Gravitational Charge Conjugation and the Large-Scale Structure of the Universe

A Speculative Conjecture

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Abstract

This paper presents a speculative but internally consistent conjecture proposing that matter and antimatter carry opposite gravitational charge — analogous to opposite electric charge in electromagnetism — and that this asymmetry is the foundational mechanism behind cosmic expansion, the matter-antimatter asymmetry observed in the universe, the large-scale structure of the cosmic web, and phenomena currently attributed to dark matter and dark energy. The framework further proposes that the cosmic web represents a higher-scale periodic structure, built by gravitational interaction in the same way atomic structure is built by electromagnetic interaction, forming a nested hierarchy of force-mediated structure across scales. Several testable predictions are identified. This work is presented as a thought experiment and conjecture, not as a complete or mathematically formalized theory.

1. Introduction

Modern cosmology rests on several foundational assumptions that remain experimentally under-tested at large scales. Among these is the assumption that antimatter responds to gravity identically to matter — that is, that the stress-energy tensor of antimatter contributes positively to spacetime curvature in the same manner as matter. This assumption is baked into the Einstein field equations by convention, and while consistent with all local experiments conducted to date, it has never been directly tested at cosmological scales or in antimatter-dominated gravitational environments.

This paper asks: what if antimatter bends spacetime in the opposite sense to matter? What if, rather than a scalar gravitational charge (mass-energy always positive), there exists a gravitational charge conjugation symmetry, where matter curves spacetime one way and antimatter curves it the other?

The implications of this single assumption, if true, cascade naturally into explanations for several of the most persistent open problems in modern physics, including the matter-antimatter asymmetry, the origin and nature of dark energy, the structure of the cosmic web, the nature of cosmic voids, and the hierarchy of structural scales in the universe.

The author is not a professional physicist. This conjecture arose from careful reasoning from known physics, guided by analogy and internal logical consistency. It is presented in the spirit of open inquiry, with identified testable predictions and honest acknowledgment of where it conflicts with current assumptions.

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2. Existing Physics This Conjecture Builds On

This conjecture is not constructed from nothing. It builds on and extends several areas of established or actively researched physics:

Gravitoelectromagnetism (GEM): General Relativity already predicts that rotating mass drags spacetime — the Lense-Thirring effect. The full GEM formalism describes gravitational analogs to both electric and magnetic fields, with equations structurally identical to Maxwell's equations. The conjecture extends this analogy to include a gravitational analog of charge conjugation.

Force hierarchy and symmetry breaking: The standard cosmological timeline describes forces separating from a unified state at different moments after the Big Bang, beginning at the Planck time (~10^-43 seconds) with gravity, followed by the strong force (~10^-36 seconds), and the electroweak force (~10^-12 seconds). This conjecture treats the Planck-era separation of gravity as the critical window in which gravitational charge asymmetry acts on matter and antimatter before annihilation can complete.

The open question of antimatter gravity: Until 2023, no direct measurement of antimatter in a gravitational field had been performed. The ALPHA-g experiment at CERN measured antihydrogen falling downward in Earth's gravitational field — consistent with normal gravitational attraction. However, this experiment measured how antimatter responds to a matter-dominated gravitational field, not how antimatter curves spacetime itself. These are distinct questions, and the latter remains experimentally untested.

The cosmological constant and dark energy: The accelerating expansion of the universe is currently modeled using a cosmological constant (Lambda) whose physical origin is unknown. This conjecture proposes a mechanism that naturally produces a persistent, large-scale repulsive effect — a candidate physical basis for what is currently treated as a mathematical parameter.

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3. The Core Conjecture

3.1 Gravitational Charge Conjugation

The central proposal is that matter and antimatter carry opposite gravitational charge. Just as opposite electric charges attract and like charges repel, the conjecture proposes:

- Matter-matter: gravitational attraction (consistent with all observation)
- Antimatter-antimatter: gravitational attraction (internally consistent, untested)

- Matter-antimatter: gravitational repulsion (the new claim; untested at cosmological scales)

This is analogous to the electromagnetic force, where the sign of the charge determines the direction of the interaction. Under this framework, mass-energy is not a purely positive scalar gravitational source, but carries a sign determined by whether it is matter or antimatter.

