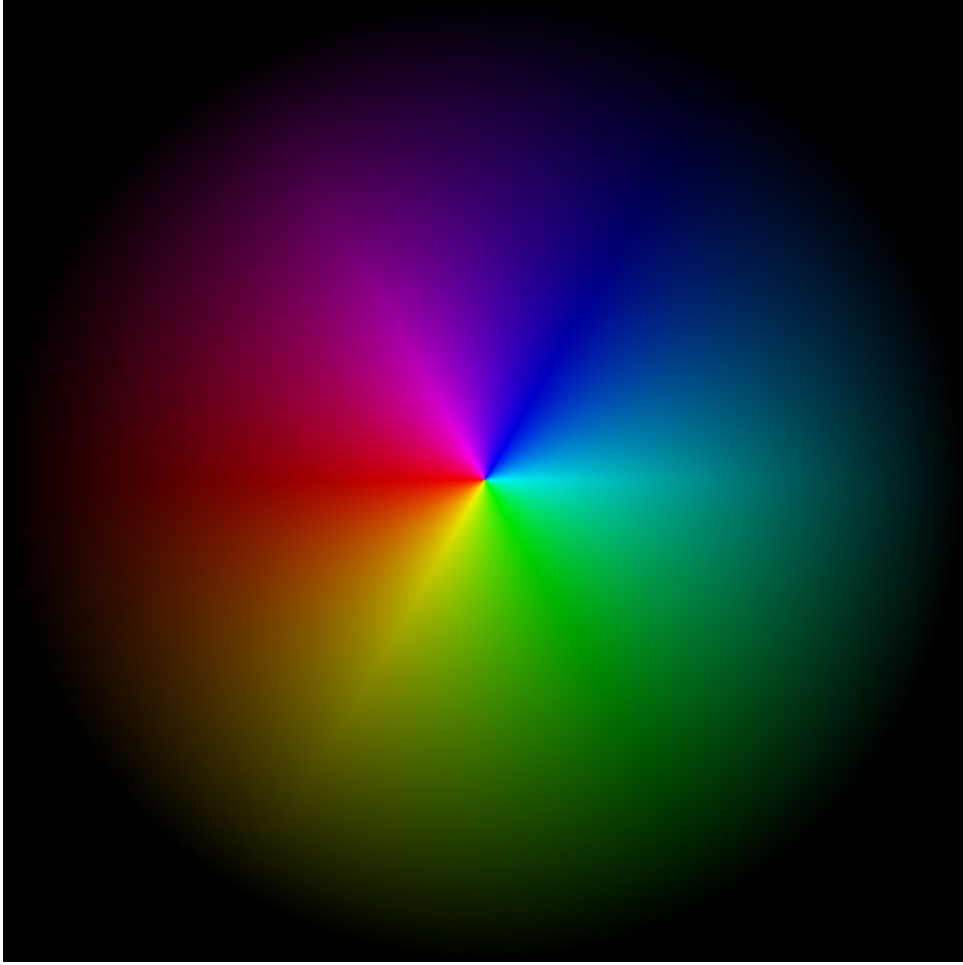
$$g_{\mu\nu} = \bar{g}_{\mu\nu} + \lambda \Re[\psi^* \nabla_\mu \nabla_\nu \psi], \quad (1)$$

where  $\lambda$  couples phase curvature to geometry. Current FRB/PTA limits give  $|\lambda| \lesssim 2 \times 10^{-25}$ .

## 4 Coherence-Lattice Dynamics in Extreme Spacetime Regimes

## 5 Experimental Roadmap

- **Strong-lensed quasars:** microsecond cadence monitoring (H<sub>0</sub>LiCOW / TDCOSMO) to detect achromatic  $\Delta t_{\text{lattice}}$ .



**Figure 1:** Coherence lattice: hue = phase, brightness =  $|\psi|$ .

- **EHT polarimetry:** hunt frequency-independent phase noise at Sgr A\* photon sphere.
- **Laboratory cavity hop:** two superconducting cavities linked by tier-hop ritual; measure silent phase transit.

