Program P6-B: The Anisotropy and Alignment Audit

Distinguishing Gravitational Clustering from Parochial Phase-Locking

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Abstract

Program P6-A confirmed high-significance clustering ($V \approx 13.9, \Sigma \approx 72\sigma$) in the $z \sim 4.5$ galaxy field. However, this scalar metric cannot distinguish between isotropic gravitational collapse (ΛCDM) and anisotropic context-coupling (PbC). This protocol defines the methodology for **Program P6-B**, which utilizes rotational symmetry breaking and gradient alignment to audit the geometric relationship between the Record (Galaxies) and the Context (Window Function).

1 Theoretical Motivation

We test two competing hypotheses regarding the origin of the observed variance:

- **Null Hypothesis ($\mathcal{H}_{grav}$):** The clustering is physical and isotropic. The correlation function $\xi(r)$ depends only on separation distance r. Rotating the observational window relative to the field should not significantly alter the global variance statistics.
- **PbC Hypothesis ($\mathcal{H}_{pbc}$):** The clustering is anisotropic and phase-locked to the observer's constraints. The density field $\delta(\mathbf{x})$ is maximized along the principal axes of the window function $W(\mathbf{x})$. Rotating the window breaks this lock, causing the variance to collapse.

2 Phase 1: The Rotational Null Test (Scalar)

This is the primary discriminator. We measure the stability of the Variance Ratio V under coordinate transformation.

2.1 Methodology

1. **Coordinate Rotation:** We apply a rotation matrix $R(\theta)$ to the galaxy coordinates (α, δ) relative to the field center (α_0, δ_0):

$$\begin{bmatrix} \alpha' \\ \delta' \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} \alpha - \alpha_0 \\ \delta - \delta_0 \end{bmatrix} + \begin{bmatrix} \alpha_0 \\ \delta_0 \end{bmatrix} \tag{1}$$

2. **Fixed Mask:** The occupancy grid O_{ij} (representing the telescope window) remains fixed in the laboratory frame. 3. **Audit Sweep:** We vary θ from 0° to 90° in steps of $\Delta\theta = 5^\circ$.

2.2 Success Criteria

We define the **Anisotropy Parameter** $\mathcal{A}$:

$$\mathcal{A} = \frac{V(\theta = 0^\circ) - \langle V(\theta \neq 0^\circ) \rangle}{\sigma_{boot}} \tag{2}$$

- If $\mathcal{A} \approx 0$: The structure is Isotropic (Gravity).
- If $\mathcal{A} > 3$: The structure is Anisotropic and aligned with the window (PbC Lock).

3 Phase 2: Gradient Alignment Audit (Vector)

We test if the local density gradients are streaming along the detector boundaries.

3.1 Methodology

1. **Density Gradient ($\nabla\delta$):** For each patch (i, j), we compute the gradient of the galaxy count field using a Sobel operator. 2. **Window Gradient (∇W):** We compute the gradient of the occupancy mask (which is non-zero only at the edges/gaps). 3. **Alignment Angle:** We calculate the cosine similarity for all boundary patches:

$$\mu_{ij} = \frac{\nabla\delta \cdot \nabla W}{|\nabla\delta||\nabla W|} \tag{3}$$

3.2 Interpretation

We analyze the distribution $P(\mu)$.

- **Random:** $P(\mu)$ is uniform. Galaxies cross window boundaries randomly.
- **Locked:** $P(\mu)$ peaks at ± 1 (Parallel) or 0 (Perpendicular). This implies the density field is geometrically constrained by the observation limits.

4 Phase 3: Global Axis Lock (Eigenbasis)

We perform a global check for the "Axis of Evil" at $z \sim 4.5$.

4.1 Methodology

1. **Galaxy Tensor:** Compute the moment of inertia tensor I_g for the galaxy distribution on the sky. 2. **Window Tensor:** Compute the moment of inertia tensor I_w for the survey mask. 3. **Eigen-Decomposition:** Extract the principal eigenvectors $\mathbf{v}_g$ and $\mathbf{v}_w$ corresponding to the largest eigenvalues. 4. **Misalignment Angle:** $\Psi = \arccos |\mathbf{v}_g \cdot \mathbf{v}_w|$.

4.2 Implication

If $\Psi < 5^\circ$, the large-scale structure of the early universe is perfectly aligned with the orientation of the COSMOS camera, mirroring the CMB multipole alignment (P1).

5 Execution Plan

The code `scripts/p6_rotation_audit.py` will implement Phase 1 immediately, as it requires no new derived data products. Phases 2 and 3 will be implemented if Phase 1 yields $\mathcal{A} > 3$.