Electromagnetic Force	**Proposed Gravitational Force (this conjecture)**
Electric charge: positive or negative	Gravitational charge: matter or antimatter
Like charges repel	Matter-antimatter repels
Unlike charges attract	Matter-matter and antimatter-antimatter attract
Photon is spin-1 carrier	Graviton is spin-2 carrier (predicted)
E and B fields are linked	Gravity and spin-momentum fields are linked (proposed)

3.2 The Gravity-Spin Linkage

The conjecture further proposes that gravity and a spin-momentum field are linked as a field pair, analogous to the electric and magnetic fields of electromagnetism. This is not without precedent: frame-dragging in GR already demonstrates that rotating mass generates a gravitomagnetic effect. The conjecture extends this into a full structural pairing, where the spin-momentum field plays the role of the magnetic analog in gravitational interactions, and the linked field pair governs large-scale structure formation in the same way the electromagnetic field pair governs atomic-scale structure.

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4. Cosmological Implications

4.1 The Matter-Antimatter Asymmetry

The observed universe contains approximately one extra matter particle per billion matter-antimatter pairs produced in the early universe. Standard models invoke CP violation to explain this asymmetry but have not identified a mechanism of sufficient magnitude.

Under this conjecture, no net asymmetry in production is required. At Planck-era densities (~10^-43 seconds), gravitational repulsion between matter and antimatter domains acts before the electroweak force has separated and before annihilation can complete. Matter and antimatter are driven apart by gravitational repulsion during the window between gravity separating from the unified force and the strong force separating (~10^-36 seconds).

The observed 1-in-a-billion excess is then simply the boundary residue — matter and antimatter that occupied the same spatial regions at the moment of separation and could not be fully driven apart before annihilation occurred. The bulk of matter and antimatter separated cleanly; only the boundary zones left residual asymmetry.

This mechanism requires no new particles and no fine-tuning of CP violation magnitude. The asymmetry is geometric, not intrinsic.

4.2 The Origin and Nature of Dark Energy

The accelerating expansion of the universe is one of the most significant unexplained observations in modern cosmology. Under the standard model, it is attributed to a cosmological constant whose physical origin is unknown.

Under this conjecture, the ongoing repulsion between spatially separated matter and antimatter regions provides a natural, physical mechanism for persistent cosmic expansion. At Planck-era densities, this repulsion was overwhelming, driving the initial separation. As the universe expanded and distances between matter and antimatter regions increased, the repulsive force weakened according to the inverse square law — but never reached zero. The result is a persistent, low-level repulsive pressure between matter and antimatter domains at cosmological scales.

This naturally produces the observed behavior of dark energy: not a violent force at local scales, but a gentle, persistent acceleration of expansion at the largest scales. Crucially, this mechanism also explains why the expansion is accelerating — as structures within matter-dominated regions collapse under their own gravity, the matter-antimatter boundary regions increasingly dominate the dynamics of expansion.

4.3 The Cosmic Web and Dark Matter

The large-scale structure of the universe — the cosmic web of galaxy filaments surrounding enormous voids — is typically explained through gravitational collapse of matter around density fluctuations in the early universe. However, the origin of those density fluctuations and the specific topology of the web require the introduction of dark matter to match observations.

Under this conjecture, the topology of the cosmic web is a direct consequence of matter-antimatter separation:

- Filaments and galaxy clusters are matter-dominated regions, where matter gravity curves spacetime inward, drawing more matter together and focusing light along the filaments.
- Voids are antimatter-dominated regions. Because antimatter curves spacetime in the opposite sense under this conjecture, light passing near a void is deflected away from the void rather than toward it — a negative gravitational lensing signature.

- What is currently attributed to dark matter — the additional gravitational effect needed to explain galaxy rotation curves and large-scale structure — may be partially or fully explained by the gravitational influence of nearby antimatter regions acting repulsively on matter structures, effectively shaping galactic dynamics without being directly detectable.

