

Lagrangian perturbative bias expansion with N-Body simulations

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Basic Idea

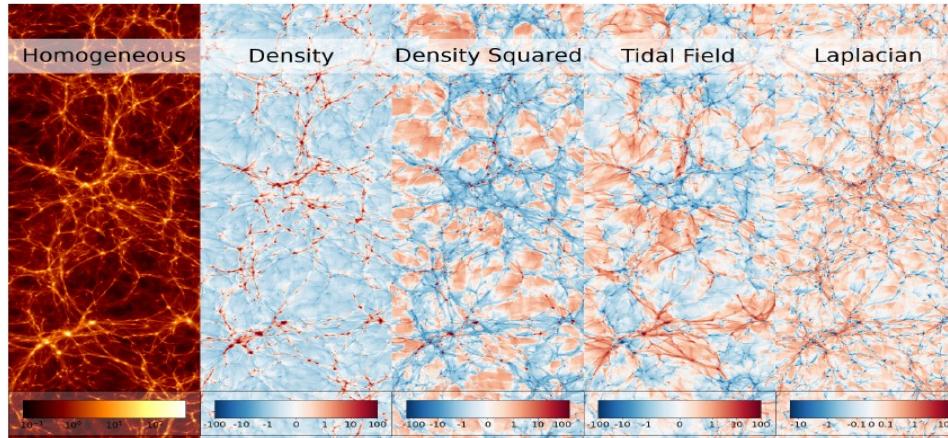
$$\delta_g(\mathbf{q}) = 1 + b_1 \delta(\mathbf{q}) + b_2 \left[\delta^2(\mathbf{q}) - \langle \delta^2 \rangle \right] + b_{s^2} \left[s^2(\mathbf{q}) - \langle s^2 \rangle \right] + b_{\nabla^2 \delta} \nabla^2 \delta(\mathbf{q})$$

Overdensity mapping between galaxies and dark matter in lagrangian coordinates
(Politzer&Wise1984, Jensen&Szalay1986, Desjacques,Jeong&Schmidt2019)

$$\delta_h(\mathbf{k}) \equiv \int d^3x (1 + \delta_h(\mathbf{x})) e^{-i\mathbf{k}\cdot\mathbf{x}} = \int d^3q (1 + \delta_h(\mathbf{q})) e^{-i\mathbf{k}\cdot(\mathbf{q}+\psi(\mathbf{q}))}$$

Time evolution (eg. Schmittfull et al. 2019)

All fields taken from N-body simulations! (Modi,Chen&White2019)



(Zennaro et al. 2021)

