The Triple Point Protocol: A Geometric Model of Hadronic Nuclear Packing, Geodesic Light Bending, and 5D Expansion

Author: Austin Brooks Magruder **Date:** August 2026 **Target Category:** Relativistic and Quantum Physics / Mathematical Physics

Abstract

The classical Big Bang framework introduces an unphysical gravitational singularity at $t = 0$, while standard nuclear physics models the short-range repulsive core of the nucleon-nucleon interaction as an empirical threshold without an explicit geometric origin. This paper introduces the **Triple Point Protocol**, an analog-derived theoretical framework grounded in non-Euclidean geometric continuous-field tessellations. We demonstrate that collapsing 4D mass-energy fields and subatomic hadronic systems encounter severe **geometric frustration** across aperiodic networks of branching impossible figures. This frustration halts structural collapse at strict physical boundaries: the femtometer nuclear core ($r_c \approx 0.8$ fm) and the Planck volume ($V_{min} = l_P^3$).

Governed by the **Axiom of Spatial Continuity**, the two-dimensional negative space field (S_{-2D}) reaches absolute saturation $(S_{-2D} = 0\%)$ without spatial tearing. At these saturation floors, hadronic matter undergoes chiral melting mediated by quantum anomaly interference of the$\eta' meson$, which locks the topological susceptibility (χ_T) of the vacuum and acts as a topological lubricant between packed nucleons. Denied further 4D contraction, compressed mass-energy executes a 90° orthogonal axis pivot across the Planck boundary. During this transition, photon geodesics undergo **topological light refraction** and lensing along the expanding 5D manifold contours. Mediated by **leptonic CP violation** and a phase-shifting **neutrino fluid**, the directional transition drives a continuous **5D expansion**—the physical event perceived macroscopically as cosmogenesis.

I. Foundational Core Pillars

1. **The Axiom of Spatial Continuity & Structural Frustration** Rather than modeling spacetime as a discrete or pixelated digital grid, this framework treats spacetime as an **analog continuous field**. Derived from physical drafting with compass and straightedge on continuous media, the **Axiom of Spatial Continuity** dictates that space cannot be torn, fragmented, or compressed to absolute zero volume.

   Under extreme gravitational or subatomic compression, a continuous coordinate field fractures into aperiodic tessellations featuring **branching impossible figures**. Characterized by opposing pinwheel vertices and thickened structural anchors, these geometries induce *geometric frustration* across the coordinate network. Opposing rotational vectors cancel out localized momentum, acting as a physical brake that halts infinite collapse.

$\texttt{4D collapse} \rightarrow \texttt{Planck saturation} \rightarrow 90^{\circ}\texttt{orthogonal pivot} \rightarrow \texttt{5D expansion}$

2. Independent Derivation of the Planck Saturation Floor To establish the physical threshold where negative space reaches complete saturation $(S_{-2D} = 0\%)$, the fractional vacuum coefficient (S_{-2D}) is dynamically derived as a function of energy density and boundary compression.

Let a collapsing mass-energy profile E be contained within a spatial sphere of radius r:

$$V = \frac{4}{3}\pi r^3$$

By invoking the Heisenberg Uncertainty Principle, compressing this spatial field to an ultra-microscopic radius $(\Delta x \approx r)$ forces a non-linear spike in localized momentum uncertainty $(\Delta p \geq \frac{\hbar}{2r})$, injecting zero-point kinetic pressure into the vacuum fabric. Concurrently, General Relativity dictates that compressing an energy profile E locks it behind an event horizon upon reaching its Schwarzschild radius $(r_s = \frac{2GE}{c^4})$.

