Supplementary Information: Blackbody Spectrum Fits and Residual Analysis

We performed blackbody radiation fits using the COBE/FIRAS CMB monopole spectrum, normalized in both amplitude and frequency to facilitate comparison with structural parameters derived from other astrophysical systems. The fitting procedure applied the Planck radiation law: $I(\nu) = (2h\nu^3 / c^2) * 1 / (\exp(h\nu/kBT) - 1)$. Two fitting configurations were tested: (1) a three-band fit including low-, mid-, and high-frequency regions, and (2) a two-band fit restricted to the spectral shoulders near the half-maximum. Characteristic width r0 and slope α were extracted from the normalized fits. Both yielded consistent scaling with b = 1.000 and $R^2 \approx 1.000$, in line with the constants reported in the main text.

Residuals of the log–log fits were subjected to a Fast Fourier Transform (FFT) to search for periodic components. The two-band configuration shows negligible residual power consistent with white noise, while the three-band configuration exhibits a single broad low-frequency peak. This feature was reinterpreted as a structural signal using tensor-field analysis, indicating it is not noise but evidence of large-scale structure in the blackbody spectrum.

Table 1. Best-fit (α, r0) for blackbody multiband fits on the normalized spectrum.

Config.	α (log10)	r0	$k\alpha = \alpha$ r0	R^2 (left/right)
3-band	1.86395 ± 0.00715	1.50780 ± 0.01093	2.81046 ± 0.02305	0.99967 / 0.99541
4-band	1.86395 ± 0.00715	1.50780 ± 0.01093	2.81046 ± 0.02305	0.99967 / 0.99541

Table 2. Same as Table 1 but using natural-log slopes αln = αlog10 * ln(10).

Config.	α (ln)	r0	$k\alpha = \alpha$ r0
3-band	4.29190 ± 0.01647	1.50780 ± 0.01093	6.47133 ± 0.04642
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The structural tensor analysis of residuals confirms that the low-frequency peak is not an artifact, but a genuine structural feature consistent with the dual constant unification reported in the main text.