Redshift Space Power Spectrum Analysis with Density Splits

Julian Wack and Florian Beutler, Shadab Alam

Power Spectrum Model

Measuring properties of large scale structures offers a variety of tests 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

Splitting a galaxy catalogue by density produces galaxy fields sampling the same volume of space but with different bias. Here, splits into deciles, referred to as density bins, are considered. The cross-correlation of the resulting tracer fields reveals relativistic effects which we expect to detect in DESI's BGS data, providing new tests for gravity on large scales [2, 3].

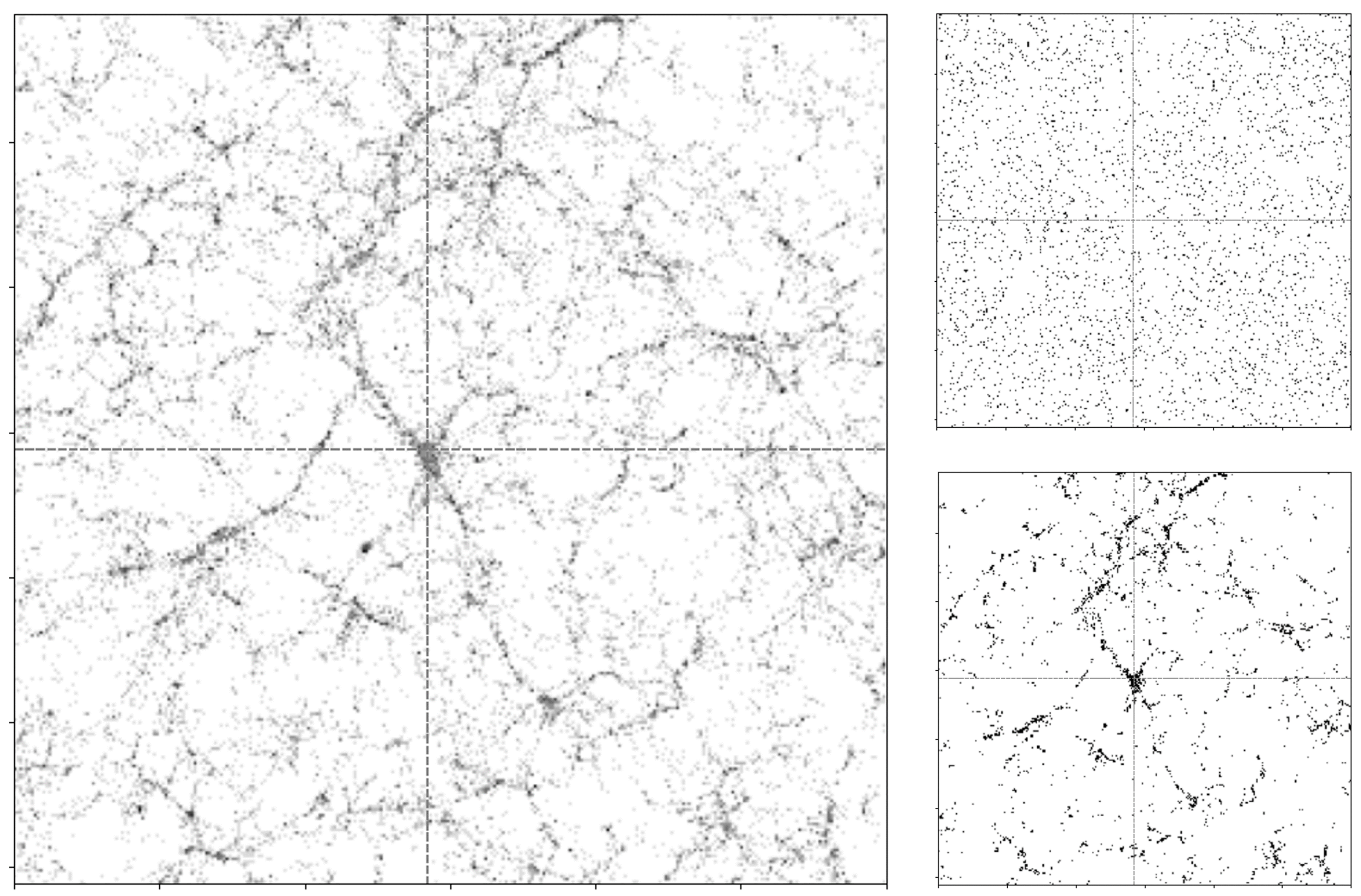

Fig. 1: Full galaxy field (left) near the most massive halo and the contributions from a low and high density bin (top right, bottom right).