Substituting the quantum zero-point energy expression $(E_{\text{quantum}} \approx \frac{\hbar c}{2r})$ directly into the Schwarzschild horizon equation isolates the physical threshold where outward quantum pressure and inward gravitational collapse lock into equilibrium$(r = r_s)$:

$$r = \frac{2G}{c^4}\left(\frac{\hbar c}{2r}\right) \implies r^2 = \frac{G\hbar}{c^3}$$

Extracting the square root independently yields the minimum radius metric, resolving directly to the Planck Length (l_P):

$$r_{min} = \sqrt{\frac{G\hbar}{c^3}} = l_P$$

Establishing this physical boundary confirms the non-zero volume floor:

$$V_{min} = l_P^3$$

Normalizing the geometric volume equation to this boundary constraint establishes the Fractional Vacuum Coefficient equation:

$$V(S_{-2D}) = (l_P)^3 + \left[V_{\texttt{initial}} - (l_P)^3\right] S_{-2D}$$

Where $S_{-2D} = 1 - \frac{\rho_E}{\rho_{max}}$. Taking the mathematical limit as negative space is entirely eliminated $(S_{-2D} \rightarrow 0)$leaves:

$$V_{min} = \lim_{S_{-2D}\rightarrow 0} V(S_{-2D}) = (l_P)^3$$

Because the coordinate canvas runs out of mathematical degrees of freedom to contract further within 4D space, the volume flatlines at this non-zero physical floor.

II. The Particle Physics & Hadronic Interference Engine

- **Hadronic Topological Susceptibility & η' Meson Anomaly:** As the 4D coordinate field contracts toward $S_{-2D} = 0\,\%$, light hadrons cannot maintain their classical bound states. The η' **meson**—a flavor-singlet quantum superposition$(\eta' \approx \frac{1}{\sqrt{3}}[u\bar{u} + d\bar{d} + s\bar{s}\,])$—acts as the primary topological mass anchor resolving the $U_A(1)$ anomaly. The topological resistance of the quantum vacuum is governed by the **Witten-Veneziano relation**:

$$m_{\eta'}^2 + m_\eta^2 - 2m_K^2 = \frac{6}{f_\pi^2}\chi_T$$

- **CP Violation as an Asymmetric Directional Constraint:** CP Violation acts as a directional geometric constraint during the 90° orthogonal axis pivot. As trapped mass-energy pivots 90° off the 4D coordinate sheet through the Planck volume boundary (∂V), it undergoes a parity transformation (P). Mirror symmetry across charge and parity is broken across the boundary, preventing mass-energy transitioning into the 5D manifold from back-propagating into the 4D collapse zone.
- **Neutrinos as the Transition Hydrodynamic Medium:** Under hyper-compression, heavy baryonic matter cannot traverse intact through the Planck-scale structural frustration zone. Heavy particles dissociate into light, highly penetrating **neutrino fields**. Possessing near-zero mass and undergoing quantum flavor oscillations, neutrinos act as the continuous, phase-shifting fluid flowing through the topological portal to seed the 5D expansion.

III. Topological Light Refraction and Geodesic Bending

During quantum collapse and subsequent 5D expansion, photon trajectories (geodesics) do not follow Euclidean straight lines. Instead, light bending occurs through three distinct topological mechanics:

1. Topological Vacuum Refraction $(n_{\text{effective}})$ As photon geodesics traverse the boundary between collapsing 4D space and the expanding 5D manifold, they encounter an extreme gradient in vacuum susceptibility (χ_T). The effective refractive index of the topological vacuum $(n_{\text{effective}})$ alters photon momentum vectors across the Planck boundary (∂V):

$$n_{\texttt{effective}} = 1 + \frac{8\pi G}{c^4}\chi_T \cdot \left(\frac{V_{\texttt{initial}}}{l_P^3}\right)$$

2. Geodesic Bending Angle Across the 90° Pivot As energy executes the 90° orthogonal pivot, photon trajectories undergo angular deflection $(\Delta\theta_{\text{light}})$ governed by the metric curvature gradient near the saturation floor:

$$\Delta\theta_{\texttt{light}} = \int_{\partial V} \frac{\nabla \chi_T}{n_{\texttt{effective}}}\, ds \approx \frac{\pi}{2}\left(1 - S_{-2D}\right)$$

At absolute saturation $(S_{-2D} = 0\%)$, light paths bend through a full 90° orthogonal arc, matching the dimensional pivot of the underlying spacetime metric.

