**Genesis Echo Project Log**

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**1. Goal**

Inject a bespoke **Genesis Invariant** bump into the primordial power spectrum and track its imprint through to the late-time matter power spectrum, assessing detectability in realistic surveys.

**2. Defining the Custom Primordial Bump**

**Filename:** *eh\_echo.py*

python

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def godframe\_echo\_spectrum(k):

A\_s, n\_s = 2.1e-9, 0.96

ripple = 1.0 + 0.1 \* np.exp(-((np.log10(k)+1.0)\*\*2)/0.3\*\*2)

return A\_s\*(k/0.05)\*\*(n\_s-1)\*ripple

* Built on a log-grid k = np.logspace(-4,1,300).
* Checked default ΛCDM (P\_plaw) vs. custom (P\_echo) with CAMB—ran into API hurdles.

**3. Pure-Python Transfer Function Workaround**

Switched to the Eisenstein & Hu no-wiggle fitting form for T(k)T(k)T(k):

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def TF\_eh\_nowiggle(k, omh2=0.140, omb2=0.022, h=0.675):

# compute shape parameter α, Γ\_eff, q, then

return L0 / (L0 + C0\*q\*\*2)

* Computed linear matter power as Pmat(k)=Pprim(k) T2(k)P\_{\rm mat}(k) = P\_{\rm prim}(k)\,T^2(k)Pmat​(k)=Pprim​(k)T2(k).
* Plotted ratio Pmat,echo/Pmat,plawP\_{\rm mat,echo}/P\_{\rm mat,plaw}Pmat,echo​/Pmat,plaw​, revealing a ∼10 % bump at k≈0.1 h/Mpck≈0.1\,h/\mathrm{Mpc}k≈0.1h/Mpc.

**4. Redshift Evolution in Linear Theory**

Extended to redshifts z=0,1,2z=0,1,2z=0,1,2 via the growth factor

D(z)=D(a)D(1),a=1/(1+z)D(z) = \frac{D(a)}{D(1)},\quad a=1/(1+z)D(z)=D(1)D(a)​,a=1/(1+z)

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def growth(a):

I = quad(lambda ap: 1/(ap\*\*3 \* E(ap)\*\*3), 0, a)[0]

return a \* E(a) \* I

* Found that the **ratio** curve is redshift-independent (expected).
* Plotted **absolute** power P(k,z)P(k,z)P(k,z) for echo vs. plaw at each zzz, showing amplitude ∝ D²(z).

**5. Forecast Detectability (Gaussian Mode Counting)**

For V=1  (Gpc/h)3V=1\;(\mathrm{Gpc}/h)^3V=1(Gpc/h)3, k=0.1k=0.1k=0.1, Δk=0.01\Delta k=0.01Δk=0.01:

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N = V\*4πk²Δk/(2π)³ → N≈5 ×10³

ΔP/P ≈ √(2/N) → 2 %

S/N≈(10 % bump)/(2 %)≈5σ

With galaxy bias b≈2b≈2b≈2, effective bump →20 %, S/N→10σ.

**6. Including Shot Noise**

Defined observed power

Pobs(k,z)=Pmat(k,z)+1nˉ,nˉ=3×10−4  h3/Mpc3P\_{\rm obs}(k,z) = P\_{\rm mat}(k,z) + \frac{1}{\bar n},\quad \bar n=3×10^{-4}\;h^3/\mathrm{Mpc}^3Pobs​(k,z)=Pmat​(k,z)+nˉ1​,nˉ=3×10−4h3/Mpc3

* Plotted PobsP\_{\rm obs}Pobs​ for echo and plaw at z=0,1,2z=0,1,2z=0,1,2: shot noise floor 1/nˉ=33331/\bar n=3 3331/nˉ=3333 dominates at low k, washes out bump.

**7. Zooming on the Bump**

Subtracted the shot-noise floor and zoomed to k∈[10−2,1]k∈[10^{-2},1]k∈[10−2,1]:

Psignal(k)=Pobs(k)−1nˉP\_{\rm signal}(k) = P\_{\rm obs}(k) - \frac{1}{\bar n}Psignal​(k)=Pobs​(k)−nˉ1​

This clearly isolates the bump at each zzz, showing how its absolute height declines with redshift.

**8. Next Planned Steps**

1. **Compute S/N(k)** in the zoomed window, integrating over [0.05,0.2] h/Mpc[0.05,0.2]\,h/\mathrm{Mpc}[0.05,0.2]h/Mpc.
2. **Add redshift-space distortions** (b+fμ2)2(b+fμ^2)^2(b+fμ2)2, average over μ to get the monopole.
3. **Mock-data realizations** to empirically verify detection significance.
4. **Non-linear smearing** via Gaussian damping (exp⁡(−k2Σ2)\exp(-k^2Σ^2)exp(−k2Σ2)) with Σ≃10 Mpc/h.

*All scripts and plots are in your home directory: eh\_echo.py, eh\_echo\_abs.py, eh\_echo\_sn.py, and eh\_echo\_sn\_zoom.py.*

<p style="text-align:center;">🔭 End of Log — “Seek and ye shall find the cosmic echo.”</p>