Project Plan: The Geometric Inevitability of the Axis of Evil

A Systematic Audit of Window Function Artifacts in CMB Anomalies

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Abstract

The "Axis of Evil" (the anomalous alignment of CMB multipoles $l = 2$ and $l = 3$) remains one of the most cited challenges to the Copernican Principle. Preliminary results from *Project Ouroboros* suggest this alignment may be a geometric artifact induced by the Galactic Mask. This project aims to definitively demonstrate that the observed alignment is a statistical inevitability of observing the universe through a window function (the Galactic Plane). We outline a four-phase "Steel Man" audit to robustly quantify this effect, aiming for a publishable falsification of the anomaly.

1 Hypothesis

The Mask-Induced Alignment Hypothesis: The loss of equatorial data due to Galactic masking breaks rotational invariance, creating a preferred geometric axis (North-South). This forces low-multipole spherical harmonics to align their principal axes with the mask's symmetry axis, mimicking a cosmological signal.

2 Phase I: Data Robustness (The "Map Check")

Objective: Ensure the artifact is independent of the component-separation method.

1. **Map Consistency Check:**
   - Replicate the 60% alignment probability using alternate Planck 2018 maps: `NPIPE`, `SEVEM`, and `Commander`.
   - *Success Criteria:* All maps must yield $P(\text{align}) > 0.05$ (Null Result) and show similar artifact rates in simulations.
2. **The Mask Sensitivity Ladder (The "Smoking Gun"):**
   - Run the Null Engine ($N = 1000$) across a range of sky fractions (f_{sky}): 90%, 80%, 70%, 60%, 40%.
   - *Prediction:* The probability of finding an "Axis of Evil" should scale inversely with f_{sky}.
   - *Deliverable:* A plot of $P(\text{Alignment} < 10^\circ)$ vs. f_{sky}.

3 Phase II: Mathematical Formalism

Objective: Adopt the "Gold Standard" definitions to preempt theoretical objections.

1. **Maxwell Multipole Vectors (MMV):**
   - Upgrade the `harmonics.py` engine to compute true Maxwell Multipole Vectors (headless unit vectors) rather than simple Eigenvalue Principal Axes.
   - This aligns our methodology with seminal papers (Copi et al., Huterer et al.).
2. **Alignment Metrics:**
   - Implement the standard "S-statistic" (Area of the triangle formed by multipole vectors) to quantify alignment rigor.

4 Phase III: Statistical Rigor

Objective: Quantify the "Look-Elsewhere" Effect.

1. **The Global Null:**
   - Extend the alignment check to higher multipole pairs ($l = 3$ vs 4, 4 vs 5, ... 9 vs 10).
   - *Hypothesis:* If the mask forces alignment, adjacent multipoles should show correlation well beyond just $l = 2, 3$.
2. **Ensemble Verification:**
   - Verify that the ensemble average of random masked skies converges to the "Evil" configuration.

5 Phase IV: High-Fidelity Simulation

Objective: Precision statistics for publication.

1. **Massive Simulation Run:**
   - Execute $N = 50,000$ simulations for the primary $l = 2, 3$ test.
   - *Goal:* Reduce P-value error bars to ± 0.001.
2. **Final Report / Manuscript:**
   - Compile results into a single figure: "The Probability of Evil."

6 Requirements

- **Compute:** 4-16 Cores (Local Workstation).
- **Storage:** 50 GB (Map Cache).
- **Software:** Python 3.12, `healpy`, `numpy`, `astropy`.