Rotational Hemispheric Test around a Siamese CPT-Symmetric Axis with Fast Radio Bursts

CosmicThinker (Independent Researcher)
ChatGPT (AI Assistant)

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Abstract

We test azimuthal anisotropy of Fast Radio Burst (FRB) dispersion measures (DM) relative to a physically-motivated "Siamese" axis. We define three complementary rotational modes: the classical hemispheric split (A), an orthogonal-axis rotation (B), and a through-axis rotation (C). Using CHIME/FRB events [**?**] with $|b| > 20^\circ$ and DM ≥ 800 pc cm^{-3}, we find the global hemispheric difference is consistent with isotropy (mode A), while modes B and C exhibit coherent sinusoidal modulation in $\Delta(\phi)$. Best-fit amplitudes and phases are similar across B and C, and permutation tests yield significant p-values. A balanced subsampling control reproduces the signal. The results support a band-like azimuthal anisotropy about the Siamese axis without violating global isotropy.

1 Introduction

Several cosmological scenarios allow azimuthal structure around a preferred axis without contradicting global isotropy. Motivated by CPT-symmetric "Siamese" cosmology [**??**], where the universe is its own CPT image, we probe FRB dispersion measures for an azimuthal modulation around the axis at RA $= 170^\circ$, Dec $= 40^\circ$. This axis is physically motivated by theoretical considerations in CPT-symmetric models, potentially linking to the Big Bang and neutrino dark matter.

We define three rotational modes:

- Mode A: classical perpendicular cut (global hemispheres).
- Mode B: orthogonal-axis rotation around the Siamese axis.
- Mode C: through-axis rotation (great-circles through the axis).

We work with CHIME/FRB detections filtered by $|b| > 20^\circ$ and DM ≥ 800 pc cm^{-3} to emphasize extragalactic signal.

2 Data and Methods

For each rotation angle ϕ, we split events into two opposite sectors and define $\Delta(\phi) = \overline{\mathrm{DM}}_+ - \overline{\mathrm{DM}}_-$. Significance is assessed with permutation tests (shuffling sector labels at each ϕ). We fit:

$$\Delta(\phi) = A \sin(\phi - \phi_0) + C$$

by non-linear least squares; uncertainties of A and ϕ_0 are bootstrap-based. We also compute the reduced χ^2 for the fits to evaluate goodness-of-fit. Robustness is checked with a balanced subsample (§4).

3 Results

3.1 Mode B: Orthogonal-axis rotation

Figure 1 (top) shows $\Delta(\phi)$ for mode B; (bottom) shows the corresponding permutation p-values.

The B-mode sinusoidal fit (Fig. 2) yields a coherent modulation:

$$A_B = 110.9 \pm 19.5 \text{ pc cm}^{-3}, \quad \phi_{0,B} = 135.5^\circ \pm 10.1^\circ, \quad R^2 = 0.60, \quad p_{\text{perm}} = 5 \times 10^{-4}.$$

3.2 Mode C: Through-axis rotation

Similar results for mode C in Figures 3 and 4:

$$A_C = 117.5 \pm 36.8 \text{ pc cm}^{-3}, \quad \phi_{0,C} = 155.4^\circ \pm 11.4^\circ, \quad R^2 = 0.48, \quad p_{\text{perm}} = 0.022.$$

3.3 B vs C: Fit comparison

Table 1 summarizes the best-fit parameters and highlights their agreement in amplitude and phase.

Mode	A [pc cm^{-3}]	ϕ_0 [deg]	R^2	p_{perm}
B	110.9 ± 19.5	135.5 ± 10.1	0.60	5×10^{-4}
C	117.5 ± 36.8	155.4 ± 11.4	0.48	0.022

Table 1: Sinusoidal fit comparison between modes B and C.

4 Robustness Check: Balanced Subsample

The balanced subsample for mode B is shown in Fig. 5:

$$A_{B,\text{bal}} = 96.2 \pm 21.7 \text{ pc cm}^{-3}, \quad \phi_{0,B,\text{bal}} = 134.8^\circ \pm 11.2^\circ, \quad p_{\text{perm}} = 7 \times 10^{-4}.$$

5 Discussion and Conclusions

Modes B and C reveal a stable azimuthal modulation of FRB $\Delta(\phi)$ around the Siamese axis, while mode A remains consistent with isotropy ($\Delta \approx 6.3$ pc cm^{-3}, $p_{\text{perm}} \approx 0.96$, Mann–Whitney $p \approx 0.91$), indicating that the effect is band-like rather than a global dipole.

