Redshift Space Power Spectrum Analysis with Density Splits

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Power Spectrum Model

Measuring properties of large scale structures offers a variety of test for cosmological theories. It is common to analyse the clustering of galaxies, whose power spectrum on linear scales is well described by the celebrated Kaiser model [1] and can be easily extended to account for peculiar velocities inside galaxy clusters, yielding the KaiserFoG model.

Density Splits

Partitioning the mock catalogue by galaxy density produces galaxy fields sampling the same volume of space but with different bias. Here, each density bin contains 10% of all galaxies. Beutler et al. showed that the cross-correlation of such tracer fields reveals relativistic effects which we aim to detect in DESI's BGS data [3].
This project informs if the KaiserFoG model offers accurate enough predictions to be used for this analysis.

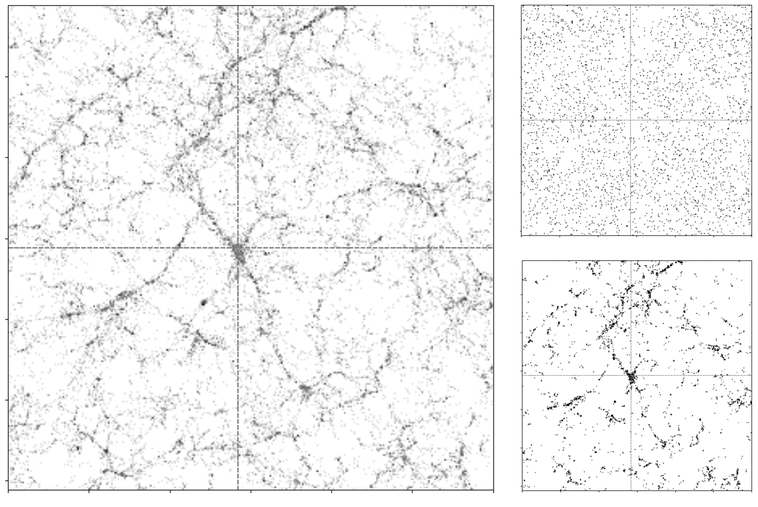

Fig. 1: Full galaxy field (left) near the most massive halo and the contributions from a low and high density bin (top right, bottom right).

Methods

For each density bin, the KaiserFoG model is fitted to simulation data via MCMC on an incrementally enlarged range of k such that results are plotted as functions of k_{max}, the upper bound of the considered k range. Uniform priors and a Gaussian likelihood with a brute force covariance matrix are used.
The quality of the fit is determined by computing the reduced χ^2 while the inferred product of growth rate and matter fluctuation is used to assess the prediction accuracy of the model.

Results

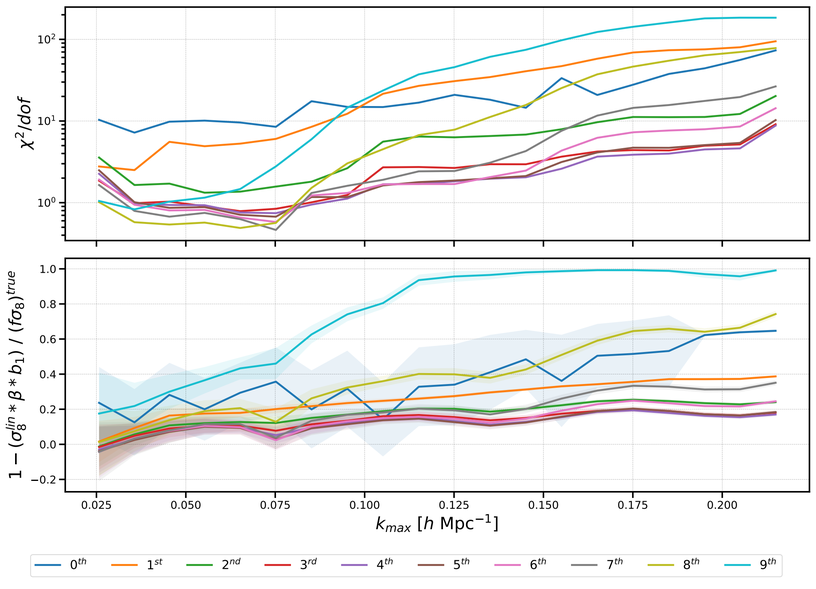

Fig. 2: Reduced χ^2 of the fit (upper) and accuracy of the predicted product of growth rate and matter fluctuation within a sphere of radius 8 Mpc/h (lower). The i^{th} bin contains galaxies with densities in the interval set by the $10*i$ % most dense and $10*(i+1)$% most dense galaxy.

Conclusion

Scan the QR code for the full project report.

- The KaiserFoG model struggles to reproduce the data for bins of extremely low density even in the linear regime. For the remaining density bins, the fit is acceptable for $k_{max} \leq 0.08\,$h/Mpc but afterwards becomes very poor for the highest density bins.
- The predicted $f\sigma_8$ suffers from a large uncertainty in the linear regime and systematic under-prediction on smaller scales, leading to an accuracy of 90% at best. As expected from the quality of the fit, extreme density bins are most problematic. These shortcomings call for a more complex model to be used in the BGS analysis.

References

[1] Nick Kaiser. "Clustering in real space and in redshift space". In: *Monthly Notices of the Royal Astronomical Society* 227 (July 1987), pp. 1–21.

[2] Florian Beutler et al. "Modeling relativistic contributions to the halo power spectrum dipole". In: *Journal of Cosmology and Astroparticle Physics* 2020.07 (July 2020), pp. 048–048.

[3] Omar Ruiz-Macias et al. "Preliminary Target Selection for the DESI Bright Galaxy Survey (BGS)". In: *Research Notes of the AAS* 4.10 (Oct. 2020), p. 187.