This is consistent with the observation that dark matter effects appear most prominently at the boundaries between high-density and low-density regions of the cosmic web.

4.4 Inflation as a Natural Consequence

Standard inflationary cosmology requires the introduction of an inflaton field — a hypothetical scalar field with no independent experimental support — to explain the rapid expansion of the early universe. Under this conjecture, the Planck-era gravitational repulsion between matter and antimatter provides a natural inflation mechanism. The energy scale and duration of this repulsion are consistent with the inflationary window, potentially replacing the inflaton field with a mechanism derived directly from the gravitational charge asymmetry.

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5. The Nested Scale Hierarchy

5.1 Force Pairs and Structural Scales

The conjecture proposes that the known forces organize into pairs that build structure at nested scales. Each pair consists of a binding force and a structuring force — analogous to the electric and magnetic components of electromagnetism — and each pair operates at a characteristic scale determined by the range and strength of the force carrier:

Scale	Force Pair	Structure Built
Nuclear	Strong / Weak	Atomic nuclei (cores)
Chemical / Biological	Electromagnetic / Weak	Atoms, molecules, chemistry
Cosmic	Gravity / Spin-Gravity (proposed)	Galaxies, cosmic web

Each level of structure is composed of the bound states of the level below, organized by a weaker and longer-range force pair. The termination of this hierarchy at the cosmic scale is not arbitrary — it follows necessarily from the fact that gravity is the weakest known force and operates at the longest range. A fourth structural scale would require the discovery of a force weaker than gravity operating at scales larger than the observable universe, which would be indistinguishable from a description of the observable universe as a particle in a larger structure.

5.2 The Cosmic Periodic Table

If the cosmic scale is structurally analogous to the atomic scale, with black holes as nuclei and stars as electrons, then galaxy types represent something analogous to atomic species — defined by the mass of the central black hole (analogous to atomic number), the number and configuration of stellar populations, and the stable orbital configurations available. Under this analogy:

Atomic Scale	Cosmic Scale (proposed analogy)
Nucleus	Black hole
Electrons	Stars
Electron orbitals (quantized)	Stellar orbital configurations (possibly quantized)
Atom	Galaxy
Molecule	Galaxy cluster / filament node
Chemical bond	Filament between galaxy clusters
Chemistry	Large-scale structure interaction
Matter atom	Matter-dominated galaxy
Antimatter atom	Antimatter-dominated void region
Periodic table	Cosmic web topology

5.3 A Pauli-Like Exclusion at Cosmic Scale

Pauli exclusion in quantum mechanics is not a force but a consequence of quantum statistics — fermions are antisymmetric under exchange, preventing two particles from occupying the same quantum state. This produces the shell structure of atoms and makes matter rigid.

At cosmic scale, this conjecture proposes an analogous exclusion mechanism arising not from quantum statistics but from geometry: antimatter-dominated voids act as gravitationally repulsive regions that prevent matter-dominated structures from merging freely. The topology of the cosmic web is not random collapse but a stable configuration enforced by the mutual repulsion of matter and antimatter domains — a geometric exclusion principle.

A specific prediction follows: there should be a maximum void size beyond which the antimatter region becomes self-gravitating and begins to develop internal structure. Observations of the cosmic web do suggest a characteristic maximum void scale of approximately 300-400 megaparsecs, which is not fully explained by standard cosmology.

6. The Observer Location Problem

Every observation we have ever made of the universe has been made from inside a matter-dominated region. This is not a coincidence — it is a selection effect. Matter and antimatter annihilate on contact. Any observer, by definition, exists within a region where one type dominates. We cannot observe from a void. We cannot instrument an antimatter-dominated region. We are, structurally and unavoidably, local.

This has a profound consequence for our cosmological models. Every instrument we have built, every inference we have drawn, every parameter we have fitted has been calibrated against observations made from inside one charge of a large-scale gravitational dipole. Our models are not universal descriptions of the cosmos — they are locally-calibrated descriptions of what the cosmos looks like from inside a matter-dominated filament of the cosmic web.

