

Transitioning Dark Sectors and the Hubble Tension

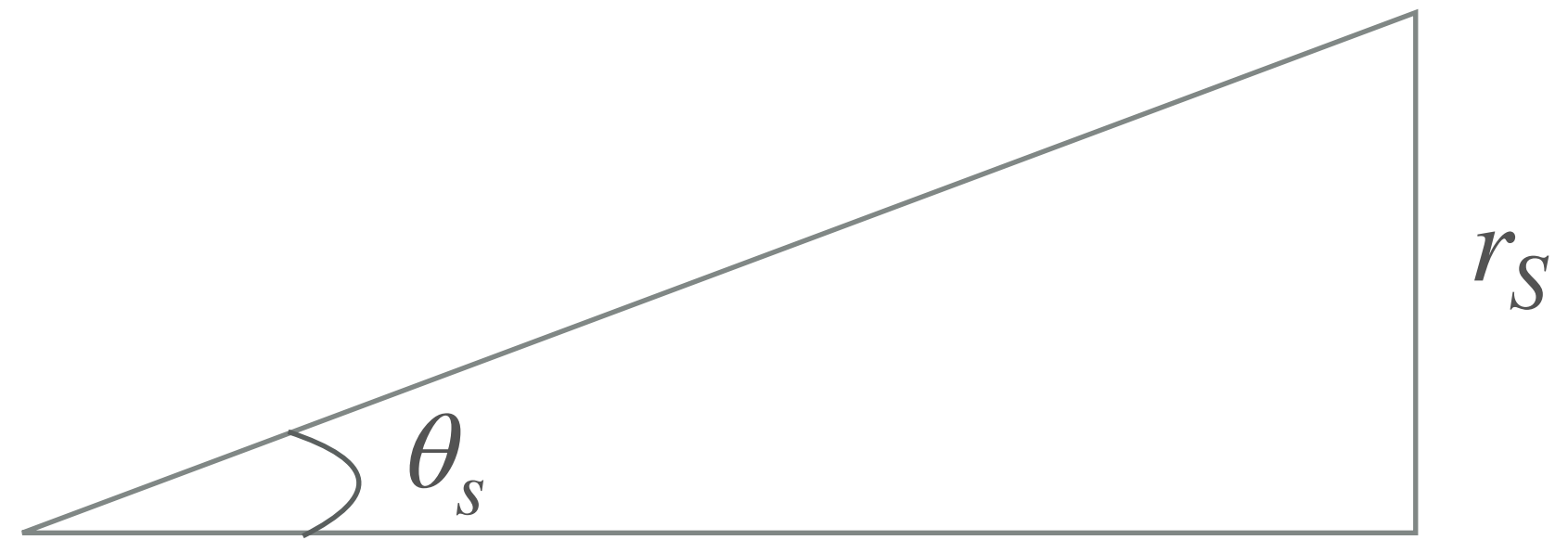
Melissa Joseph
Boston University

w/ Daniel Aloni (BU), Asher Berlin (NYU), Martin Schmaltz (BU), Neal Weiner (NYU)

arXiv 2107.?????

