Cosmological Pangaea and the Reported Galaxy Spin Asymmetry: A Geometry-First Interpretation of Residual Topological Memory

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Abstract

Recent observational analyses of the James Webb Space Telescope Advanced Deep Extragalactic Survey (JWST JADES) report a pronounced statistical asymmetry in the parity-defined rotation directions of distant spiral galaxies, with the magnitude of the imbalance strengthening systematically at higher redshifts (z). Standard physical cosmology (ΛCDM) treats large-scale statistical isotropy as a foundational axiom derived from early-universe inflationary dynamics.

Within the Cosmological Pangaea framework, which models the early universe as originating from the geometric fracture of a finite, zero-entropy primordial manifold, this reported chirality is interpreted not as a localized anomaly or a global rotation, but as residual topological memory.

This paper builds out the three-layer architectural hierarchy of Cosmological Pangaea:

1. **Foundational Geometry** (low Weyl curvature initial states),
2. **Physical Mechanism** (fracture dynamics and Crest-Null persistence), and
3. **Multi-Observable Consequences** (orientation statistics, CMB anomalies, and distance calibration biases).

We formulate conceptual and mathematical derivations linking the redshift-dependent decay of this statistical chirality to non-equilibrium thermodynamic decoherence and the growth of the Weyl tensor (C_{abcd}). Finally, we establish explicit observational protocols to

render the framework fully falsifiable across upcoming surveys (e.g., Euclid, Vera C. Rubin Observatory).

1. Introduction and Foundational Premise

The standard model of cosmology, ΛCDM, relies heavily on the Cosmological Principle: the assumption that, on sufficiently large scales, the distribution of matter and energy in the universe is both homogeneous and isotropic. Mathematically, this manifests as the Friedmann–Lemaître–Robertson–Walker (FLRW) metric, where localized perturbations are treated as zero-mean Gaussian random fluctuations generated during cosmic inflation.

However, a growing body of high-redshift observations, including the accelerated assembly of massive early galaxies, large-scale coherent velocity flows ("dark flow"), Cosmic Microwave Background (CMB) hemispherical power asymmetries, and recent spiral galaxy chirality counts, continues to strain the pure spatial isotropy assumed by standard inflation.

Model Comparison: Initial States and Evolutionary Trajectories

- **Standard Model (ΛCDM):**
  - *Initial State:* Featureless, infinite, homogeneous initial condition.
  - *Mechanism:* Symmetric inflationary smoothing.
  - *Late-Time Result:* Isotropic cosmic expansion with zero-mean, random local perturbations.
- **Cosmological Pangaea:**
  - *Initial State:* Finite, zero-entropy primordial geometric manifold.
  - *Mechanism:* Geometric fracture (phase transition).
  - *Late-Time Result:* Inherited topological invariants with residual chirality that undergo thermodynamic decoherence and redshift dilution over cosmic time.

Cosmological Pangaea approaches these observed tensions from an inverse, geometry-first posture. Rather than treating anomalies as isolated empirical flaws requiring bespoke scalar fields or ad hoc dynamic additions, Cosmological Pangaea posits that the universe originated as a finite, zero-entropy, highly structured geometric state.

Within this framework:

- The early universe was not featureless.

- Perfect spatial isotropy is an emergent, late-time statistical approximation resulting from cosmic expansion and gravitational mixing.
- Observed parity imbalances represent residual topological memory, geometric invariants preserved across the primordial structural state transition.

This premise directly aligns with, and extends, Roger Penrose's Weyl Curvature Hypothesis (WCH). While WCH posits a vanishing Weyl curvature tensor ($C_{abcd} \to 0$) at the initial singularity to account for the second law of thermodynamics, Cosmological Pangaea embeds this constraint within a bounded, non-singular, finite primordial manifold whose initial structural fracture sets the arrow of time and defines the subsequent geometric evolution of spacetime.

2. Galaxy Spin Asymmetry and Redshift Dependence

2.1 Empirical Context

Analyses of deep-field imaging programs, specifically the JWST Advanced Deep Extragalactic Survey (JADES), by Lior Shamir and collaborators report a statistically significant asymmetry in the relative distribution of clockwise (CW) versus counter-clockwise (CCW) spiral galaxy handedness as viewed from an Earth-centered observational frame.

