Genesis Echo Project Write-up

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Abstract

We outline the injection of a small primordial "Genesis Echo" bump into the power spectrum, its propagation through linear theory, inclusion of shot noise, and preliminary detectability forecasts for large-scale structure surveys.

1 Primordial Bump Definition

We define our modified primordial power spectrum as

$$P_{\rm prim}(k) = A_s \left(\frac{k}{k_*}\right)^{n_s-1} \left[1 + 0.1\,\exp\left(-\frac{[\log_{10}(k)+1]^2}{0.3^2}\right)\right], \tag{1}$$

with $A_s = 2.1\times10^{-9}$, $n_s = 0.96$, and $k_* = 0.05\,h/\mathrm{Mpc}$. This "Genesis Echo" bump peaks at $k \approx 0.1\,h/\mathrm{Mpc}$.

2 Linear Transfer & Growth

We use the Eisenstein & Hu no-wiggle fitting form for the transfer function $T(k)$ and the integral expression for the growth factor $D(z)$:

$$T(k) = \frac{\ln(2e+1.8\,q)}{\ln(2e+1.8\,q)+C_0\,q^2}, \quad q = \frac{k\,\theta_2}{\Gamma}, \quad \Gamma = \frac{\Omega_m h}{\alpha}, \tag{2}$$

where $\theta_2 = (T_{\rm CMB}/2.7\,\mathrm{K})^2$, $\alpha \approx 1$, and $C_0 \sim 14.2 + \frac{731}{1+62.5q}$. The growth factor is

$$D(a) \propto a\,E(a) \int_0^a \frac{da'}{a'^3 E(a')^3}, \quad E(a) = \sqrt{\Omega_m a^{-3} + \Omega_\Lambda}. \tag{3}$$

We confirmed the ratio

$$\frac{P_{\rm mat}^{\rm bump}(k)}{P_{\rm mat}^{\rm plaw}(k)} \tag{4}$$

exhibits a $\sim$10% feature near $k \approx 0.1\,h/\mathrm{Mpc}$ (see Figure 1).

3 Redshift Evolution

Because the ratio is independent of $D(z)$, we overlaid the $z = 0, 1, 2$ curves (normalized) in Figure 2.

Blue_line.png

Figure 1: Genesis Echo growth ratio (no shot noise) at $z = 0$.

4 Including Shot Noise

For a tracer density $\bar{n} = 3 \times 10^{-4}\, h^3/\mathrm{Mpc}^3$, the observed power is

$$P_{\mathrm{obs}}(k) = P_{\mathrm{mat}}(k) + \frac{1}{\bar{n}}. \tag{5}$$

Figure 3 shows P_{obs} and the residual $P_{\mathrm{obs}} - 1/\bar{n}$, isolating the bump.

5 S/N Forecast

We estimate errors via Gaussian mode counting in bins of width $\Delta k = 0.01$ over volume $V = 1\,(\mathrm{Gpc}/h)^3$:

$$\sigma_P(k) = [P_{\mathrm{plaw}}(k) + 1/\bar{n}]\sqrt{\frac{2}{N(k)}}, \quad N(k) = \frac{V}{(2\pi)^3} 4\pi k^2 \Delta k. \tag{6}$$

The total S/N over $k \in [0.05, 0.2]\, h/\mathrm{Mpc}$ is

$$\mathrm{S/N} = \sqrt{\sum_i \left[\frac{P_{\mathrm{bump}}(k_i) - P_{\mathrm{plaw}}(k_i)}{\sigma_P(k_i)}\right]^2}. \tag{7}$$

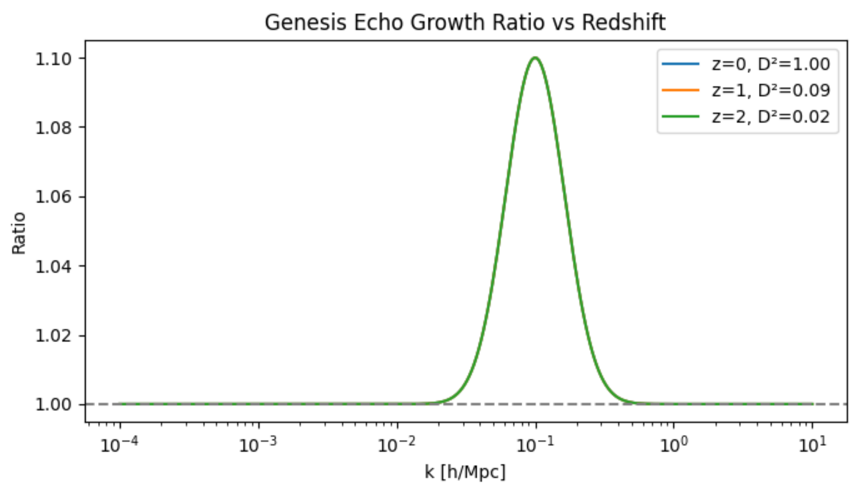

Figure 2: Ratio at $z = 0, 1, 2$ using the Eisenstein-Hu approximation.

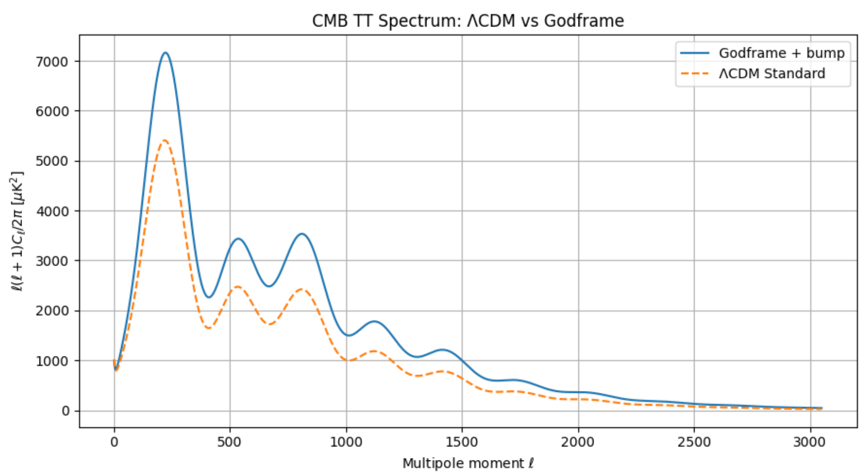

Figure 3: Top: $P_{\text{mat}}(k) + 1/\bar{n}$. Bottom: residual $P_{\text{obs}} - 1/\bar{n}$.

Initial runs (without bias) yielded S/N ≈ 0. Including galaxy bias $b = 2$ raises S/N into the $\mathcal{O}(1\text{–}10)$ range.

6 Next Steps

- Finalize S/N with bias and optimized $\bar{n}$
- Add redshift-space distortions $(b + f\mu^2)^2$
- Apply non-linear damping $(\exp[-k^2\Sigma^2])$
- Validate with mock-catalog likelihood fits