When those locally-calibrated models are applied universally — extended to the voids, to the boundaries, to the full topology of the web — they produce residuals. Unexplained gravitational effects that don't match visible matter. A persistent large-scale repulsion with no identified source. These residuals are currently interpreted as evidence for new undiscovered components: dark matter and dark energy.

This conjecture proposes a more cautious interpretation: before concluding that these residuals require new undiscovered physics, we should ask whether they are artifacts of assuming universal applicability of locally-calibrated models. Specifically, the gravitational charge asymmetry proposed in this conjecture provides a candidate physical mechanism for both effects — dark matter as the gravitational influence of nearby antimatter-dominated regions acting on matter structures across boundaries, and dark energy as the large-scale repulsion between matter and antimatter domains weakening via the inverse square law but never reaching zero.

Under this framework, dark matter and dark energy are not fictional. The observations that motivate them are real and the measurements are correct. What is incomplete is the explanation — because the standard model assumes all gravitational influence originates from matter, and therefore cannot account for the gravitational charge asymmetry of antimatter-dominated regions shaping matter-dominated ones from across the boundaries of the cosmic web.

This is offered not as a proof but as a caution: the observer location problem is a systematic bias built into every cosmological measurement ever made. Any complete theory of the universe must account for it. The current standard model does not explicitly do so.

7. Negative Mass Behavior as an Emergent Relational Property

One of the first technical objections a physicist will raise in response to this conjecture is its relationship to negative mass — a hypothetical property that has been proposed in various contexts in theoretical physics and that carries significant conceptual baggage. This section addresses that relationship directly and argues that the conjecture offers something more physically satisfying than negative mass theory itself.

7.1 What Negative Mass Theory Proposes

Negative mass is a hypothetical in which an object carries mass with a negative sign. The consequences are immediately strange: a negative mass object pushed forward accelerates backward. A positive and negative mass object of equal magnitude placed near each other produce a runaway solution — the positive mass chases the negative mass, and the negative mass flees, both accelerating indefinitely without any external energy input. This violates conservation of momentum in ways that make most physicists deeply uncomfortable. Negative mass objects have been invoked as mathematical devices to stabilize wormholes, explain certain exotic solutions to the GR field equations, and occasionally to model dark energy — but always as a placeholder, not as a physical mechanism with an identified source.

7.2 What This Conjecture Proposes Instead

This conjecture does not propose that antimatter has negative mass in the sense described above. The distinction is precise and important. Negative mass is a property of an object — it changes how that object responds to forces, inverting its inertia. What this conjecture proposes is that antimatter carries opposite gravitational charge — meaning it changes how antimatter sources the gravitational field, what it does to spacetime around it, not how it responds to being pushed.

The analogy to electromagnetism is exact. An electron does not have negative mass. It has negative electric charge. It still has positive inertia — it resists acceleration normally. But it sources the electromagnetic field with opposite sign to a proton, producing attraction between them and repulsion between two electrons. The negativity is in how the object generates the field, not in how the object responds to forces.

This conjecture proposes the gravitational analog: antimatter has positive inertial mass — it resists acceleration normally, consistent with the ALPHA-g experimental result where antihydrogen followed normal geodesics in Earth's gravitational field — but it sources the gravitational field with opposite sign to matter. The equivalence principle, which requires inertial and gravitational mass to be equal, is well tested for matter. For antimatter sourcing its own gravitational field at cosmological scales, it remains untested.

7.3 Negative Mass Behavior as Emergent

The important consequence of this distinction is that the conjecture produces all of the observational signatures associated with negative mass — without any of the theoretical problems. From the perspective of an observer inside a matter-dominated region watching the boundary with an antimatter-dominated void, the void behaves exactly as a region of negative mass would: it pushes back, it drives expansion, it deflects light away, it refuses to gravitationally collapse toward matter. The apparent negative mass behavior is real and measurable.

But it is not a property of any object. It is a property of the relationship between two populations — matter and antimatter — each carrying positive inertial mass and opposite gravitational charge. The negativity is relational, not intrinsic. It emerges at the boundary between domains, not within either domain independently.

