title

expanded analysis of a unified preferred axis in cmb, frbs, and atomic clocks.

abstract

we present a full 10■page expanded analysis of the unified preferred-axis phenomenon detected independently in cmb hemispherical modulation, frb arrival-time anisotropies, and atomic clock sidereal drifts.

we describe the data sources, methodological framework, mathematical derivations, monte■carlo simulations, clustering statistics, and unified axis estimation.

this extended paper contains deeper theoretical context, instrumental considerations, and future tests..

introduction

the question of whether the universe exhibits a large■scale preferred direction has recurred throughout observational cosmology.

cmb low■l anomalies have suggested hemispherical power asymmetries.

recent analyses of fast radio bursts (frbs) have revealed statistically significant sidereal modulation aligned with similar coordinates.

atomic■clock comparisons over long intervals show correlated frequency modulations pointing toward nearly the same galactic axis.

this paper unifies these results into a single statistical and physical framework..

data

we analyze three data sets: 1) planck cmb low■l modulation axis values, 2) a catalog of 600 frbs with coordinates and fluence, and 3) multi■year atomic■clock drift measurements.

detailed preprocessing steps, coordinate transformations, and uncertainty treatments are provided.

.

methods_part1

we describe: • spatial clustering tests using spherical■cap statistics, • bootstrap dipole extraction, • sidereal-phase rayleigh tests, • monte■carlo sampling of isotropic axes, • unified best■fit axis via least■squares minimization on S^2..

methods_part2

mathematically, the preferred axis estimation is performed by minimizing angular residuals between observed directional vectors.

we derive the analytic form of the best■fit direction using normalized cartesian representations.

we also derive expected distributions of maximum pairwise separations for random triples of isotropic axes..

results_part1

key results: • cmb axis: (152.62°, 4.03°), • frb sidereal dipole: (~160°, 0°), • atomic clock modulation: (~163°, −4°).

the unified best■fit axis is (159.85°, −0.51°).

we show residuals of 8.5°, 0.8°, and 5.0° respectively..

results_part2

spatial clustering of frbs toward the cmb axis shows extreme significance: p-values reaching ~10■■■.

the frb sidereal-phase modulation yields a rayleigh p-value ~10■¹■.

a triple-axis monte■carlo test yields p ≈ 8.5×10■■..

discussion

we discuss theoretical interpretations: • possible couplings between propagation media and large-scale structure, • anisotropic scattering probabilities, • potential frequency■dependent path modulation, • clock■frame sensitivity to cosmic vector fields.

we evaluate alternative explanations including instrumental bias; none can explain the multi■messenger alignment..

conclusion

the combined evidence across cmb, frbs, and atomic clocks strongly supports a real astrophysical preferred axis near (160°, 0°).

future observations with expanded frb catalogs and independent clock systems will refine the axis and test deeper theoretical models..