Difference w.r.t. LPT

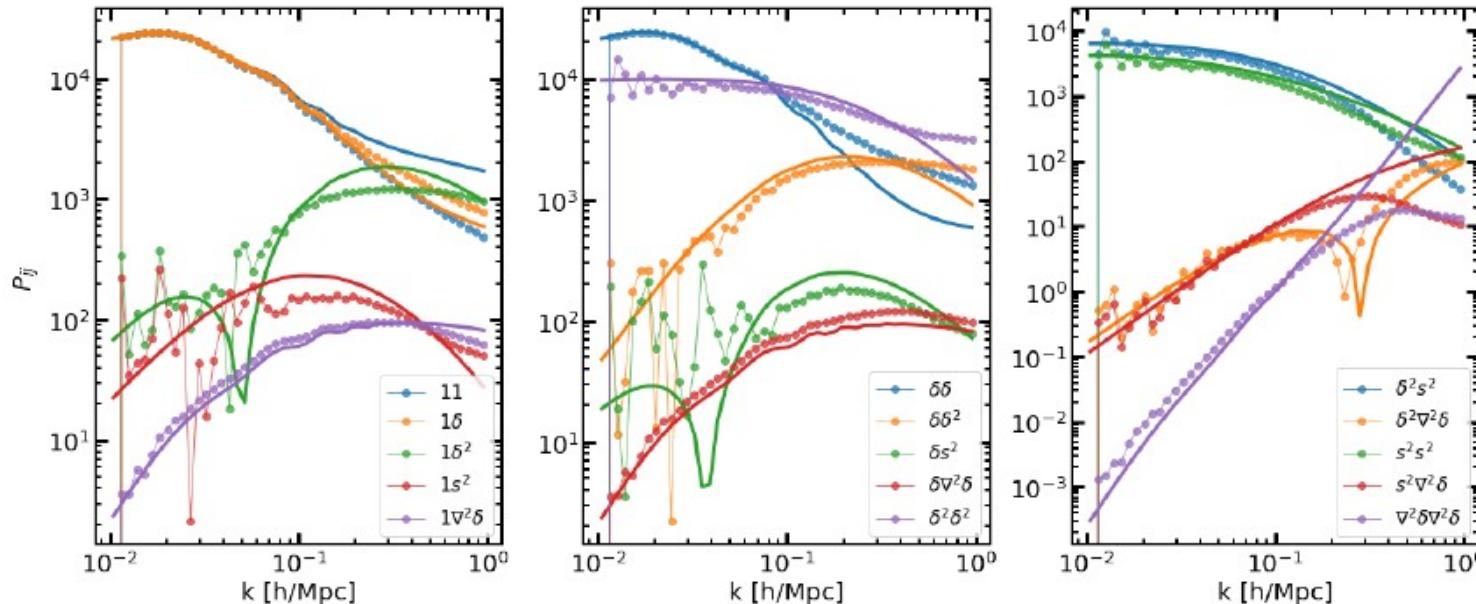
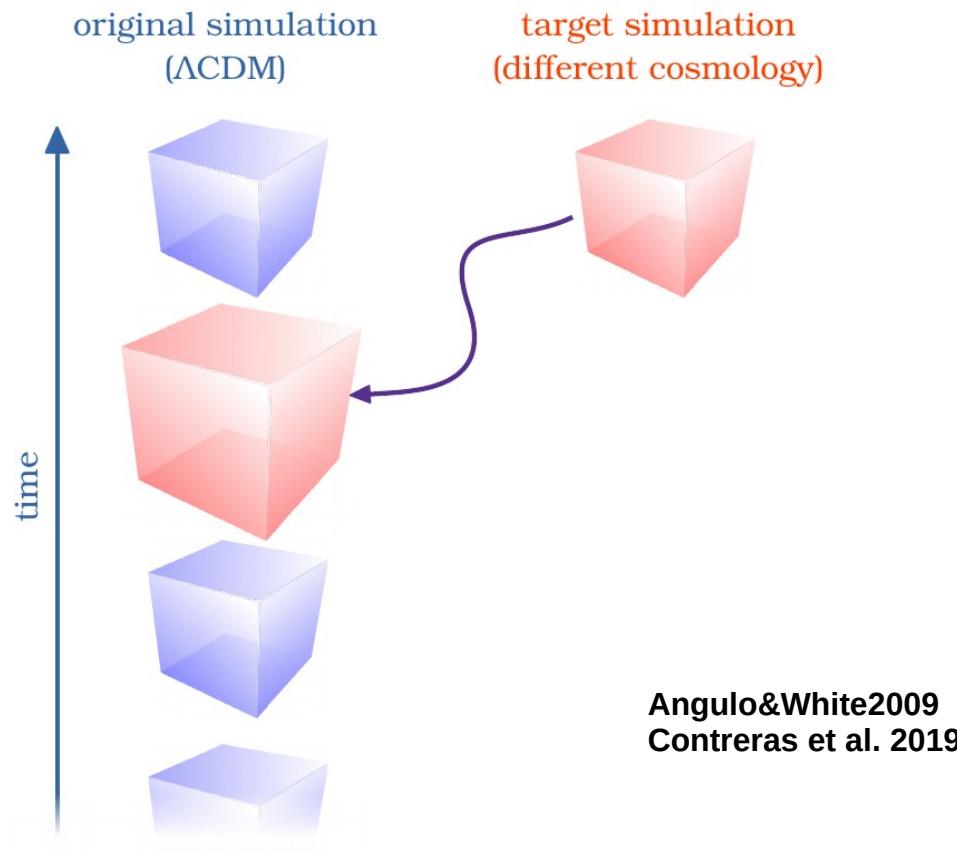


Figure 4. The cross spectra of various Lagrangian fields advected to Eulerian space, P_{ij} where $i, j = \{1, \delta, \delta^2, s^2, \nabla^2 \delta\}$. Symbols display the measurements employing a randomly-selected cosmology from our training data at $z \sim 0$. We note that these measurements corresponds to cosmology-rescaled high-resolution simulations, which have been created with the “Paired-&-Fixed” method. For comparison, solid lines show the predictions of our analytic LPT calculation for each respective cross-spectrum.