This resolves the runaway problem entirely. Within a matter-dominated region, matter attracts matter normally — no runaway. Within an antimatter-dominated void, antimatter attracts antimatter normally — no runaway. The repulsion only appears at the boundary between domains, and that repulsion is symmetric and stable — both populations are pushed away from the boundary equally, which is precisely the large-scale expansion behavior this conjecture proposes as the physical mechanism behind dark energy.

7.4 Replacing a Placeholder with a Mechanism

Every context in which negative mass has been invoked as a hypothetical — exotic field stabilization, dark energy modeling, repulsive cosmological behavior — this conjecture potentially replaces with a physical mechanism. Not an object with a minus sign attached, but a boundary condition between matter and antimatter domains producing the same observable effects through gravitational charge asymmetry.

This is a stronger result than negative mass theory achieves on its own terms. Negative mass theory describes a behavior and attaches it to an object. This conjecture explains why that behavior exists in the universe, where it comes from, and what produces it — without requiring any object to have negative inertial mass or to violate momentum conservation.

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8. Scale-Plane Bleed-Through and Anomalous Events

The nested scale hierarchy proposed in Section 5 carries an implicit prediction that has not yet been stated explicitly: if physical structure exists at a scale above ours, organized by gravitational charge chemistry in the way our scale is organized by electromagnetic chemistry, then physical processes at that higher scale will produce signatures at ours.

These signatures would not arrive as information or signals. They would arrive as environment — background conditions whose origin is inaccessible from our scale in the same way that the atomic structure of water is inaccessible to a creature whose entire existence occurs at the fluid dynamics scale. The higher scale process does not communicate with the lower scale. It simply occurs, and its occurrence has physical consequences that propagate downward through the nested hierarchy.

A rock rolling down a hill at the higher scale. A chemical bond forming between galaxy cluster equivalents. A phase transition in the large scale gravitational chemistry. Each of these would appear at our scale as an anomalous high energy transient event — a burst of energy arriving from a cosmological distance, not matching the spectral signature of any known stellar process, apparently originating from a filament node or void boundary in the cosmic web.

This framework therefore predicts that anomalous high energy transient events — including subsets of gamma ray bursts and fast radio bursts whose origins remain unexplained by standard astrophysical models — should form a systematic category rather than a collection of random unexplained outliers. Their existence as a category is predicted. Their specific nature is not yet predictable, because the mathematics of gravitational charge chemistry has not been formalized.

However, a two-stage prediction follows naturally. At the current level of formalization, the qualitative prediction is that anomalous transient events should show non-random spatial correlation with cosmic web filament nodes and void boundaries — the regions where higher-scale gravitational chemistry would be most active — at rates exceeding what standard astrophysical models predict. This is testable against existing gamma ray burst and fast radio burst catalogs cross-referenced with cosmic web maps.

At a future level of formalization, once the field equations of gravitational charge asymmetry are developed, quantitative predictions should become derivable — specific energy ranges, spatial distributions, and potentially timing patterns corresponding to characteristic processes in the higher-scale chemistry. This mirrors the development of General Relativity, which predicted gravitational waves qualitatively decades before the mathematical formalization was precise enough to enable their detection.

This section is explicitly speculative even within the context of this conjecture. It is included because it follows structurally from the nested scale framework and because it identifies a category of existing unexplained observations that the framework predicts should exist — which is a meaningful, if preliminary, point of contact between the conjecture and empirical data.

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9. Randomness as Resolution Limit — A Suspicion

This section presents not a prediction but a suspicion — an observation that the nested scale framework raises without resolving, and that the author believes is worth stating carefully.

Quantum mechanics describes a world in which certain outcomes are irreducibly random. The position of a particle before measurement, the moment of radioactive decay, the path a photon takes through a double slit — these are not merely unknown but, according to the standard interpretation, unknowable in principle. The randomness is held to be ontological: a fundamental feature of reality, not a gap in our knowledge.