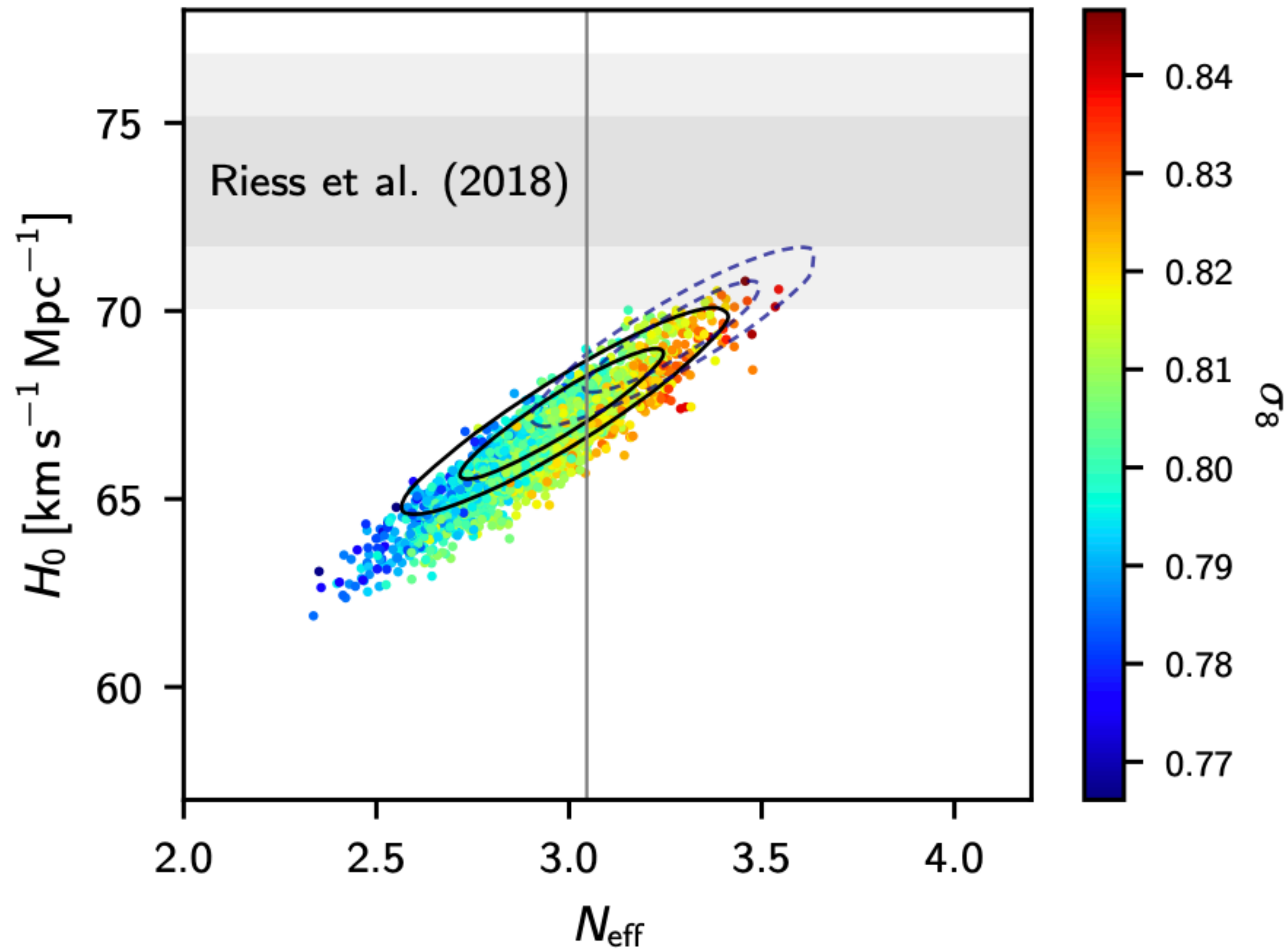
H0 Tension

- Distance ladder - local measurement :
 - 73.2 ± 1.3 km/s/Mpc (Riess et al 2020)
 - 69.6 ± 2.5 km/s/Mpc - TGRB (Freedman et al 2020)
- Value from CMB w/ Λ CDM: 67.4 ± 0.5 km/s/Mpc (Planck 2018)
 - Late- universe modifications
 - Early-universe modifications