Aims and Methods

This project informs up to what scales the KaiserFoG model can reproduce simulation data and if it offers accurate enough predictions to be used in the analysis of BGS data.
For each density bin, the KaiserFoG model is fitted to BGS mock 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 employed.
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

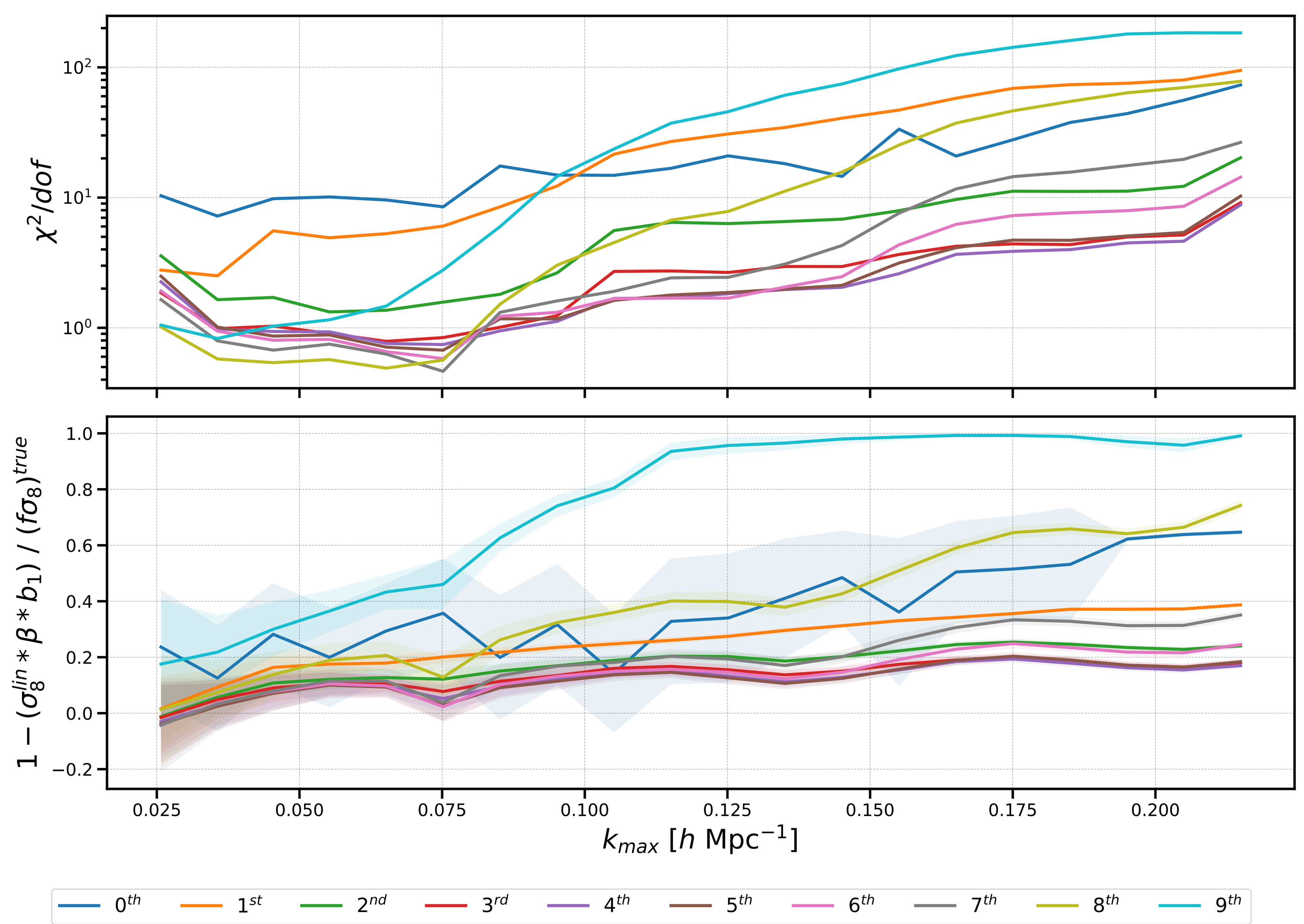

Fig. 2: Reduced χ^2 of the fit (upper) and error of the predicted product of growth rate and matter fluctuation within a sphere of radius 8 Mpc/h (lower). The i^{th} density bin corresponds to the $(i+1)^{th}$ decile.

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 quickly becomes 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 and Enea Di Dio. "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.