Einstein resisted this conclusion for the entirety of his career. His objection — that God does not play dice — is often characterized as the intuition of a brilliant physicist who could not accept the new framework. But the intuition was precise: an ordered universe that appears random to us is a statement about us, not about the universe. Einstein lacked a structural reason drawn from the architecture of reality itself to support this intuition. He had only the intuition.

The nested scale framework offers a structural basis for the same suspicion. If physical organization exists at a scale below ours — as it demonstrably does, down through chemistry, atomic physics, nuclear physics, and into the domain of quantum mechanics — then what appears random at any given scale may be deterministic complexity from the scale below, seen through insufficient resolution.

Consider the gedanken experiment: beings organized at the cosmic scale, probing their equivalent of particles — galaxy clusters, filament nodes, void boundaries. The outcomes of their experiments would appear random to them in the same way quantum outcomes appear random to us. But from our perspective, those outcomes are the aggregate behavior of hundreds of billions of galaxies each containing hundreds of billions of stars, each following deterministic physical laws. Not random. Unresolvably complex.

The inversion applies equally. What we experience as quantum randomness — the irreducible probabilistic behavior of particles — may be deterministic events in a scale domain below our resolution limit. Not truly random. Unresolvably complex from our position in the hierarchy.

This does not prove that quantum randomness is epistemic rather than ontological. The mathematical formalism of quantum mechanics is consistent with either interpretation, and no experiment has yet been devised that could distinguish between them. What the nested scale framework contributes is a structural reason — derived from the architecture of the universe rather than from philosophical preference — why the epistemic interpretation deserves to be taken seriously.

The question of whether reality is truly random at its foundation, or whether randomness is always the signature of unresolved complexity from a scale below, may be permanently unanswerable from any single scale of organization. That is itself a meaningful conclusion: not a failure of physics, but a structural feature of nested hierarchical reality.

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10. Testable Predictions

A conjecture without testable predictions is philosophy, not science. The following predictions follow directly from the framework and are in principle testable against existing or near-future observational data:

Prediction 1 — Negative gravitational lensing at void boundaries: Standard gravitational lensing produces characteristic distortion signatures as light passes near massive objects. If cosmic voids are antimatter-dominated regions with inverted spacetime curvature, light passing near void boundaries should show a measurable negative lensing signature — deflection away from the void rather than toward it. This is distinct from the absence of lensing and should be detectable in weak lensing surveys such as those conducted by the Euclid telescope or the Vera Rubin Observatory.

Prediction 2 — CMB cold spots correlating with void centers: The CMB Cold Spot and similar anomalies in the cosmic microwave background are not fully explained by standard cosmology. Under this conjecture, antimatter-dominated voids would produce characteristic cold signatures in the CMB due to inverted spacetime curvature affecting photon propagation. A statistical excess of CMB cold spots at void centers — beyond what the standard Integrated Sachs-Wolfe effect predicts — would support this conjecture.

Prediction 3 — Characteristic maximum void size: If antimatter regions become self-gravitating beyond a characteristic scale, the size distribution of cosmic voids should show a hard upper limit. This limit should be calculable from the conjecture's parameters once formalized. Current observational data suggesting a maximum void scale of 300-400 megaparsecs is consistent with this prediction but not conclusive.

Prediction 4 — Quantization-like periodicity in stellar orbital distributions: If the cosmic-scale structure is dynamically analogous to atomic structure, stellar orbital distributions around galactic black holes should show preferred radii analogous to quantized atomic orbitals. This would manifest as non-random periodicities in spiral arm spacing and stellar density waves. Some unexplained periodicities in galactic structure are already observed; a systematic survey testing whether these follow a pattern analogous to atomic orbital spacing would be a meaningful test.

Prediction 5 — Anomalous transient events correlating with cosmic web structure: If higher-scale physical processes produce lower-scale energy signatures as described in Section 7, anomalous gamma ray bursts and fast radio bursts lacking standard astrophysical explanations should show statistically significant spatial correlation with cosmic web filament nodes and void boundaries. This is testable against existing transient event catalogs cross-referenced with current cosmic web maps, and requires no new instrumentation.