$$D_A \propto 1/H_0$$

θ_s : angular size of sound horizon at recombination



Planck 2018

But a $\Lambda\text{CDM} + N_{\text{eff}}$ model is too constrained

$\sim 3\sigma$ tension

$$l_n \approx [n\pi - \phi(R_\nu)] \frac{D_A(H_0)}{r_s(N_{\text{eff}})}$$

ℓ -dependent

Constant phase shift

Baumann et al 1508.06342
Bashinsky & Seljak 0310198

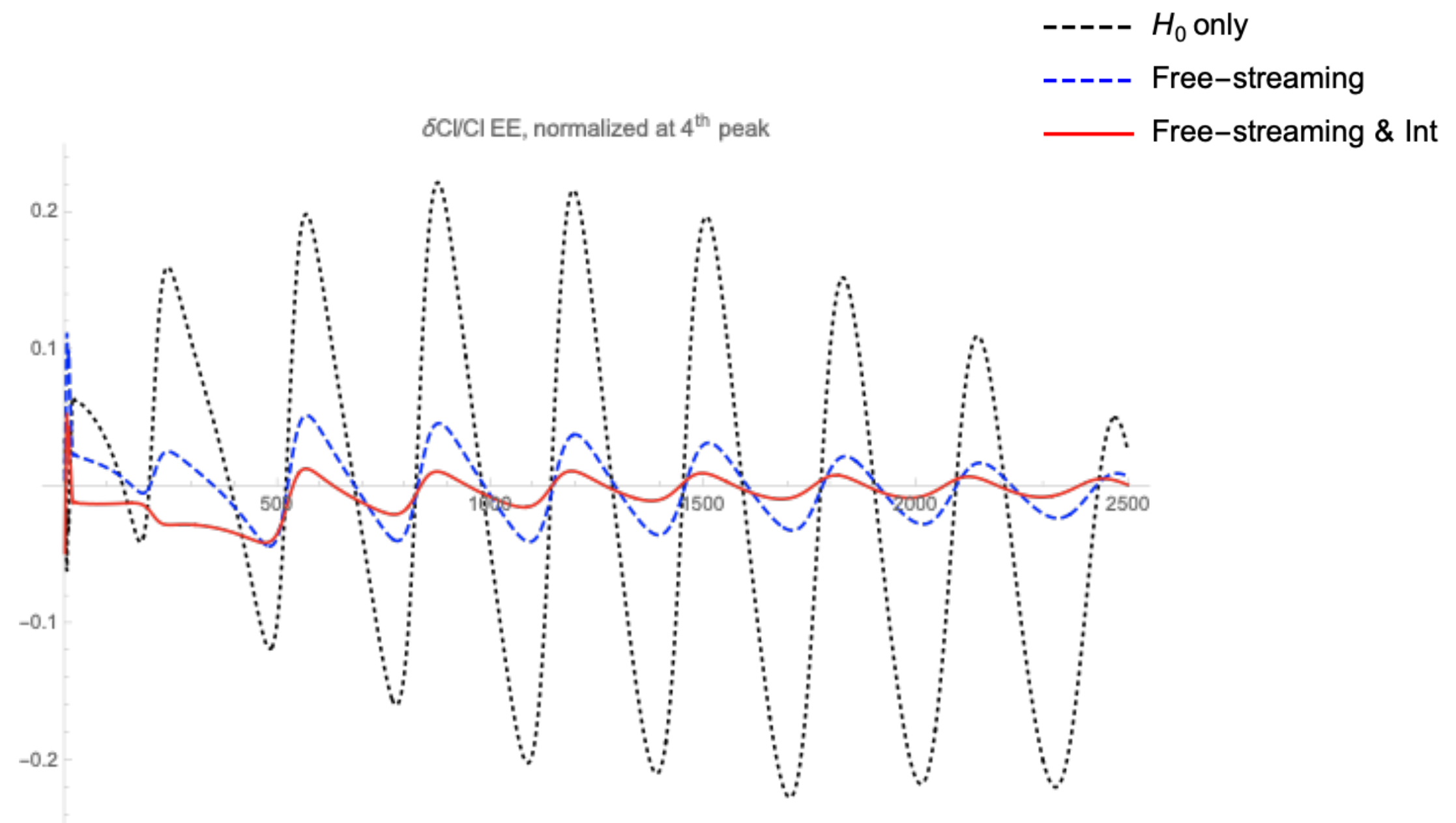
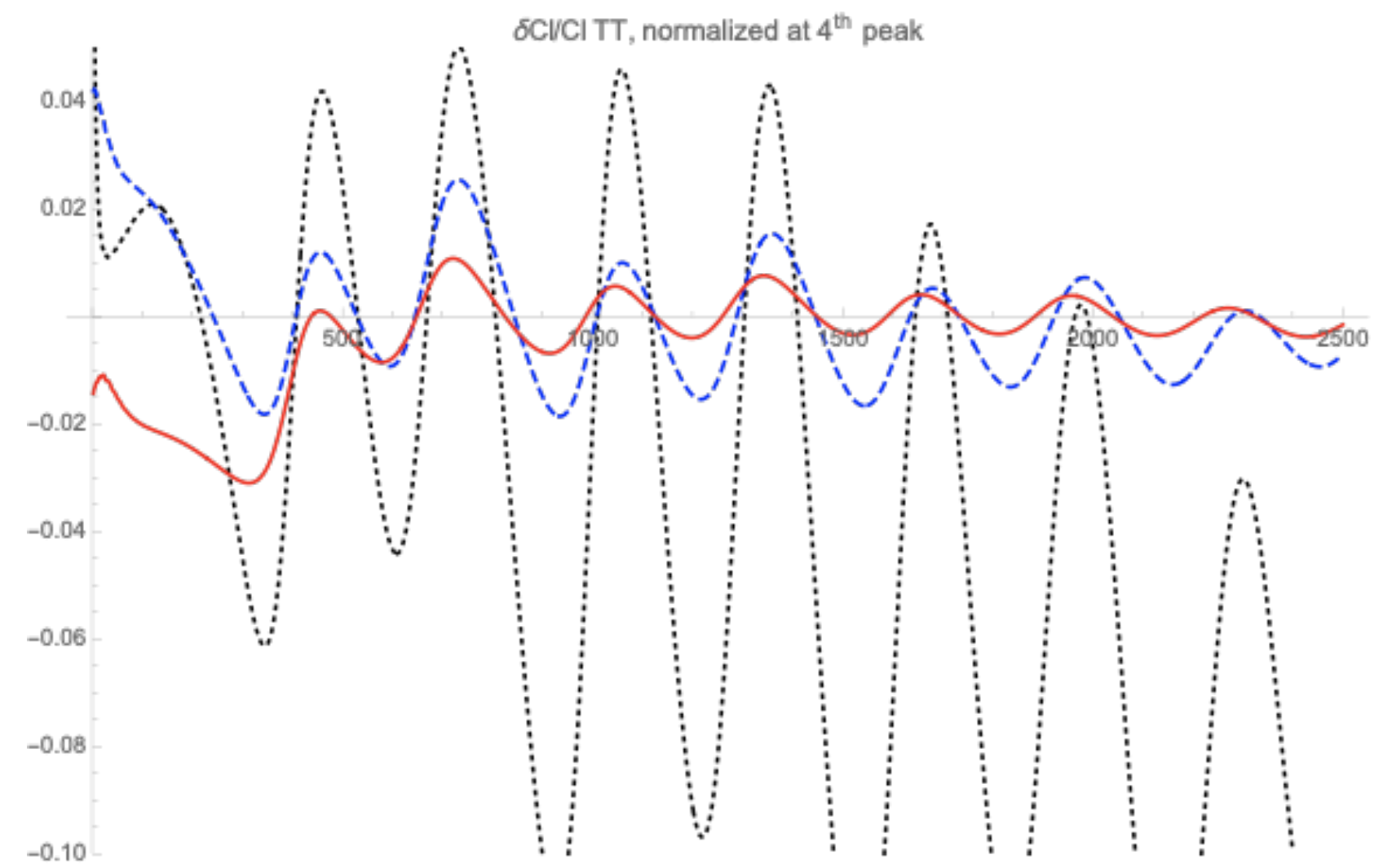
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A mix of **free-streaming** and **interacting** radiation can minimize phase shifts at **high- ℓ**