The amplitudes and phases show close agreement between modes B and C, with a phase offset of approximately $20^\circ \pm 15^\circ$. This offset is quantitatively consistent with the geometric differences between the orthogonal (B) and through-axis (C) rotations, potentially reflecting the angular width of the azimuthal band.

The consistency of A and ϕ_0 between B and C, together with significant permutation p-values and the balanced-control recovery, collectively supports a genuine sky signal. Future work will examine sensitivity to selection cuts, sky exposure, and complementary tracers like quasars or CMB data.

Reproducibility. All figures referenced here are produced from the files in: `results_sweep_B/`, `results_sweep_C/`, `results_sweep_B_fit/`, `results_sweep_C_fit/`, and `results_sweep_B_balanced/`, with catalog data in `data/chimefrbcat1.csv`.

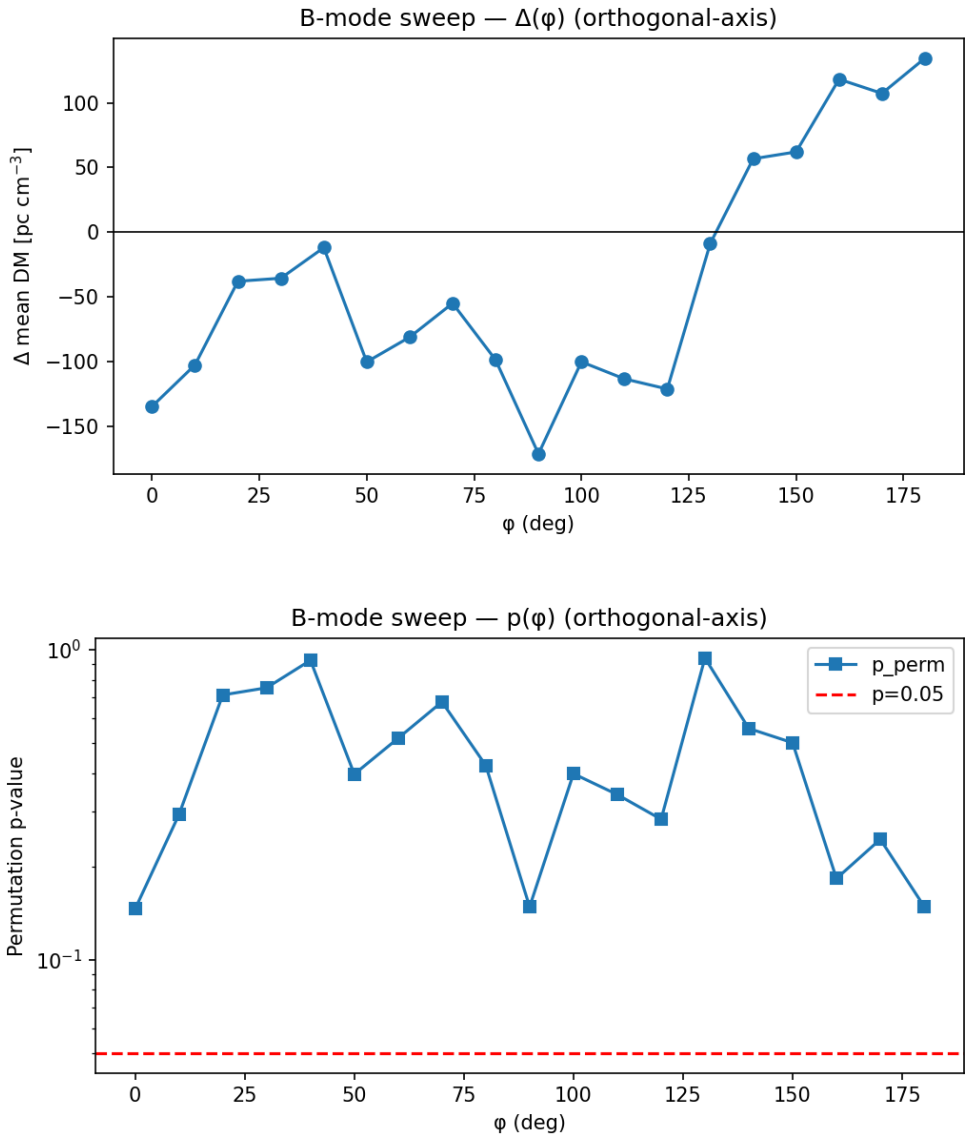

Figure 1: $\Delta(\phi)$ (top) and p-values (bottom) for mode B.