3. Manifold Uncoiling Lensing As the 5D expansion proceeds, the evolving manifold contours induce macro-scale gravitational lensing. Light following these uncoiling geodesics bends around expanding cosmic voids, forming curved light arcs around hyper-dense cosmic web filaments.

IV. Subatomic Hadronic Packing, the Femtometer Floor, and Nuclear Structure

The **Triple Point Protocol** governs subatomic nuclear structure in parallel to macroscopic spacetime collapse, providing a geometric explanation for nuclear binding:

1. The Femtometer Saturation Floor $(r_c \approx 0.8$ **fm**$)$ In nucleon-nucleon $(N - N)$ scattering, the strong force exhibits a short-range repulsive core at inter-nucleon distances below 0.8 fm. Under this protocol, this core represents the **Subatomic Saturation Floor**. When protons and neutrons are compressed together, the inter-hadronic negative space field reaches absolute saturation $(S_{-2D} = 0\%)$. Geometric frustration across the overlapping color fields prevents nucleons from collapsing into a zero-volume point, generating the short-range repulsion observed in nuclear physics without requiring an infinite energy potential.

2. Zero Negative Space Hadronic Packing Quarks within hadrons are bound by color-charged gluons (R, G, B). At the nuclear scale, three-color symmetry $(SU(3)_c)$maps directly to the three-way vertex symmetry of the Triple Point Protocol. When nucleons pack inside an atomic nucleus, their overlapping gluon fields form an interlocking aperiodic lattice. This eliminates loose 2D negative space between nucleons, explaining why atomic nuclei exhibit uniform interior energy densities.

3. Mesons as Topological Vacuum Lubricants The exchange of virtual pions (π) and vector mesons (ρ, ω) between nucleons acts as a **topological lubricant**. Mediated by the \eta' meson's vacuum susceptibility (χ_T), meson exchange fills subatomic boundary voids, maintaining phase continuity across the nuclear volume. This enables the nucleus to exhibit both liquid-drop flow properties and crystalline shell structure.

V. Mathematical Formulation of the 5D Expansion Flux

The transition of energy from the collapsed 4D coordinate sheet onto the expanding 5D sheet is governed by an orthogonal **Flux Operator** (Φ) operating across the boundary of the Planck volume (∂V):

$$\Phi_{\texttt{Energy}} = \oint_{\partial V} \mathbf{E} \cdot d\mathbf{A}$$

Because energy conservation is preserved across the dimensional threshold, the volumetric rate of the 5D expansion $(\frac{dV_{5D}}{dt})$ is directly coupled to the incoming collapse rate on the opposite side of the boundary:

$$\frac{dV_{5D}}{dt} = \kappa \cdot \left[V_{\texttt{initial}} - (l_P^3)\right]$$

Where \kappa represents the dimensional transfer constant mediated by the CP-violating neutrino fluid tensor and conditioned by the hadronic topological susceptibility(χ_T).

VI. Macro-Cosmic Evolution Timeline

1. **Primordial 4D Macro-Collapse:** Matter on one side of a closed boundary implodes under intense gravitational load.

2. **Structural Lock at $S_{-2D} = 0\,\%$:** The collapse reaches the Planck volume floor(l_P^3). Counter-rotational branching impossible figures engage, enforcing the Axiom of Spatial Continuity and halting the singularity.
3. **Subatomic Nuclear Binding:** On microscopic scales, nucleons bind via $SU(3)_c$ color symmetry, reaching the femtometer saturation floor $(0.8$ fm$)$ to lock atomic nuclei into stable, incompressible zero-negative-space states.
4. **\eta' Topological Melting & Vacuum Susceptibility Locking:** Topological susceptibility reaches saturation (χ_T). Quantum anomaly interference induced by η' meson field coupling melts heavy hadronic matter into light leptonic constituents.
5. **The 90° CP-Violating Pivot & Light Refraction**: Denied 4D spatial clearance, trapped energy and photon geodesics execute an orthogonal 90° pivot. Light undergoes sharp topological refraction $(\Delta\theta \to \frac{\pi}{2})$.
6. **Cosmogenesis (5D Expansion):** Energy transitions through the topological portal as a phase-shifting neutrino fluid, driving a continuous 5D expansion.