Scaling to different cosmologies

Cosmology scaling algorithm

- From original to target
- Find length and time scaling that minimize difference in linear fluctuations
 $\sigma(R), R \in [0.1, 10] h^{-1} \text{ Mpc}$
- Corr. large scale modes
- Corr. nonlinear velocities
- Corr. halo concentration



Scaling to different cosmologies

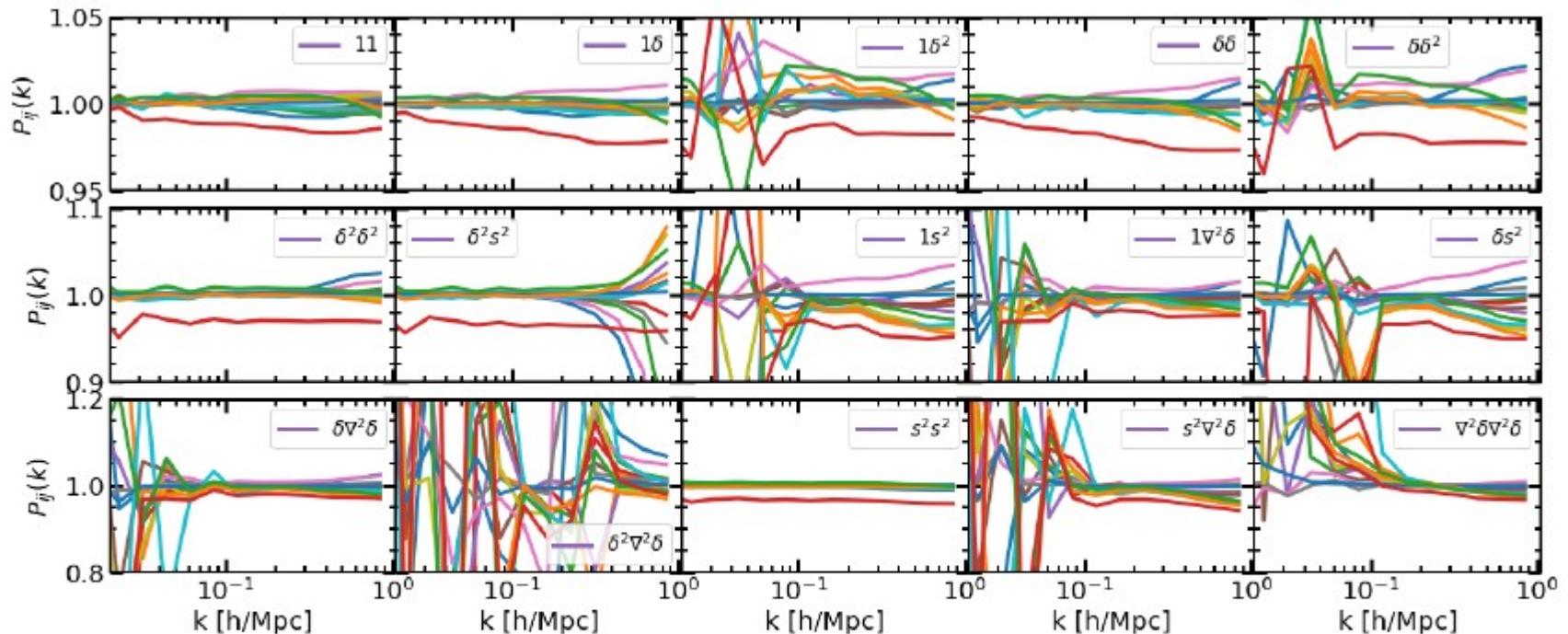
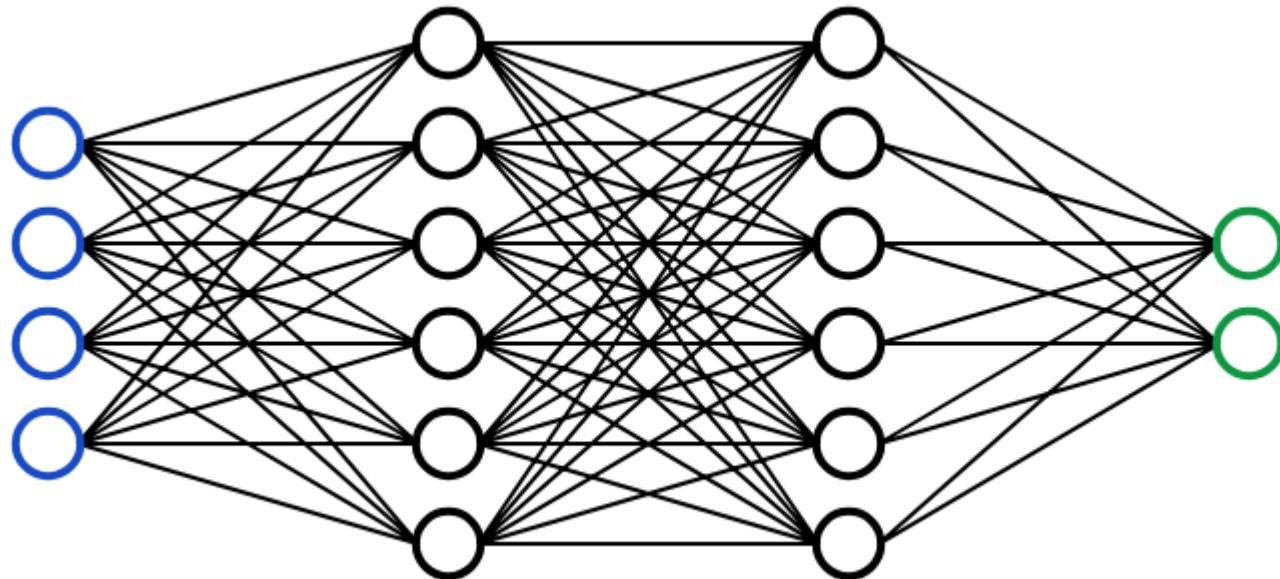