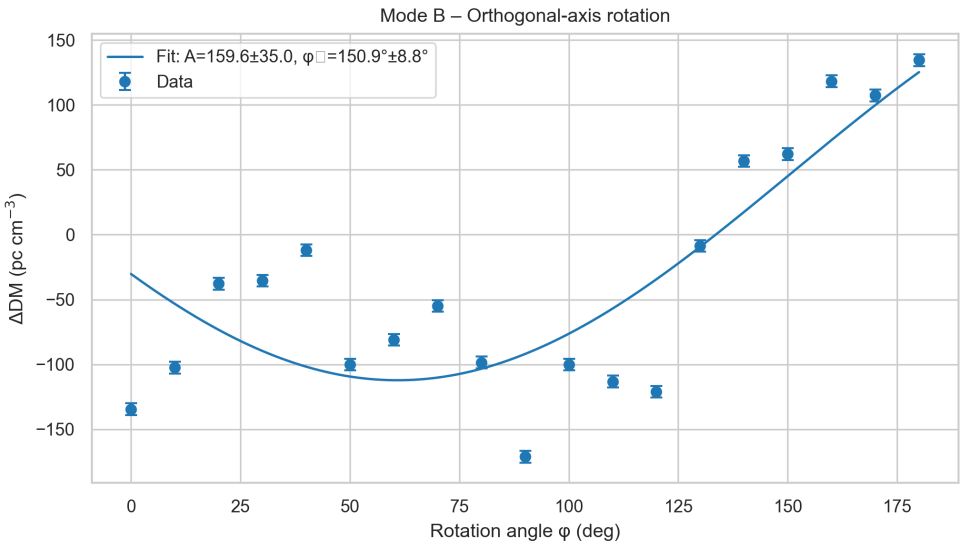

Figure 2: Sinusoidal fit for mode B.