7. **Chiral Meson Uncoiling & Void Formation:** As hyper-dense energy expands outward, it uncoils from tight string-folds. Light paths bend around expanding triangular cosmic voids.
8. **Cosmic Web Filament Locking:** Expanding 5D domains collide, squeezing negative space to zero along their boundaries and freezing into the permanent crystalline tracks of the Cosmic Web.

VII. Hypotheses for Empirical Testing

- **Subatomic Hard-Core Repulsion Invariance:** High-energy nucleon-nucleon scattering at ultra-relativistic speeds (such as at RHIC or CERN) will confirm that the 0.8 fm repulsive core radius remains an immutable geometric boundary invariant under extreme pressure.
- **Singularity Cutoff in CMB Data:** Cosmic Microwave Background analysis will reveal an absolute lower-bound cutoff in primordial temperature fluctuations, confirming space never contracted past a non-zero Planck volume floor (l_P^3).
- **Topological Vacuum Refraction Cutoff:** High-energy photon beam scattering at Planck-scale energies will exhibit a non-linear refractive deflection matching the predicted $n_{\text{effective}}$ limit.
- **Topological Vacuum Residue in QGP**: High-energy heavy-ion collisions forcing chiral meson melting inside a Quark-Gluon Plasma will exhibit an uncollapsable topological vacuum residue corresponding directly to the η' Witten-Veneziano susceptibility limit (χ_T).
- **Orthogonal Gravitational Wave Polarization:** Deep-space detection of primordial gravitational waves will exhibit distinct $90°$ polarization offsets, confirming a multi-axis dimensional pivot at cosmogenesis.

References

[1] Penrose, R. (1965). "Gravitational Collapse and Space-Time Singularities." *Physical Review Letters*, 14(3), 57-59.

[2] Penrose, R. (1974). "The Role of Aesthetics in Pure and Applied Mathematical Research." *Bulletin of the Institute of Mathematics and its Applications*, 10, 266-271.

[3] Jastrow, R. (1951). "Many-Body Problem with Hard-Core Forces." *Physical Review*, 81(1), 165.

[4] Machleidt, R. (1989). "The meson theory of nuclear forces and nuclear structure." *Advances in Nuclear Physics*, 19, 189-376.

[5] 't Hooft, G. (1976). "Computation of the Quantum-Effects Due to a Four-Dimensional Pseudoparticle." *Physical Review D*, 14(12), 3432.

[6] Witten, E. (1979). "Current Algebra Theorems for the U(1) 'Goldstone' Boson." *Nuclear Physics B*, 156(2), 269-283.

[7] Veneziano, G. (1979). "U(1) without instantons." *Nuclear Physics B*, 159(1-2), 213-224.

[8] Christenson, J. H., Cronin, J. W., Fitch, V. L., & Turlay, R. (1964). "Evidence for the 2pi Decay of the K0_2 Meson." *Physical Review Letters*, 13(4), 138.

[9] Fukuda, Y., et al. (Super-Kamiokande Collaboration). (1998). "Evidence for Oscillation of Atmospheric Neutrinos." *Physical Review Letters*, 81(8), 1562.

[10] Randall, L., & Sundrum, R. (1999). "An Alternative to Compactification." *Physical Review Letters*, 83(23), 4690-4693.

[11] Shuryak, E. V. (1993). "Which mesons should melt in the quark-gluon plasma?" *Physical Review D*, 47(11), 5116.

[12] Bond, J. R., Kofman, L., & Pogosyan, D. (1996). "How filaments of the cosmic web are woven." *Nature*, 380(6575), 603-606.