Figure 2. Ratio showing the comparison of the power spectrum of linear lagrangian fields advected to Eulerian coordinates as predicted by N -body simulation and by cosmology-rescaled simulations. Each panel displays the results for the cross-spectra of different linear fields, P_{ij} , as indicated by the legend; whereas lines of different colours shows different cosmological models in our test suite, which includes dynamical dark energy an massive neutrinos.

Emulator



Emulator

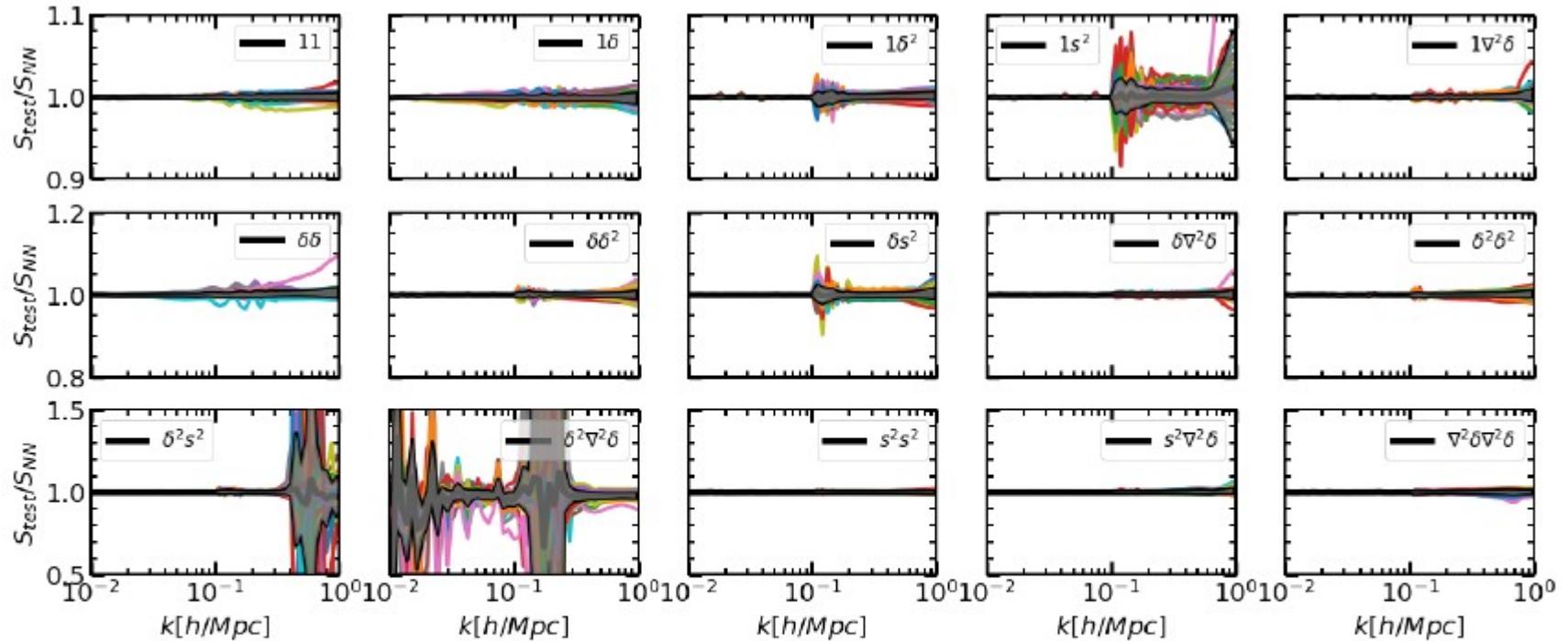
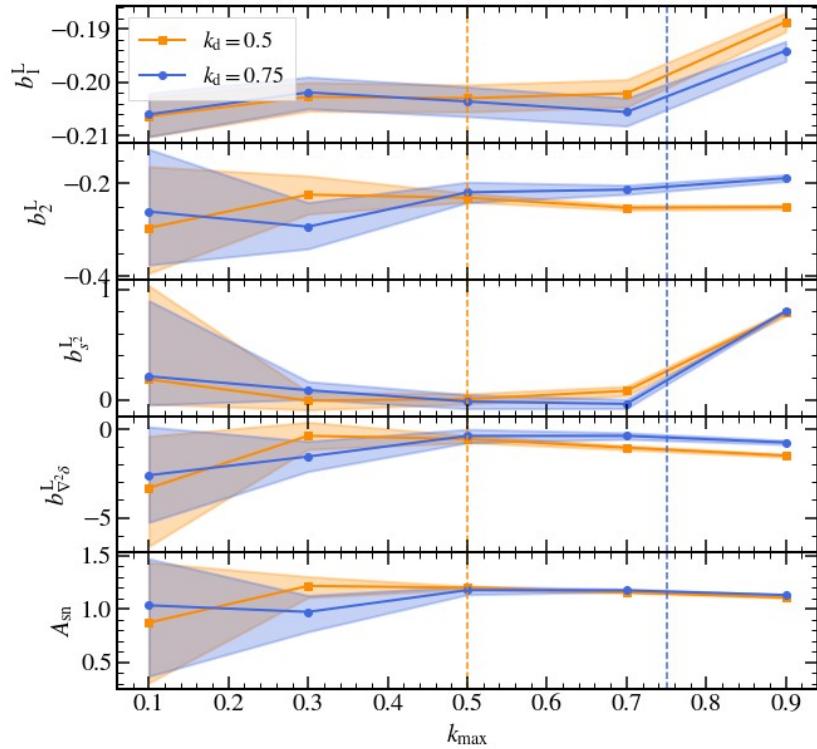
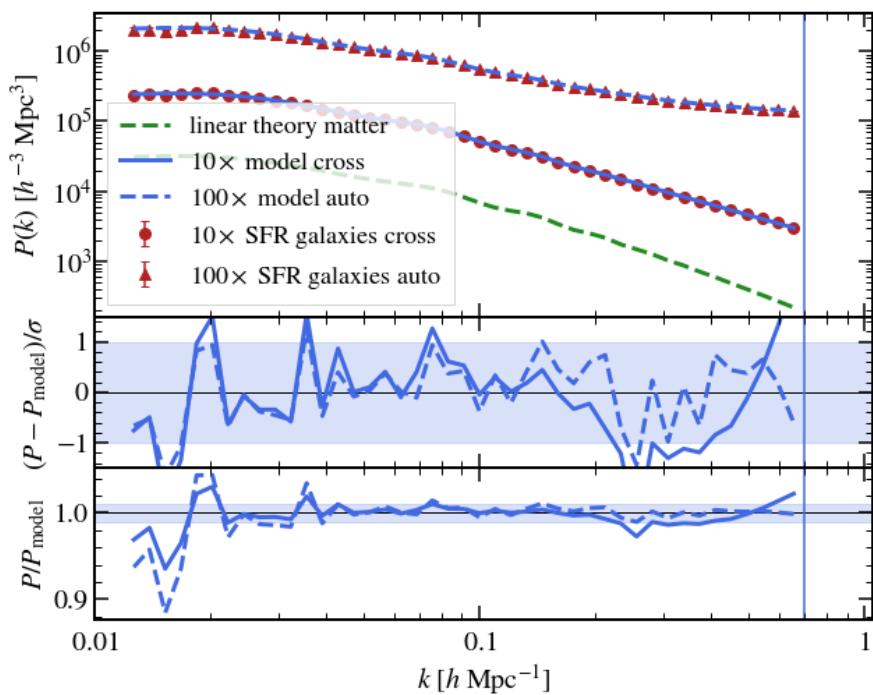