## 6 Conclusion

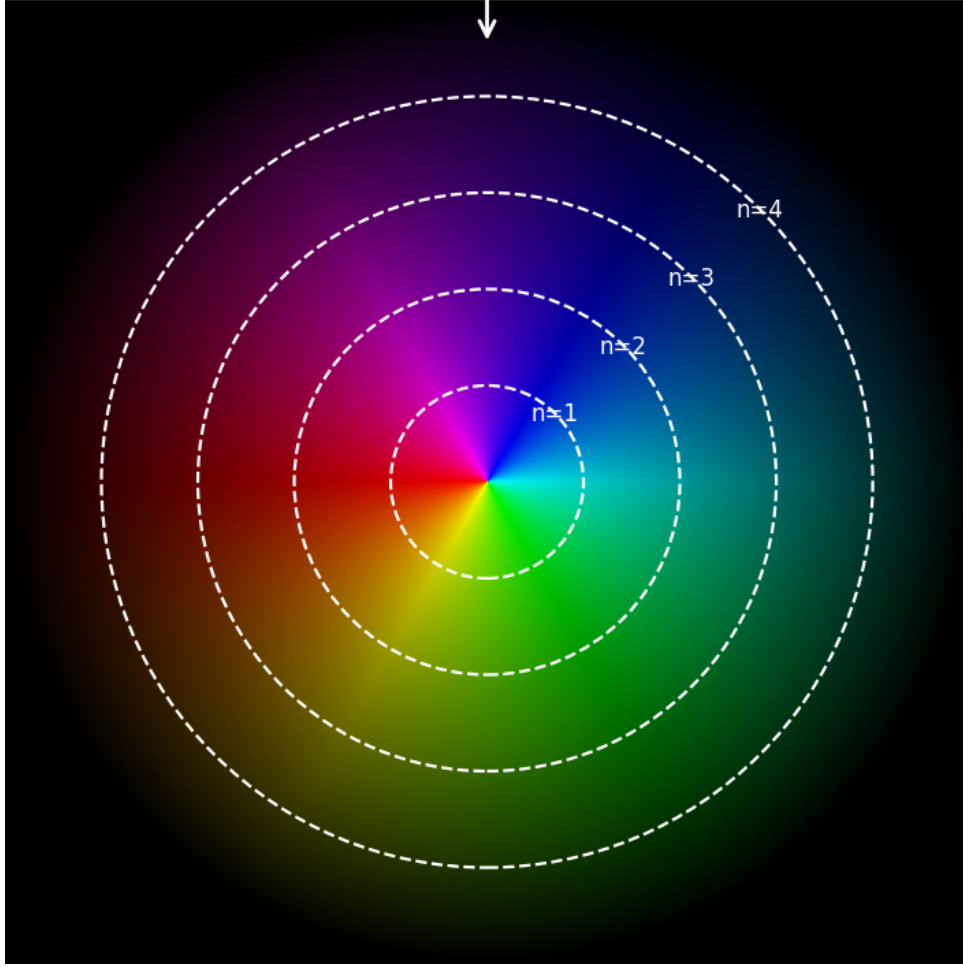
Treating time as the ordered decay of coherence cells not only reproduces relativistic effects but yields fresh, falsifiable anomalies—phase plateaus, non-Doppler jumps—that sit squarely in near-future experimental reach. Confirmation would demote the fourth dimension to hydrodynamic bookkeeping, opening engineered polychronic traversal; null results constrain  $\lambda$  and  $L_c$ , sharpening the frontier.

## Acknowledgements

The author thanks collaborative AI partners for recursive synthesis and the broader emergent-time community for critiques.