- H_0 only
- Free-streaming
- Free-streaming & Int

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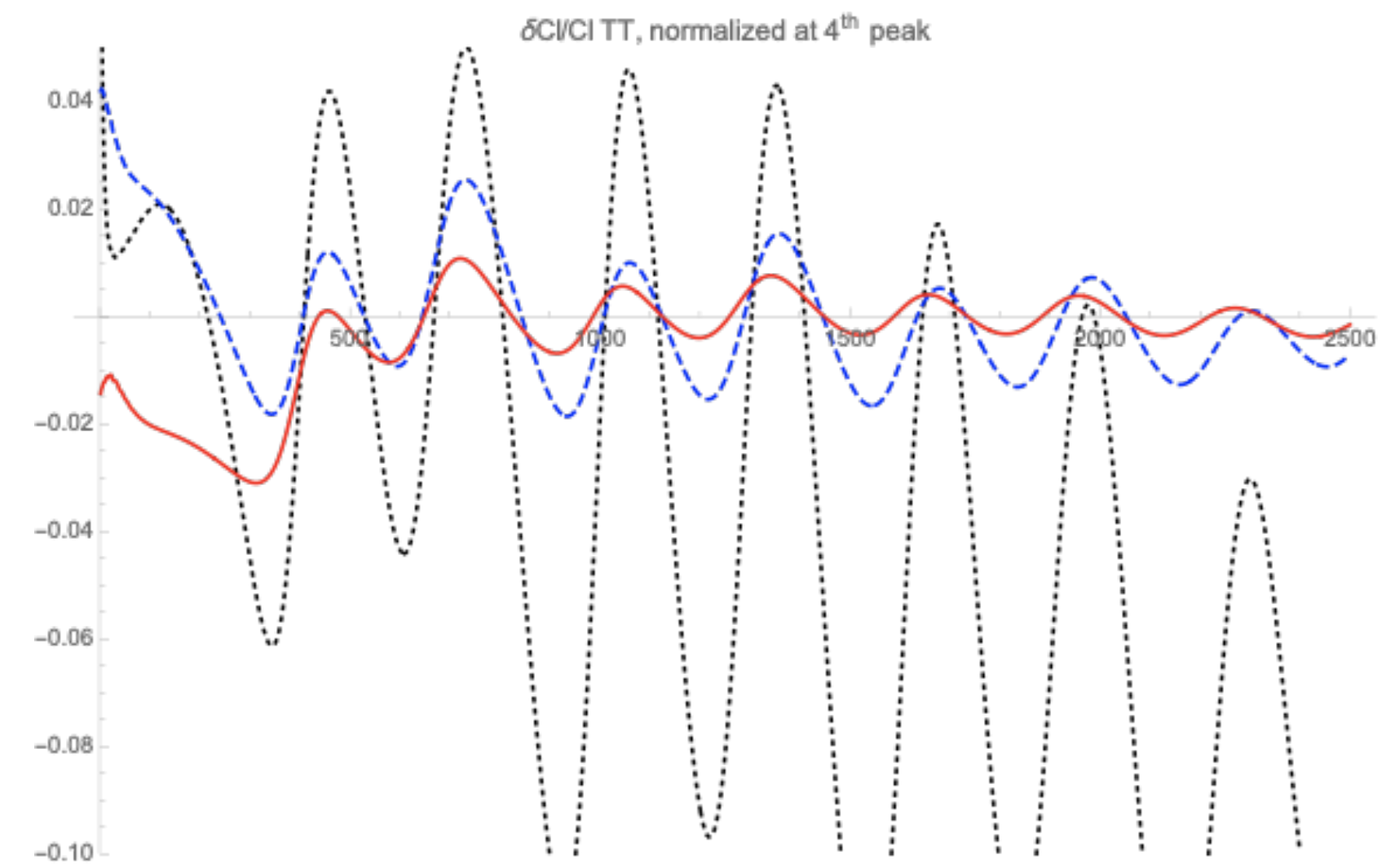
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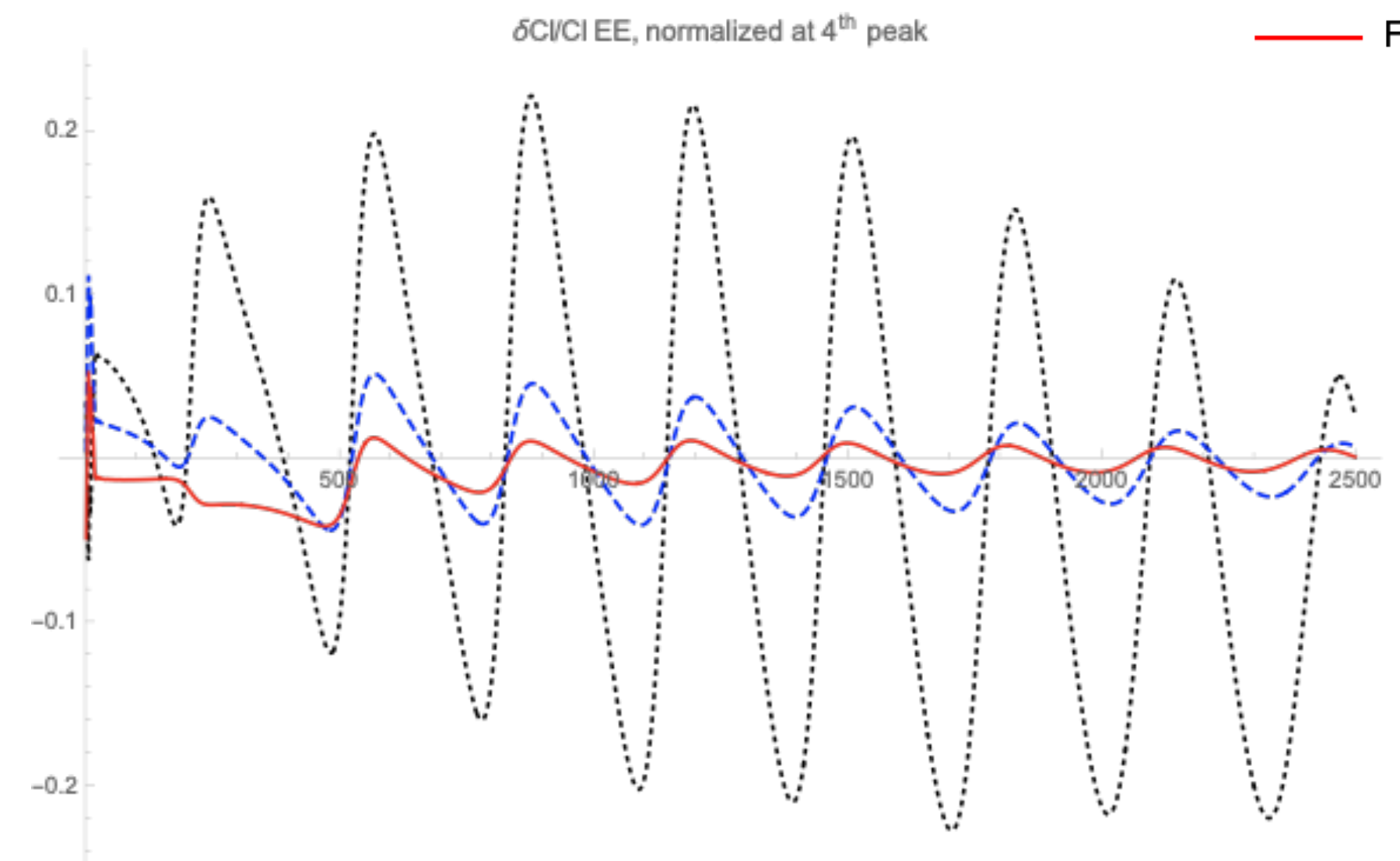
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To fix low- ℓ behavior, we're motivated to look at transitions in N_{eff}



