Modeling the Lyman alpha forest for next-generation surveys
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Extracting cosmological information from the Lyman alpha forest power spectrum requires predictions for the clustering of neutral hydrogen clouds as a function of cosmological model and IGM properties. These predictions require running many large simulations which explore parameter space, or using fewer simulations fed into an emulator which predicts unexplored parameter space. The best way forward is currently unclear. In this project, we are working out applications of paired and fixed simulations, where you invert the initial conditions, to constrain cosmology from the lyman alpha forest (arxiv:1511.04090). The paired and fixed simulations can minimize the statistical noise in the extracted observables from each parameter choice, and can therefore serve as better sparse samples of the parameter space to feed into an emulator.

As a first step, we decided to work through some simplified examples with minimal parameters in paired and fixed simulations to try to understand the best way forward from the modeling point of view for constraining cosmology using the lyman alpha forest. We are using the MP-Gadget code to run the simulations, which is still actively being developed to scale well to large numbers of nodes and therefore evolve the simulation efficiently. Though we only plan to run 2 paired simulations, we will compare to an ensemble of ~50 simulations, so scalable code is appreciated. We will initially test the method on simulations with $256^3$ particles in a 20 Mpc box run to a redshift of 2. After this initial test, we will scale the box size and resolution as needed. We also put together an initial pipeline to project the simulations into the observed power spectrum to compare with observations. This was all built using code developed by Keir Rogers and Simeon Bird.

In general, we will develop a method which uses the paired/fixed simulation technique to minimize statistical noise in a simulation, or a pair of simulations, which represent a cosmological parameter choice. The methods we explore will build a better understanding of the minimal number of CPU hours needed to constrain a cosmological parameter. Efficiently constraining one parameter allows more time per allocation to explore larger numbers of cosmological parameters. These methods will eventually be documented in a refereed paper, and will hopefully guide simulation choices for constraining cosmology with the next generation surveys.

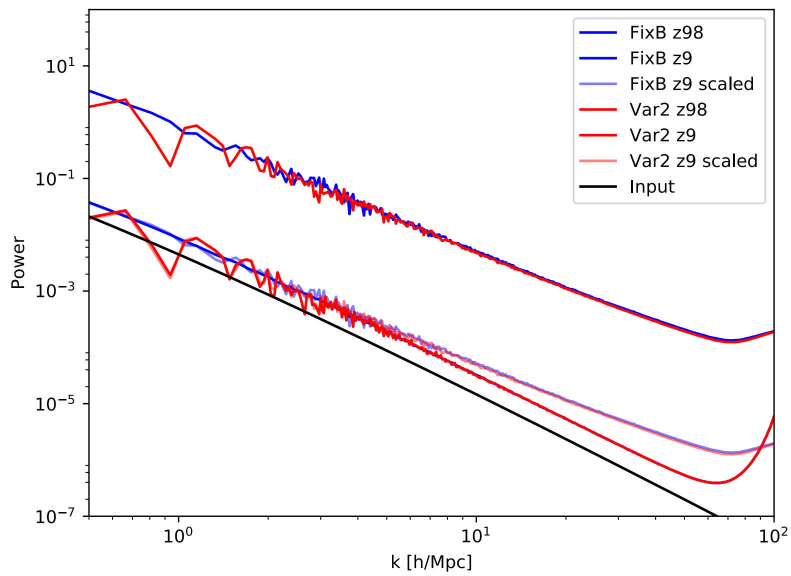


Figure 1: The 3D matter power spectrum for an example of a random simulation (red) compared with one of the fixed and paired simulations (blue), at z = 9 and 98. By fixing the power spectrum you see a decrease in variance at the largest scales, small k. The random and fixed simulations have similar variance at small scales, large k, but the variance will hopefully be equal and opposite to it's pair in the fixed/paired simulation. Only one of the pairs is shown here. The scaled plots, shown with a lighter hue, are scaled down using the linear growth scale to show the simulations are evolving properly.