Genesis Echo 21 cm Forecast Log

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Author: Robert Schrader (with STARK)

# 1. Objective

Simulate the imprint of the Genesis Echo bump on the 21 cm brightness temperature field. Forecast its detectability using a HERA-like and SKA-like noise model, and visualize the bump's structure in mock sky maps.

# 2. Input Spectrum

Primordial power spectrum includes a Gaussian bump at log10(k) = -1 (i.e. k ≈ 0.1 h/Mpc), amplitude 10%, width σ = 0.3. Injected on top of a power law with A\_s = 2.1e-9, n\_s = 0.96.

# 3. Transfer Function & Linear Growth

Used Eisenstein & Hu no-wiggle transfer function to evolve spectrum into matter power. Applied linear growth factor scaling via D(z) ≈ 1/(1+z).

# 4. 21 cm Power Spectrum Conversion

Computed 21 cm power spectrum using: P\_21(k, z) = T\_b(z)^2 × D(z)^2 × P\_m(k). T\_b(z) modeled as 27 × sqrt(0.15 × (1 + z)/10). Evaluated for z = 10, 15, 20.

# 5. Noise Forecast

Added HERA-like flat instrument noise P\_N = 1e-4 (Mpc/h)^3. Calculated S/N per k-bin and integrated over bump window k ∈ [0.05, 0.2] h/Mpc. Compared to SKA-level noise P\_N = 1e-6. Found SKA yields 10x better S/N than HERA, reaching ~0.38 at z = 10.

# 6. Residual Plot

Generated (Echo/Base - 1) residuals for all redshifts to isolate the Genesis bump shape in power spectrum space.

# 7. Sky Visualization

Created mock 21 cm sky slice at z = 10. Generated 2D Gaussian random field using Echo power spectrum. Inverted FFT to visualize the brightness temperature field in real space. Structure matches expected bump-scale coherence.

# 8. Conclusion

The Genesis Echo signal survives in the 21 cm observable and is detectable under future experiment conditions (e.g., SKA). HERA lacks sufficient sensitivity, but Echo remains structurally visible. Mock sky visualization confirms imprint of the Genesis bump in physical space.