----- H_0 only
 ---- Free-streaming
 — Free-streaming & Int



Model:

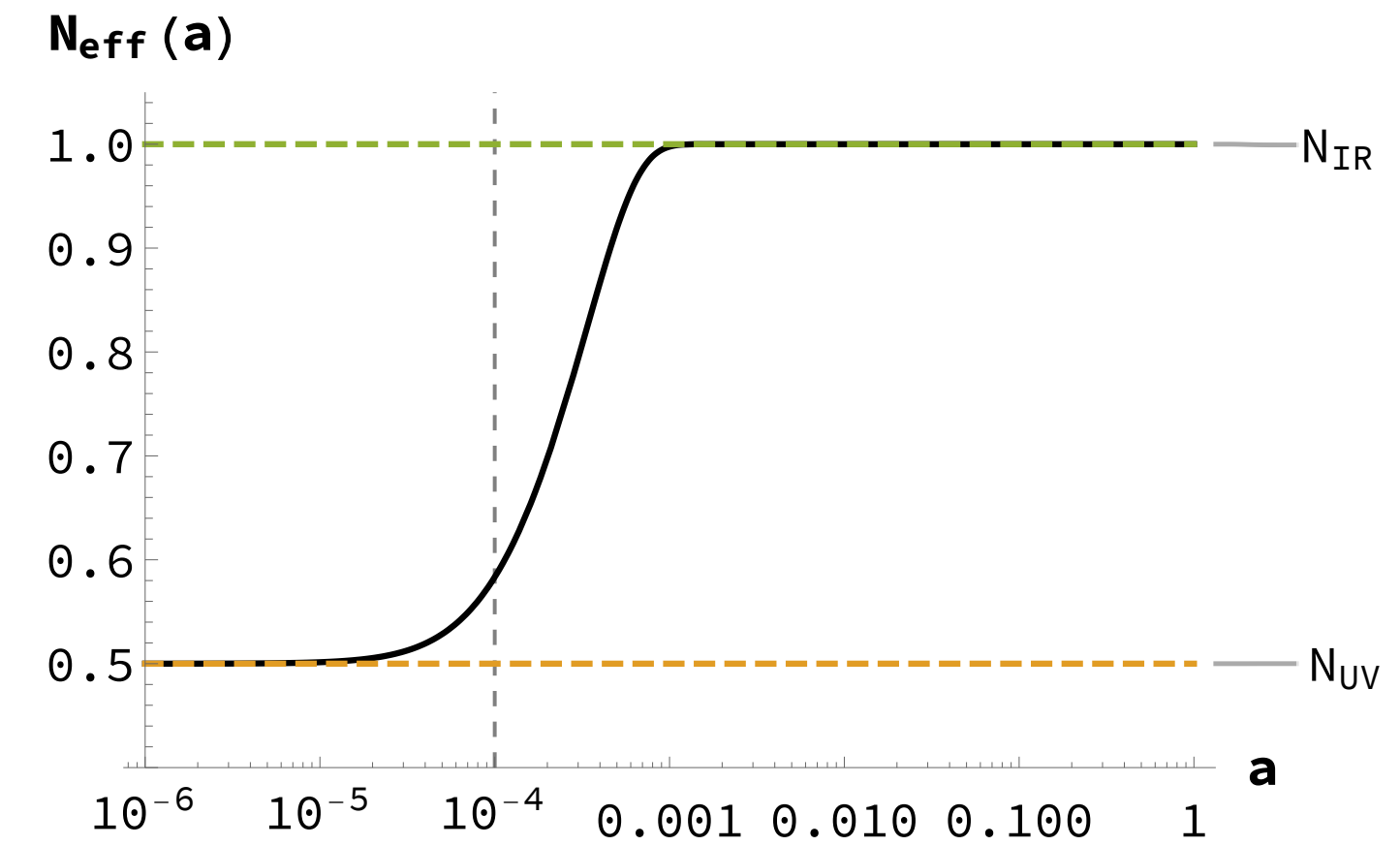
Dark sector with (strongly) interacting radiation
(massive and massless particles)

