A Causal Mechanical Framework for Space-Time

Resolving Cosmic Anisotropy and the Hubble Tension through Fluid Dynamics

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Abstract

This paper introduces a Causal Mechanical framework for cosmology that replaces metric-dependent space-time abstractions with a physically grounded fluid-dynamic model. The universe is treated as a compressible gravitational medium ("the Sea") shaped by turbulence in the Stochastic Gravitational Wave Background. Within this framework, cosmic expansion, void anisotropy, and black hole energetics emerge from pressure-driven mechanical interactions rather than geometric curvature. This approach eliminates the need for dark energy and reinterprets the Hubble Tension as a local pressure-gradient artefact arising from Earth's position inside a low-density rebound zone. The model yields testable predictions based on void geometry, gravitational-wave interference patterns, and large-scale flow fields.

Introduction

Contemporary cosmology relies on metric-based interpretations of space-time, where gravitational behaviour is encoded in geometric curvature. While mathematically powerful, this approach has led to a growing dependence on unobserved entities such as dark energy and has produced persistent tensions in key measurements, most notably the Hubble constant discrepancy.

This paper proposes a return to mechanical first principles. Instead of treating space-time as an abstract four-dimensional manifold, the universe is modelled as a compressible, dynamic medium permeated by a Stochastic Gravitational Wave Background. In this view, curvature, inertia, and cosmic structure arise from fluid-like pressure interactions within this gravitational "Sea."

By reframing cosmology in causal-mechanical terms, several long-standing anomalies become natural consequences of the medium's behaviour. Black holes act as pressure-regulating feedback valves, cosmic voids preserve the geometry of primordial wavefronts, and the Hubble Tension emerges as a local pressure rebound rather than a universal acceleration.

The following sections outline the core components of this framework, pairing scholarly explanations with simplified mechanical analogies to maintain clarity and accessibility.

I. The Stochastic Gravitational Background (The "Universal Soup")

Scholarly Insight: Space-time is modelled as a compressible superfluid permeated by a Stochastic Gravitational Wave Background (SGWB). This medium provides the mechanical substrate through which curvature, inertia, and large-scale structure emerge.

Simple Logic: Space isn't empty. It's a liquid-like sea filled with constant ripples. Gravity is the water — everywhere, unblocked, and always in motion.

II. Timeless Causal Interaction

Scholarly Insight: Time is treated not as a fundamental dimension but as an emergent relational operator. Physical evolution is governed by Causal Constraints — the sequential unfolding of interactions within the gravitational medium.

Simple Logic: Clocks don't run the universe. Cause and effect does. One interaction leads to the next inside the gravitational sea.

III. Singularities as Homeostatic Feedback Valves

Scholarly Insight: Black holes function as negative-feedback regulators within the cosmic fluid engine. They relieve gravitational overpressure by redistributing mechanical energy through relativistic jets and gravitational-wave emission.

Simple Logic: Black holes are safety valves. When gravity piles up too much, they spin and release energy back into the sea so the engine stays balanced.

IV. Geometric Forensics of Voids

Scholarly Insight: The axial anisotropy of cosmic voids encodes fossilised wavefront geometry. Their stretched shapes record the convergence and interference patterns of primordial gravitational waves.

Simple Logic: Voids aren't empty gaps. They're footprints of giant waves. Their shapes tell us how many waves met there and pushed matter aside.

V. The Hubble Tension: A Local Pressure Rebound

Scholarly Insight: The Hubble constant discrepancy arises from our position inside a low-density rebound zone. Matter is accelerating toward surrounding high-pressure filament walls, creating an apparent local expansion rate higher than the cosmic mean.

Simple Logic: Nearby galaxies look like they're racing away because we're sitting in a low-pressure pocket. Everything is flowing toward the denser edges of our local sea. It's not a mystery of time — it's a local surge.

VI. Predictions and Testable Consequences

A causal-mechanical cosmology must produce measurable signatures that differ from metric-based interpretations. The following predictions arise naturally from the fluid-dynamic framework and can be evaluated using existing or near-future observational tools.

1. Void Anisotropy as Wavefront Fossils

Scholarly Insight: If cosmic voids are shaped by interference patterns in the SGWB, their axial ratios should correlate with the predicted geometry of convergent wavefronts. Voids along the same large-scale flow lines should show aligned elongation vectors.

Simple Logic: If voids are footprints of giant waves, voids pushed by the same waves should stretch in the same direction.

2. Local Hubble Variation as a Pressure Gradient

Scholarly Insight: The Hubble constant should vary smoothly with position inside a rebound zone. Observers nearer filament walls should measure a lower H_0, while those deeper in the centre should measure a higher H_0.

Simple Logic: If we're in a low-pressure pocket, people in different parts of the pocket should see slightly different "speeds" of expansion.

3. Black Hole Jet Power Scaling with Local Overpressure

Scholarly Insight: If black holes regulate pressure, jet power and gravitational-wave output should correlate with local density gradients.

Simple Logic: If black holes are safety valves, the "burps" should be stronger where the pressure is higher.

4. Gravitational Wave Turbulence Spectrum

Scholarly Insight: A fluid-like SGWB should show turbulence patterns similar to Kolmogorov scaling.

Simple Logic: If the universe is a sea, its waves should follow patterns — not random noise.

5. Large-Scale Flow Fields

Scholarly Insight: Matter should drift along pressure gradients, producing bulk flows larger than ΛCDM predicts.

Simple Logic: If the sea has currents, galaxies should drift with them.

VII. Conclusion

This paper presents a Causal Mechanical framework that reinterprets space-time as a dynamic, compressible gravitational medium rather than a static geometric manifold. By grounding cosmology in fluid dynamics and causal interaction, several long-standing anomalies become natural consequences of the medium's behaviour.

- The SGWB provides the substrate for curvature and structure.
- Time emerges from sequential causation rather than existing as a fundamental dimension.
- Black holes act as homeostatic regulators.
- Cosmic voids preserve the geometry of primordial wavefronts.
- The Hubble Tension arises from local pressure gradients, not universal acceleration.

This approach removes the need for dark energy and replaces abstract metric expansion with a physically intuitive mechanism: pressure-driven flow in a gravitational sea. The predictions outlined above offer clear paths for empirical evaluation.

Author's Note

The author used Large Language Model (LLM) assistance for structural organization, linguistic refinement, and translation of concepts into scholarly terminology. All core theoretical ideas, mechanical analogies, and observational interpretations presented in this paper are entirely the author's original work.

Personal Reflection

We must confront the blatant fact that every single thing in existence resides within a literal sea of gravity. It touches all, affects all, and can be stopped by nothing. We have overlooked the profound simplicity of its nature by ignoring the most perfect analogue available to us: our own oceans.

The application of fluid dynamics is a natural and intuitive fit for the gravitational medium we inhabit. Our local cosmic void, for example, exhibits the geometric consequences of converging and rebounding gravitational waves. Its elongated shape is not a mystery of abstract mathematics or "time"; it is a physical record of a "master wave" interaction — a natural rebound process we observe in every fluid on Earth.

Tides, eddies, currents, and energy-giving whirlpools are the vocabulary of the universe. This model was reached not through complex equations, but through a deliberate step back to basic observable facts. The reality that someone outside formal academia, with no traditional scientific training, can independently identify these universal mechanics should highlight the urgency of our situation: we must return to the fundamentals of cause and effect if we are to truly understand the engine of reality.