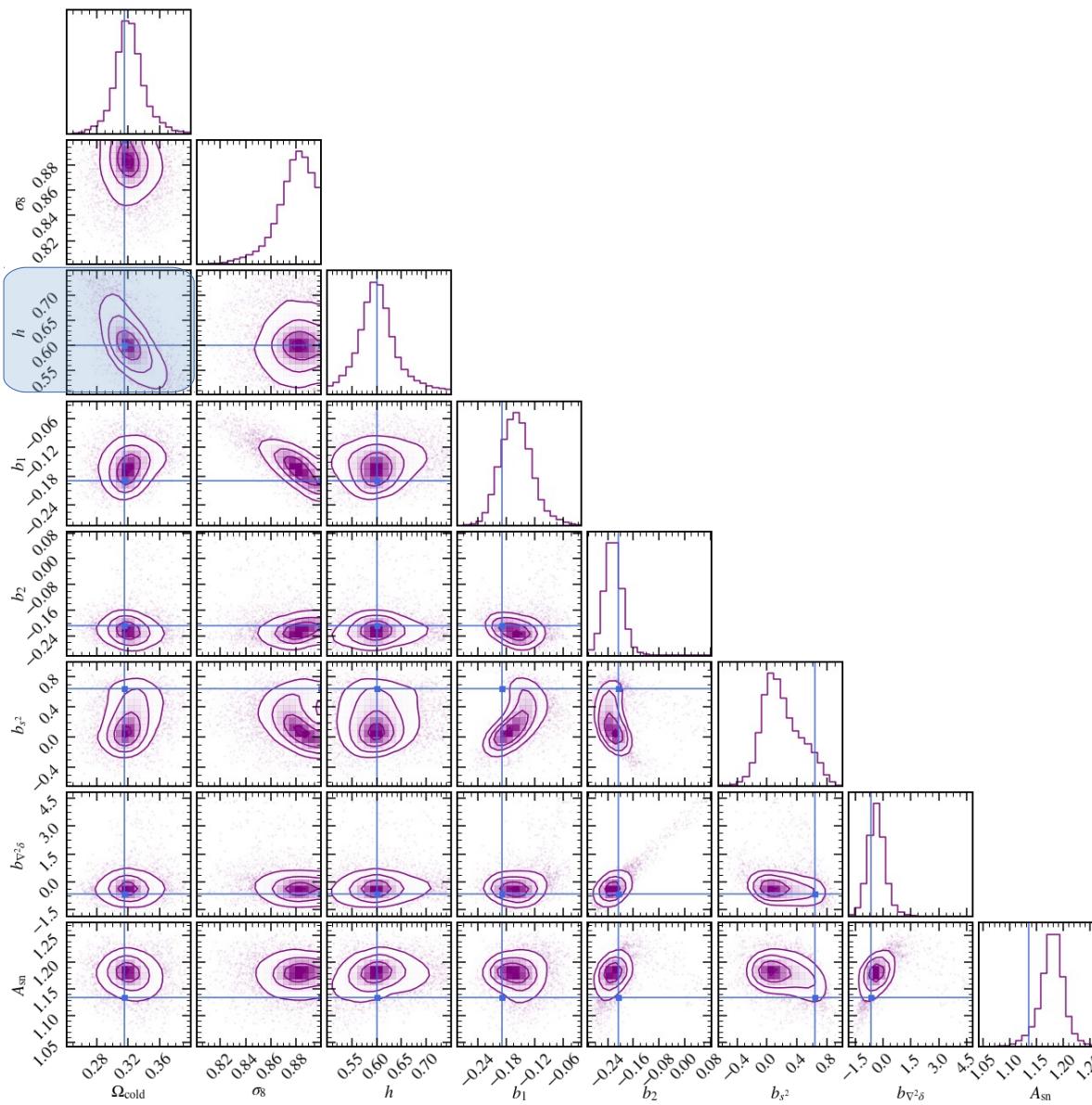
Figure 5. Ratio between the cross spectra in our validation set over the predictions of our neural network emulation. As in previous plots, each panel display results for a different combination of Lagrangian fields in Eulerian coordinates. Lines of different colour show specific test cosmologies, whereas shaded regions denote the are enclosing 95% of the distribution with the mean indicated by the tick black line. Note the predictions are percent accurate over most cases, and the largest fractional discrepancies occur when the emulated quantities crosses zero.

(Zennaro et al. 2021)

Results



We can
constrain
cosmological
parameters!



(Zennaro in prep. 2021)