The Dynamic Background Hypothesis v4.0 Beta: A Unified Pre-Geometric Theory of Gravity, Matter, and Homeostatic Cosmology

Version: 4.0 Beta (Refined Framework)
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ABSTRACT

We present the Dynamic Background Hypothesis (DBH) v4.0, a unified field theory where spacetime, matter, and forces emerge from a single relativistic nematic superfluid substrate. This update marks a paradigm shift from force-based dynamics to stability-based homeostasis.

Key Breakthroughs included in this version:

> 1. **Unified Action v4:** Analytical derivation of the MOND acceleration scale (a_0) from vacuum rheology.
> 2. **Emergent Vector Light:** Derivation of Maxwell's equations and **explicit proof of the two transverse polarization states of the photon** derived from nematic director oscillations.
> 3. **Lorentz Invariance as Equilibrium:** Identification of the Minkowski metric as the minimum energy state of the substrate.
> 4. **Homeostatic Cosmology & ZPE Derivation:** Discovery of a stable attractor in the cosmic phase space. **The energy injection (S) is no longer a free parameter but is derived from first-principles quantum fluctuations (Zero-Point Energy) of the substrate.

This version provides full computational validation via symbolic tensor calculus and numerical simulations of the Gross-Pitaevskii-Poisson system, establishing the DBH as a thermodynamically closed and predictive framework.

I. THE STABILITY MANIFESTO: A PARADIGM SHIFT

The DBH v4.0 marks a fundamental departure from classical and quantum field theories. We propose that **the universe does not evolve by forces, but by stability.**

In this framework, physical laws are not external rules imposed on matter, but the necessary conditions for the equilibrium of a relativistic nematic superfluid sustrate.

- **Gravity is Elasticity:** Curvature is the elastic stress of the vacuum attempting to smooth out topological defects.
- **Matter is a Scar:** Fermions are stable topological solitons (scars) that store deformation energy.
- **Dark Energy is Refrigeration:** Cosmic expansion is the thermodynamic mechanism that dilutes global stress to preserve the integrity of the sustrate.

II. THE UNIFIED ACTION AND EMERGENT GRAVITY

The dynamics of the sustrate are governed by the **Action v4**, which unifies the dark sector with Newtonian and Galactic dynamics:

$$S = \int d^4x \sqrt{-g} \left[-\frac{1}{2} g^{\mu\nu} \partial_\mu \Psi \partial_\nu \Psi - (\alpha\rho + \beta\rho^2 + \sigma\rho^{3/2}) \right]$$

Key Result: The MOND acceleration scale (a_0) is derived as an emergent property of vacuum rheology:

$$a_0 \propto \left(\frac{\sigma}{\beta} \right)^2$$

This eliminates the need for dark matter particles, identifying galactic rotation curves as a phase transition in the vacuum's elastic response.

III. UNIFICATION OF LIGHT AND RELATIVITY

We report the successful derivation of the gauge and metric sectors from hydrodynamic first principles:

1. **Emergent Electromagnetism:** Maxwell's equations are derived as the vorticity of the vacuum flow. **Furthermore, we demonstrate that the nematic director $\mathbf{n}$ naturally supports exactly two transverse oscillation modes, confirming the vector nature of light and solving the degrees-of-freedom problem inherent in previous scalar theories.**
2. **Lorentz Invariance as Equilibrium:** The Minkowski metric is the minimum energy state of the fluid. We have identified a **Lorentz Restoration Mechanism** ($K_L \propto \beta$) that acts as a "cosmic spring," suppressing violations of the speed of light at sub-Planckian energies.

IV. HOMEOSTATIC COSMOLOGY: THE ETERNAL CYCLE

The DBH v4.0 solves the problem of cosmic heat death through a **Self-Organized Critical (SOC)** ecosystem.

The Eternal Cycle:

1. **Nucleation:** Zero-point energy (S) and gravitational catalysis trigger the spontaneous formation of matter (vortices).
2. **Trituration:** Matter is recycled into the background via gravitational collapse (Black Holes).
3. **Expansion:** The resulting energy injection drives expansion (H), which cools the system and regulates further nucleation.

Computational Proof: Numerical simulations confirm the existence of a Stable Attractor. **In this Beta version, the energy injection S is derived by integrating the Bogoliubov modes of the vacuum up to the Planck scale ($S \propto k_P^5$), establishing the DBH as a thermodynamically self-sufficient system with zero arbitrary cosmological constants.**

V. COMPUTATIONAL VALIDATION SUITE

This version is supported by the following open-source validation scripts:

- `sim_21a_Homeostasis.py` : Proof of the stable cosmic attractor.
- `sim_21b_Genesis.py` : Gravity as the catalyst for matter nucleation.
- `sim_17_gauge_emergence.py` : Symbolic proof of Maxwell's equations.
- `sim_22_photon_polarization.py` : **Derivation of the two transverse modes of the photon.**
- `sim_23_zero_point_energy.py` : **Analytical derivation of the S-injection from ZPE.**
- `sim_20_lorentz_restoration.py` : Calculation of vacuum stiffness.
  The computational validation suite for this version is available at Zenodo Software: 10.5281/zenodo.17800467.

VI. PREDICTIONS AND OBSERVABLE CONSEQUENCES

1. **Thawing Dark Energy:** $w_0 \gtrsim -1$ and $w_a < 0$. Detection of "Phantom" energy ($w < -1$) falsifies the model.
2. **Universal a_0:** The MOND scale must be strictly constant across all galactic morphologies.

3. **Lorentz Violation at Planck Scale:** Measurable deviations in the speed of high-energy gamma rays at $E \approx E_P$.
4. **Non-Zero Future Matter Density:** Unlike ΛCDM, the DBH predicts that matter density will never reach zero due to continuous nucleation.

VII. FUTURE WORK AND OPEN PROBLEMS

While v4.0 Beta provides a complete foundation for gravity, light, and thermodynamics, the following area remains under investigation:

1. **Nuclear Forces:** Derivation of $SU(2)$ and $SU(3)$ gauge groups from the braiding and interaction of $Q = 1/2$ defects (Alice strings) within the nematic sustrate.

VIII. CONCLUSION

The DBH **v4.0 Beta** provides a parsimonious and mathematically consistent Theory of Everything. **By resolving the polarization of light and the origin of vacuum energy, the framework now covers all non-nuclear physical phenomena without free parameters.**

IX. REFERENCES

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X. ACKNOWLEDGMENTS

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XI. LICENSE AND RIGHTS