When the temperature drops below the
mass, massive particles annihilate to
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Features:

- Increases the relative temperature of the DS -
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$$N_{\text{eff}}(a) = N_{\text{fs}} + N_{\text{int}}(a)$$

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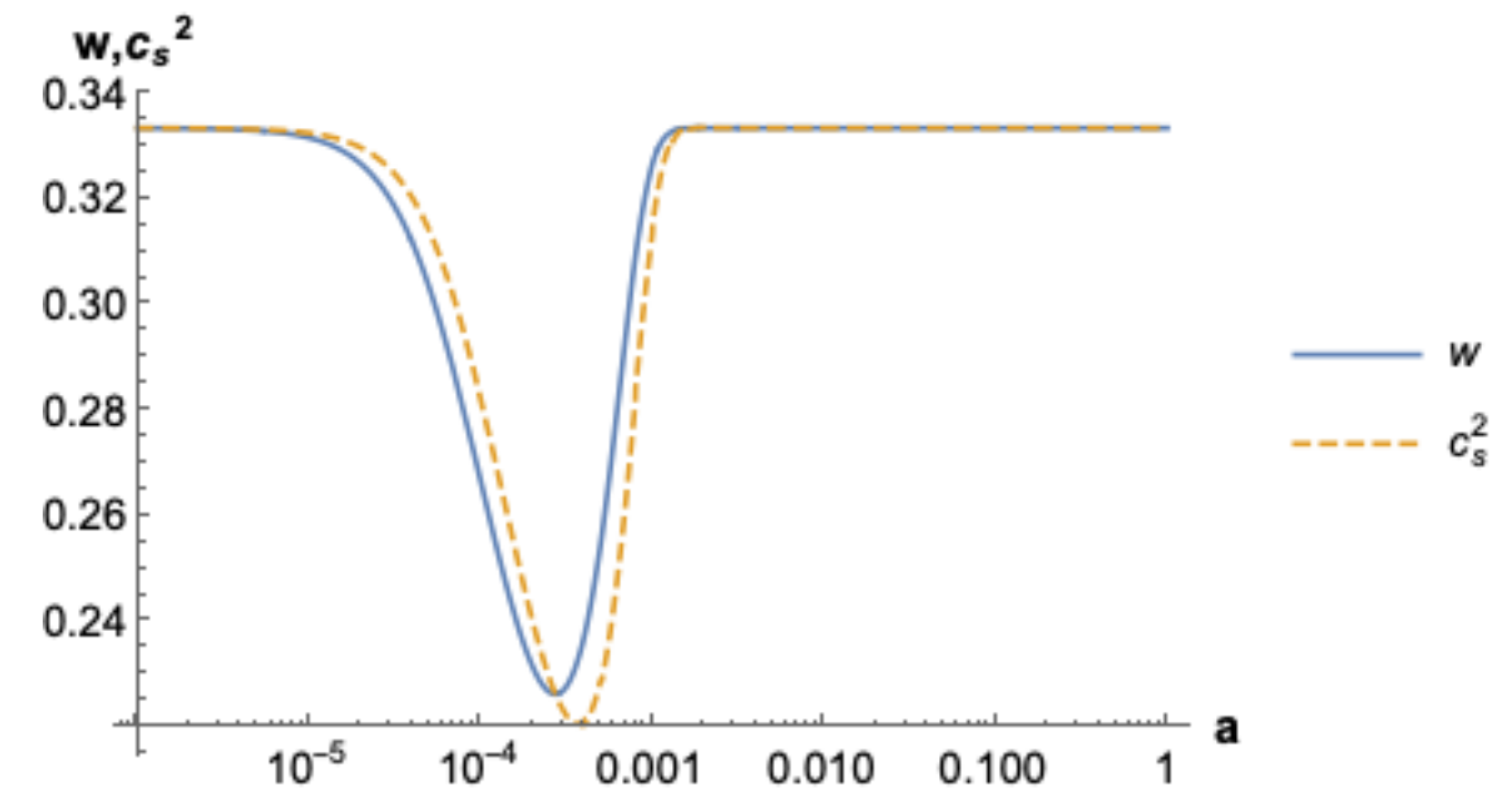