In candidate samples of high-redshift spiral galaxies with clearly resolvable arms, the CW-to-CCW distribution yields a pronounced variance (e.g., approximately 158 CW vs. 105 CCW in specific deep-field partitions), representing an apparent asymmetry near 50%.

Crucially, this asymmetry displays a distinct spatial trend:

- **Local Universe ($z \approx 0$ to 0.1):** Large-scale surveys (SDSS, DES) register a minor, near-threshold asymmetry ($\sim$ 1%--2%).
- **Intermediate Deep Fields ($z \approx 0.5$ to 1.5):** Space-based surveys (HST) show a moderately elevated signal.
- **Ultra-Deep Fields ($z > 2$):** JWST observations display the strongest statistical divergence from parity symmetry.

2.2 Interpretation Within Cosmological Pangaea

In standard astrophysics, a redshift-dependent increase in chirality is difficult to reconcile without invoking global rotation or late-stage vector fields. Cosmological Pangaea reframes this empirical trend entirely: The signal is not growing over cosmic time; it is being erased.

The persistence of this signal across structural state transitions is governed by the broader Crest-Null Persistence Principle, which establishes that when a high-order geometric network undergoes a phase reset or structural fracture, global information is not instantaneously thermalized. Instead, low-entropy invariants survive as persistent statistical boundaries along the network's expanding edges.

Epoch Dynamics: High Redshift vs. Low Redshift

- **High Redshift (Early Epochs - Close to Primordial Fracture State):**
  - *Chiral Bias:* High ($\approx$ 50% Asymmetry).
  - *Physical Conditions:* Low gravitational entropy, minimal virialization, dominant topological memory.
- **Low Redshift (Late Epochs - Billions of Years of Mixing):**
  - *Chiral Bias:* Low ($\approx$ 1%--2% Residual).
  - *Physical Conditions:* High gravitational entropy, non-linear phase-mixing, largely erased primordial information.

2.3 Mathematical Derivation of Redshift-Dependent Decoherence

Let the observed spin asymmetry amplitude at look-back time t be quantified by the dimensionless chirality parameter $A(t)$:

$$A(t) = \frac{N_{\mathrm{CW}}(t) - N_{\mathrm{CCW}}(t)}{N_{\mathrm{CW}}(t) + N_{\mathrm{CCW}}(t)}$$

where N_{CW} and N_{CCW} denote the statistical counts of clockwise and counter-clockwise galaxies within a co-moving volume element.

At the initial primordial fracture event ($t = t_0$, corresponding to $z \to \infty$), the structural breakdown of the zero-entropy initial condition imprints an initial topological chirality $A_0 \neq 0$.

As cosmic time progresses ($t_0 \to t_{\mathrm{today}}$), non-linear gravitational collapse, virialization of dark matter halos, orbital frame-dragging, and mergers introduce stochastic angular momentum exchange. We model this dilution process via a non-equilibrium thermodynamic decoherence rate $\Gamma(t)$:

$$\frac{dA(t)}{dt} = -\Gamma(t)A(t)$$

Integrating from the primordial epoch t_0 to an observational epoch corresponding to redshift z:

$$A(z) = A_0 \exp\left(-\int_{t(z)}^{t_0} \Gamma\,(t')\,dt'\right)$$

Because the look-back time $t(z)$ decreases as redshift z increases, the integral over the decoherence rate $\Gamma(t')$ covers a smaller time interval for high-z objects. Consequently:

$$\lim_{z\to\infty} A(z) \to A_0 \quad \text{and} \quad \lim_{z\to 0} A(z) \to \epsilon \ll A_0$$

2.4 The Weyl Curvature Connection

The rate of topological decoherence $\Gamma(t)$ is directly driven by the growth of gravitational entropy. Under Penrose's formulation, gravitational entropy is proportional to the scalar norm of the Weyl curvature tensor C_{abcd}, normalized by the Ricci tensor components:

$$S_{\text{grav}} \propto \int_V |\, C_{abcd}C^{abcd}|\, dV$$

In the early post-fracture universe, matter is uniformly distributed and $C_{abcd} \approx 0$. As structure forms, inhomogeneous clumping causes $|C|^2 \equiv C_{abcd}C^{abcd}$ to grow exponentially within localized bound systems. We couple the logarithmic decay of the structural chirality directly to the volume-averaged Weyl curvature invariant $\langle|C|2\rangle$:

$$\frac{d\ln A}{dt} = -\alpha\,\langle|C|2\rangle$$

where α is a dimensional coupling coefficient governing the rate at which gravitational entropy production erases initial geometric memory.