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11. Where This Conjecture Conflicts With Current Understanding

Intellectual honesty requires clear identification of where this conjecture conflicts with established physics:

The stress-energy tensor: General Relativity's field equations treat all energy — including antimatter — as contributing positively to spacetime curvature. Allowing antimatter to contribute negatively requires modifying the stress-energy tensor, which is a significant departure from the standard formulation. However, this is an assumption of the framework, not a proven experimental result at cosmological scales.

The ALPHA-g result: The CERN ALPHA-g experiment (2023) showed antihydrogen falling downward in Earth's gravitational field, consistent with normal gravitational attraction. This conjecture accommodates this result by noting that the experiment measured antimatter responding to a matter-generated gravitational field — following geodesics in curved spacetime — rather than measuring how antimatter curves spacetime itself. The conjecture predicts that antimatter would fall normally in a matter gravitational field, while still curving spacetime oppositely when it is the dominant source.

This distinction must be made explicit in any formal version of this conjecture and is a potential weakness if the distinction cannot be made mathematically rigorous.

The uniformity of the CMB: The cosmic microwave background is remarkably uniform, suggesting the early universe was nearly homogeneous. Large-scale matter-antimatter separation should produce boundary signatures. The conjecture requires that separation occurred early and cleanly enough that the boundaries were thin relative to the scale of the observable universe. This is plausible given the Planck-era timescale but requires quantitative support.

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12. Conclusion

This conjecture proposes a single foundational modification to our understanding of gravity — that matter and antimatter carry opposite gravitational charge — and traces the consequences of that modification across cosmological scales. The resulting framework naturally explains the matter-antimatter asymmetry, provides a physical mechanism for dark energy, offers a new interpretation of the cosmic web and cosmic voids, recontextualizes phenomena currently attributed to dark matter and dark energy as effects of gravitational charge asymmetry seen from inside a matter-dominated region, and suggests that the cosmic web represents a higher-scale periodic structure analogous to atomic structure, built by the same logical mechanism operating through a different force carrier.

The framework further proposes that apparent negative mass behavior in the universe is not an intrinsic property of any object but an emergent relational property arising at the boundaries between matter and antimatter domains — resolving the theoretical problems of negative mass theory while preserving all of its observational signatures. Three additional propositions follow: that our cosmological models carry a systematic observer location bias; that anomalous high energy transient events may constitute a predicted category of higher-scale process signatures; and that quantum randomness may be a resolution limit artifact rather than a fundamental feature of reality.

The conjecture is not mathematically complete. A formal version would require modifying the stress-energy tensor to allow for negative gravitational charge, deriving the resulting field equations, and checking consistency with the full suite of cosmological observations. That work is beyond the scope of this paper and the background of its author.

What is offered here is a structured logical framework with internal consistency, grounding in established physics where possible, honest identification of conflicts with current assumptions, and five concrete testable predictions. The history of physics includes examples of correct intuitions preceding their mathematical formalization by decades. This conjecture is offered in that spirit — not as a claim of discovery, but as a question worth asking carefully. The author has carried these ideas for many years, and offers them now in the hope that someone with the mathematical tools to formalize them will find the framework worth pursuing.

If even one of the testable predictions is confirmed by future observational data, the framework merits formal mathematical investigation.

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13. Acknowledgments

The author thanks the open science community and the educators, communicators, and researchers whose public work made this kind of independent reasoning possible. This conjecture was developed through careful thought and conversation, not through formal academic training. The author acknowledges that professional physicists may identify errors or conflicts not recognized here, and welcomes that engagement.

Note on Related Prior Work

The author was not aware of the following works during the development of this conjecture, but notes their relevance for completeness: Massimo Villata has published on gravitational repulsion between matter and antimatter as a driver of cosmic expansion. The ALPHA-g collaboration at CERN has directly measured antihydrogen in gravitational fields. Roger Penrose's Conformal Cyclic Cosmology addresses related questions about the ultimate fate of the universe. Gravitoelectromagnetism as a formalism is well-established within General Relativity. The independent parallel development of related ideas by credentialed researchers supports the view that these are legitimate open questions in physics.

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