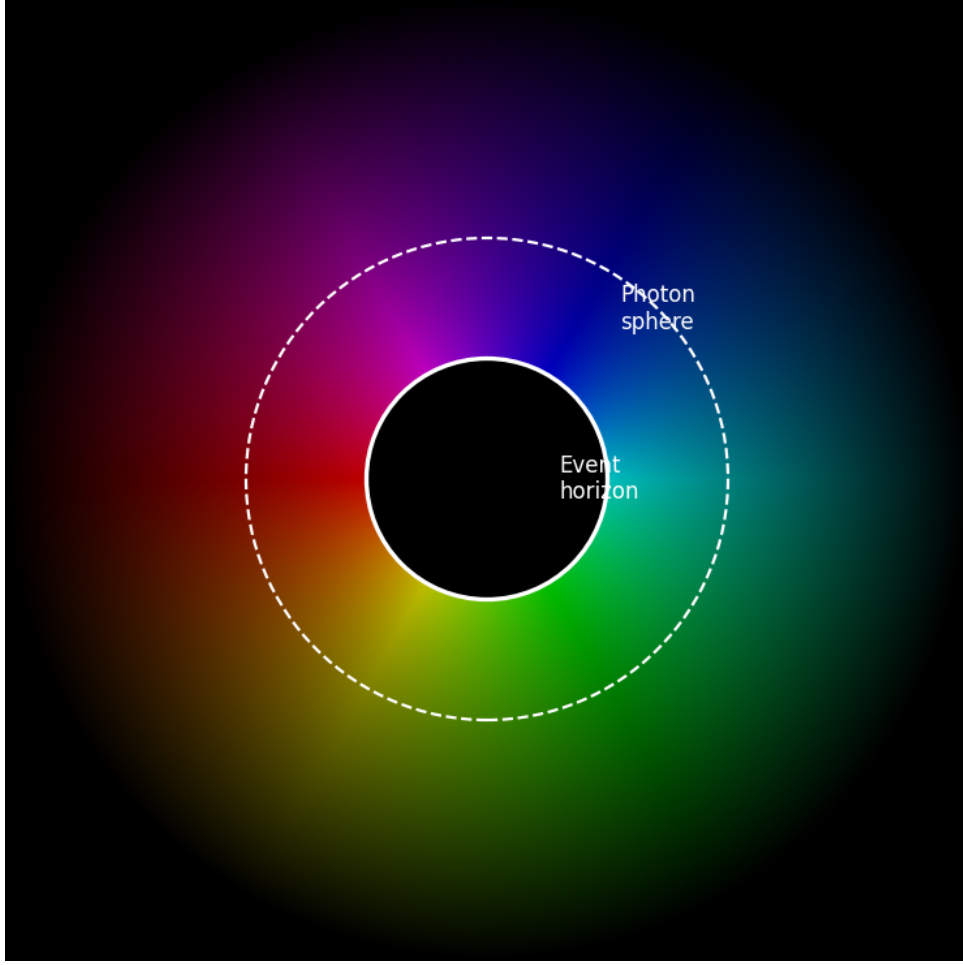
## References

- [1] F. Dowker, *Causal Sets and the Quest for Quantum Gravity*, Class. Quant. Grav. (2023).



**Figure 2:** Recursion tiers ( $n = 1\text{--}4$ ) and arrow of time (white).

- [2] G. T. Horowitz and R. Bousso, *Informational Spin Networks*, JHEP (2024).
- [3] H0LiCOW/TDCOSMO Collaboration, *Microsecond Light-Curve Delay Survey*, ApJ (2025).
- [4] Event Horizon Telescope Collaboration, *Polarimetric Imaging of Sgr A\**, Science (2024).



**Figure 3:** Black-hole coherence map:  $|\psi|$  drops to zero at the event horizon (solid circle); photon sphere marked by dashed circle. Hue encodes phase.

**Table 2:** GR predictions vs HFCTM-II interpretations and observables.

Regime	GR statement	Lattice interpretation	Testable signal
Orbiting SMBH	Red-shift $\sqrt{1 - 2GM/rc^2}$	= Steep $\nabla \psi $ slows recursion	Lensed $\Delta t_{\text{lattice}} \approx 0.03 \mu\text{s}$
Photon sphere	Proper $t \rightarrow 0$	Phase winds while $ \psi $ near critical	Polarisation phase noise (EHT)
Event horizon	$t_{\infty} \rightarrow \infty$	Cell production halts; arrow freezes	Millisecond plateaus in flare light-curves
Inside horizon	Inevitable singularity	Tier order inverts; info non-return	Firewall unnecessary—decoherence acts
Near/Faster- $c$ travel	Time dilation $\gamma$	Tier hops mimic FTL	Non-Doppler phase jump in cavity test