This establishes a quantitative bridge: **Higher redshift observations sample epochs where localized Weyl curvature invariants were minimal, preserving the primordial geometric orientation of the fracture.**

3. Unified Mechanism: Three-Layer Architecture

To maintain methodological rigor and prevent the framework from collapsing into an anomaly-fitting exercise, Cosmological Pangaea isolates its theoretical claims into three explicit layers.

Architectural Hierarchy

1. **Level 1: Foundational Geometry**

- *Premise:* Finite, Zero-Entropy Primordial Geometry (Low Weyl Curvature Constraint).

2. **Level 2: Physical Mechanism**
   - *Sequence:* Geometric Fracture ⟶ Residual Topological Memory (Crest-Null Invariants) ⟶ Weak Statistical Residuals.
3. **Level 3: Observables & Downstream Effects**
   - *Branch A (Chiral Parity):* Galaxy Spin Statistics ⟶ Distance Calibration Discrepancies.
   - *Branch B (Multipolar Alignment):* CMB Anomalies ⟶ Luminosity Biases in Supernovae.
   - *Branch C (Coherent Structure):* Large-Scale Structure ⟶ Inferred Hubble Tension (H_0).

4. Falsifiability and Observational Testing

Cosmological Pangaea maintains a clear boundary between its core hypothesis and individual observational datasets. The multi-layer architecture ensures that the framework is fully falsifiable without relying on any single data point.

Observational Validation Pipeline

- **Primary Survey Pipelines (Euclid / Vera C. Rubin Observatory):**
  - *Method:* Automated, pipeline-mirrored galaxy chirality catalogs.
  - *If Null Result (Symmetric Split):* The galaxy spin leaf of Level 3 is disconfirmed and removed, but the core Level 1 geometric model survives to be tested across other branches.
- **Secondary Survey Pipelines (Next-Gen CMB / 21cm Cosmology):**
  - *Method:* Cross-correlation of directional distance biases and construction of directional H_0 maps.
  - *Evaluation:* Directly tests remaining structural predictions across independent cosmic observables.

Key Falsification Protocols

1. **Pipeline Mirroring & Chirality Audits:** Future automated sky surveys, such as those conducted by the Euclid Space Telescope and the Vera C. Rubin Observatory, must

run strictly mirrored image-analysis pipelines to eliminate human and algorithmic selection biases. If automated, parity-mirrored analyses across billions of galaxies demonstrate that $A(z) = 0$ at all $z > 2$, the galaxy spin branch of Level 3 is formally disconfirmed.

2. **Cross-Observable Correlation Tests:** If galaxy spin chirality is a genuine manifestation of residual topological memory, the spatial orientation vectors derived from galaxy spin preferred axes must align statistically with the preferred dipole/quadrupole alignment vectors identified in CMB temperature anisotropy maps. A complete statistical independence between large-scale spin bias axes and CMB preferred axes would invalidate the unified Level 2 mechanism.
3. **Redshift Decay Scaling:** The framework predicts that the rate of chirality decay must track non-linear structure formation. Quantitative measurements demonstrating an *increase* in chirality at lower redshifts ($z \to 0$) would contradict the second law of thermodynamics as expressed through Weyl tensor growth, thereby falsifying the decay model.

5. Conclusion and Outlook

The principal question raised by Cosmological Pangaea is empirical rather than philosophical: Do multiple, independent cosmological observables exhibit statistically consistent signatures of a common primordial geometric origin?

The reported galaxy spin asymmetry identified in deep-field imaging provides a compelling, real-time observational test case. Rather than treating this asymmetry as an isolated anomaly or forcing it into standard inflationary models via exotic vector fields, Cosmological Pangaea demonstrates that a geometry-first approach naturally predicts the existence and redshift-dependence of residual chirality.

As observational astrophysics enters the era of high-precision deep-space surveys, driven by JWST, Euclid, the Vera C. Rubin Observatory, and next-generation CMB polarimetry, the empirical tools required to evaluate this hypothesis quantitatively are now operational.

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