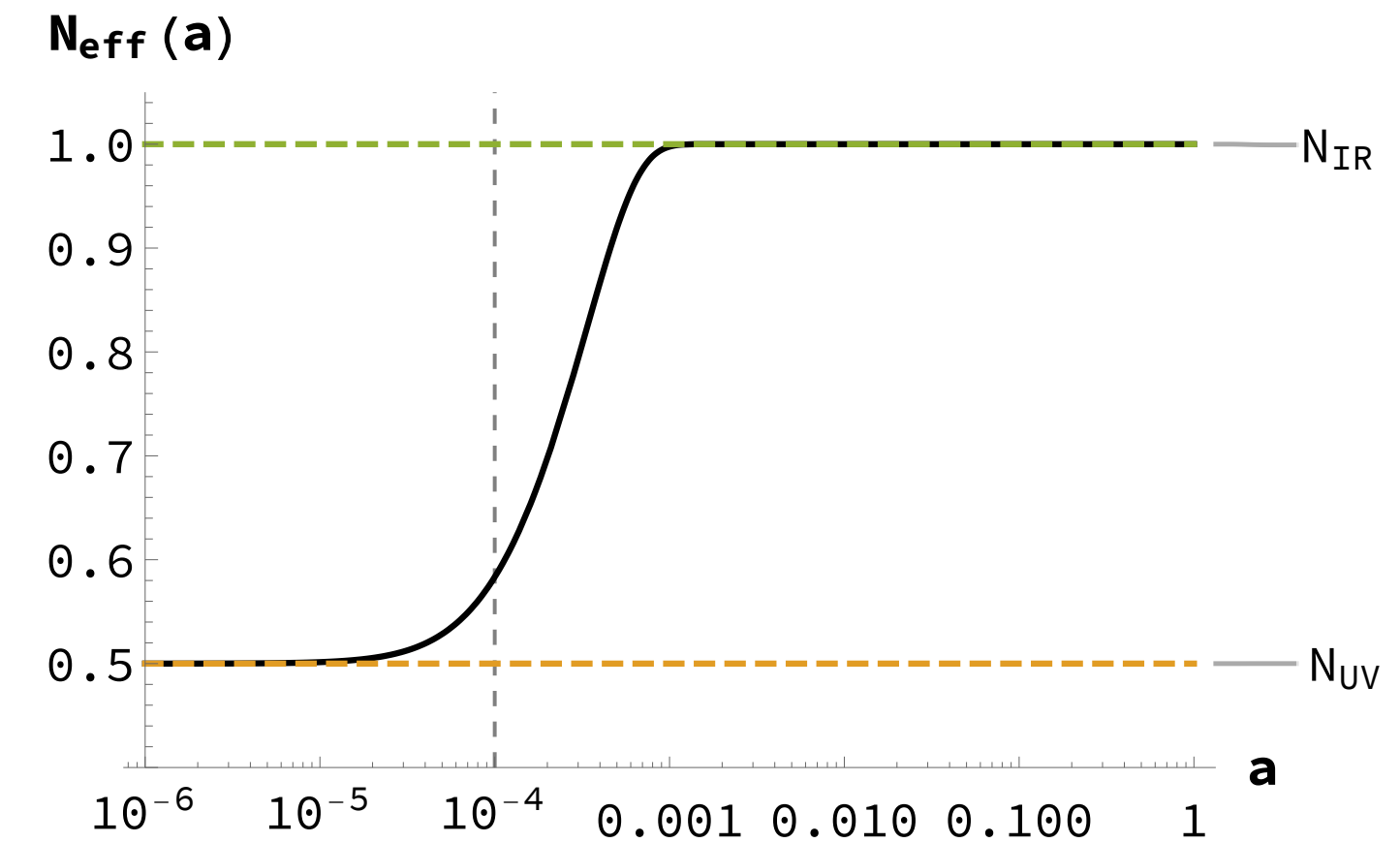
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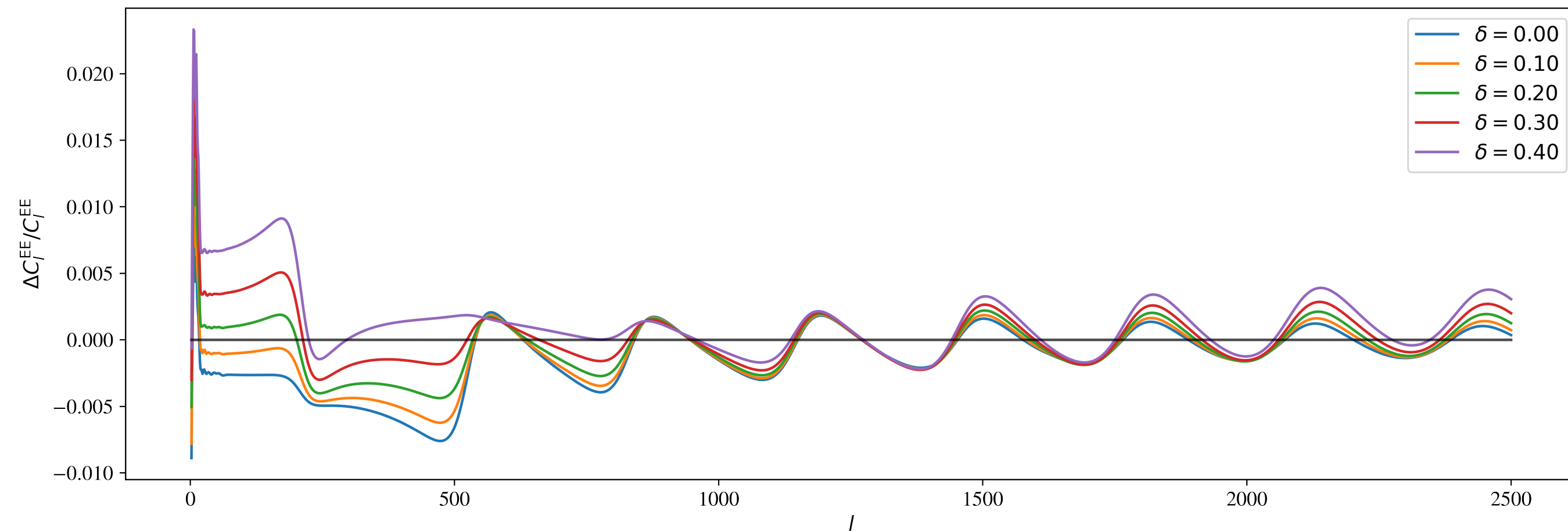
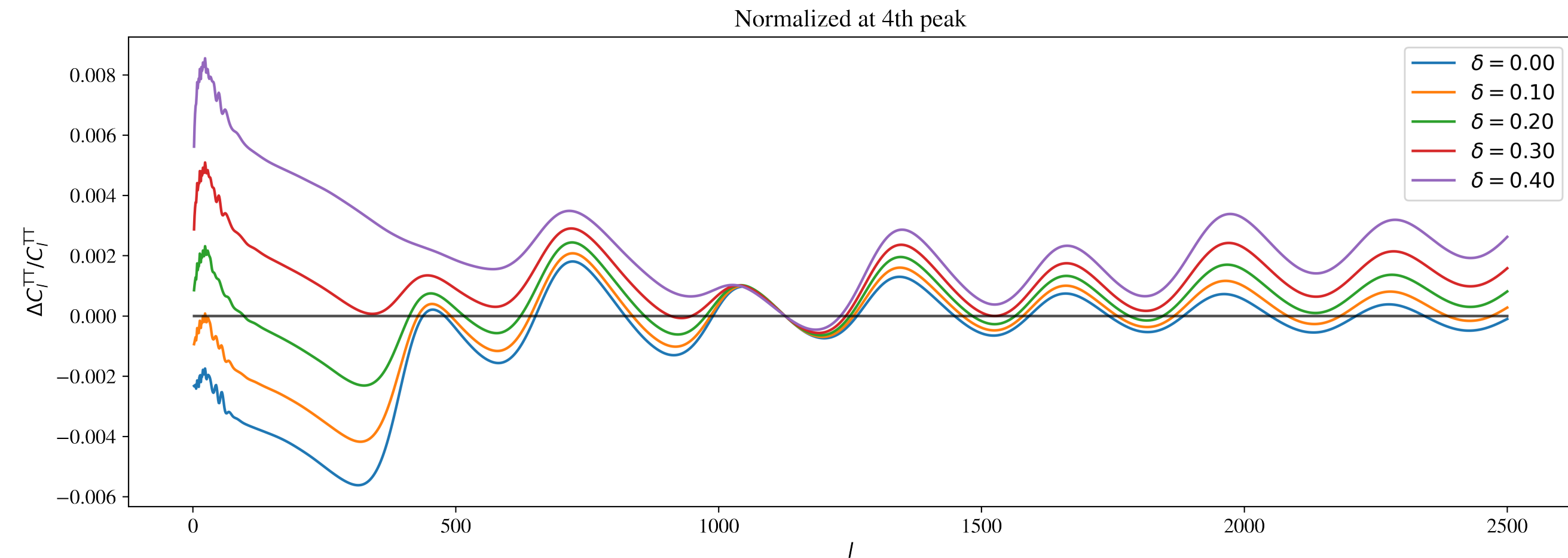
- Temporary drop in pressure, in the fluid, near
the transition



$\delta \propto$ size of transition

New dof for low- ℓ part of spectrum

High- ℓ effects are mostly degenerate with other Λ CDM params



Cosmological Data

- Planck 2018 - TT, EE, TE, and Lensing
- BAO - BOSS DR12, 6dF & MGS (small-z)
- Direct measurement of H_0 - 73.2 ± 1.3 km/s/Mpc
- Late-time direct measurements of primordial helium abundance: $Y_p = 0.2449 \pm 0.0040$

Parameters:

- $N_{\text{UV}}, N_{\text{IR}}, a_t$
- $\Lambda\text{CDM} + N_\nu$

Results