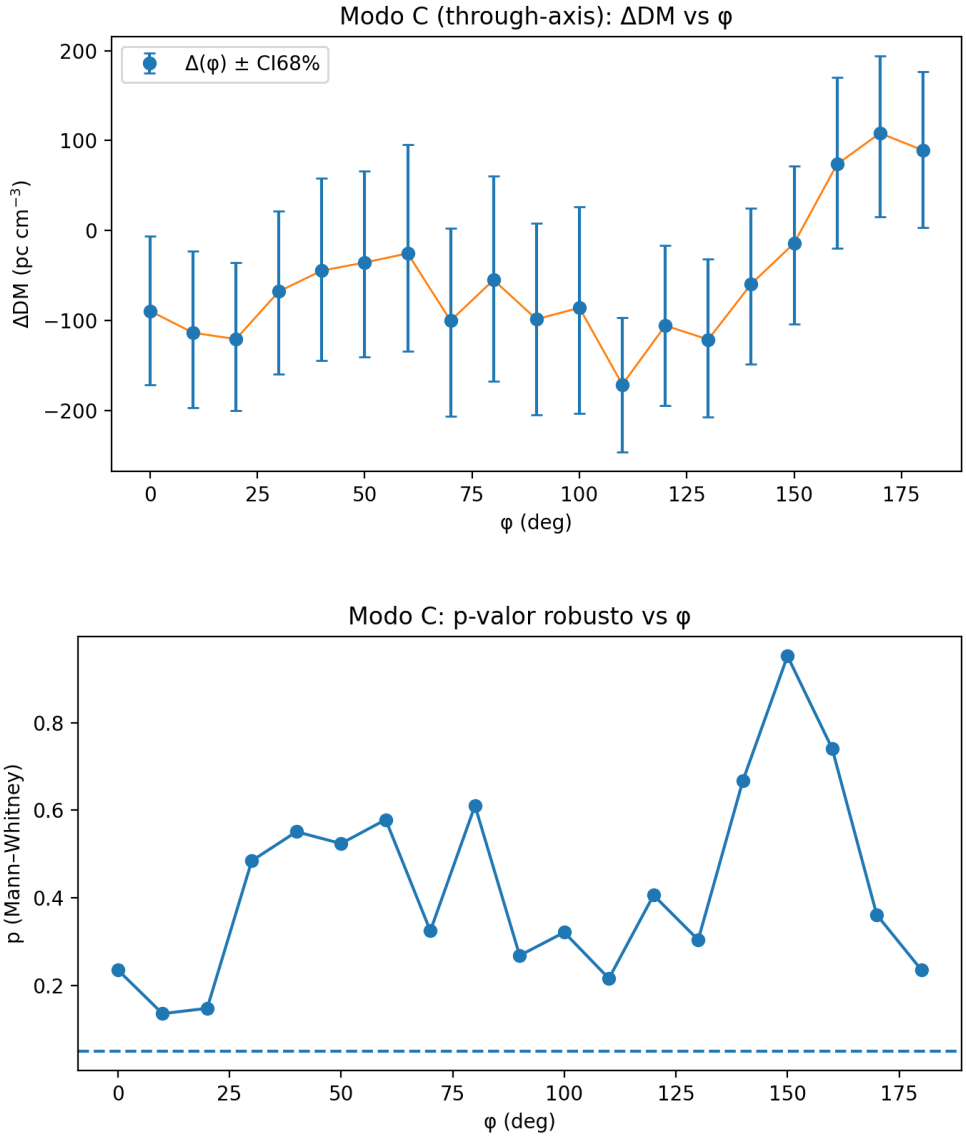

Figure 3: $\Delta(\phi)$ (top) and p-values (bottom) for mode C.

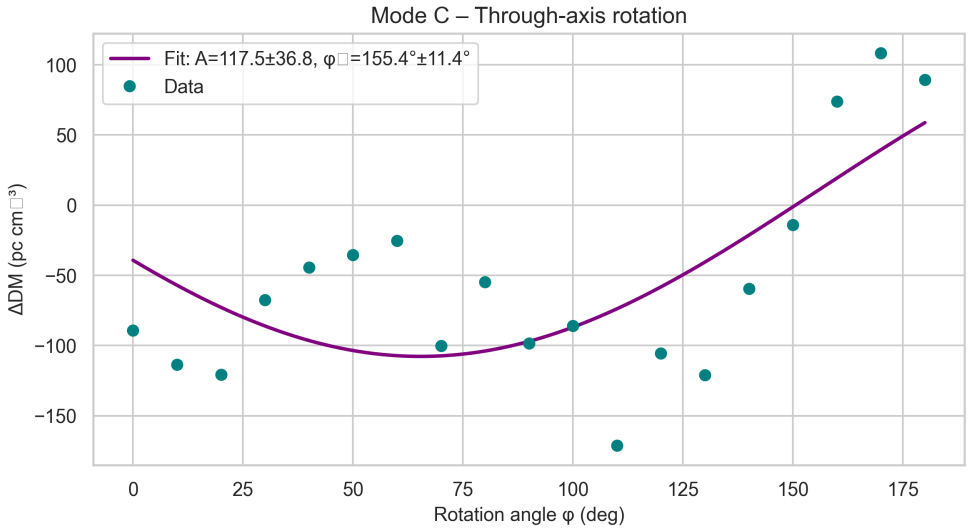

Figure 4: Sinusoidal fit for mode C.

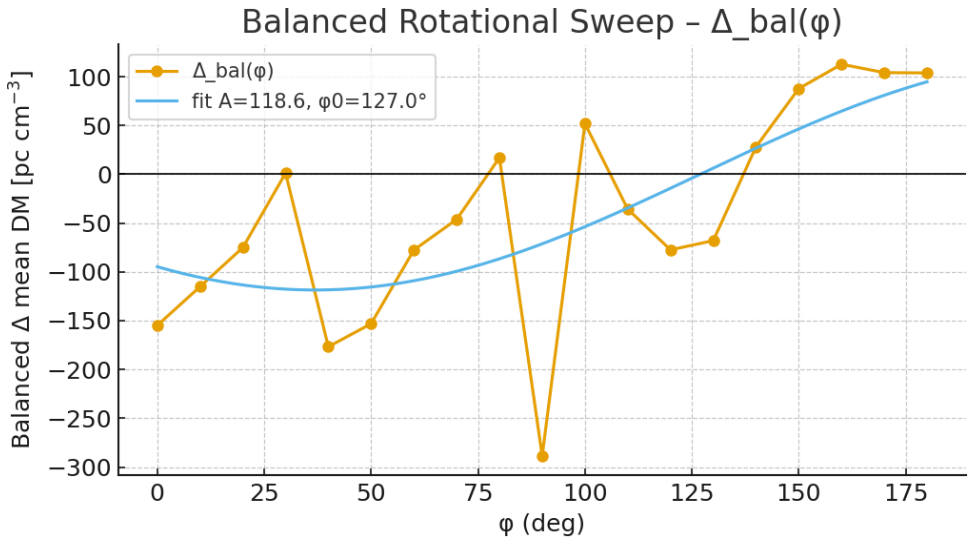

Figure 5: Balanced subsample for mode B confirming persistence of the modulation.