# Redshift Space Power Spectrum Analysis with Density Splits

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# Background

**Power Spectrum**

$$\delta(\boldsymbol{r}) \equiv \frac{\rho(\boldsymbol{r}) - \langle\rho\rangle}{\langle\rho\rangle}, \quad \xi(\boldsymbol{r_{12}}) \equiv \langle\delta(\boldsymbol{r_1})\delta(\boldsymbol{r_2})\rangle, \quad P(\boldsymbol{k}) \equiv \mathcal{FT}[\xi(\boldsymbol{r})]$$

**Kaiser Model and Redshift Space Distortions**
$\delta \ll 1$ gives Kaiser model:

$$P^s(k,\mu) = (1+\beta\mu^2)^2 b_1^2 P(k), \quad P^s(k,\mu) \xrightarrow{FoG} e^{-0.5(\sigma k\mu)^2} P^s(k,\mu)$$

# Density Splits

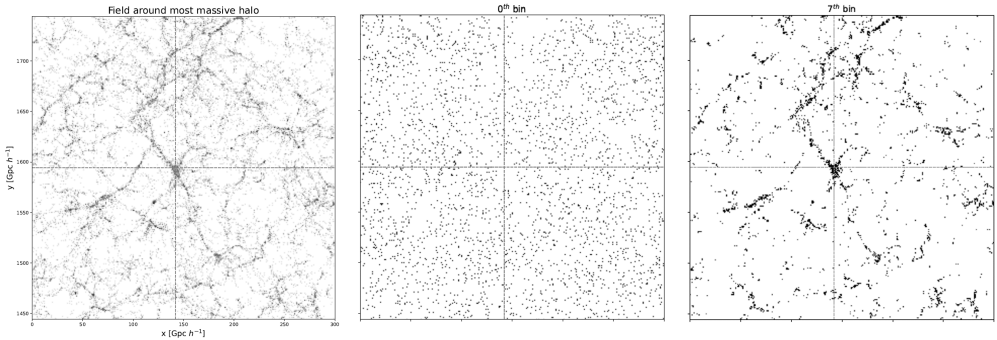


**Figure 1:** Galaxy fields around the most massive halo: all galaxies, $0-10\%$ most dense, and $70-80\%$ most dense.

# Model Fitting

**MCMC Set Up**

i) 3 parameter KaiserFoG model: $[b_1, \beta, \sigma]$

ii) Multipoles: $P^s_\ell(k) = \int_{-1}^{1} \frac{2\ell+1}{2} L_\ell(\mu) P^s(k,\mu) d\mu$
Fit monopole ($\ell = 0$) and quadrupole ($\ell = 2$) only

iii) Gaussian likelihood with $\chi^2 = (\boldsymbol{D} - \boldsymbol{\mathcal{M}})^T \cdot C^{-1} \cdot (\boldsymbol{D} - \boldsymbol{\mathcal{M}})$
$\boldsymbol{\mathcal{M}}, \boldsymbol{\mathcal{D}}$ : Model prediction and data of power spectrum monopole and quadrupole

iv) Uniform priors

# Fitting Results

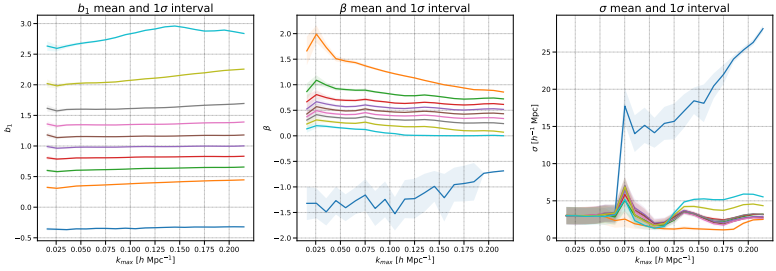


**Figure 2:** Fitted parameters and $\chi^2$ per DoF

# Fitting Results Lowest Density Bin

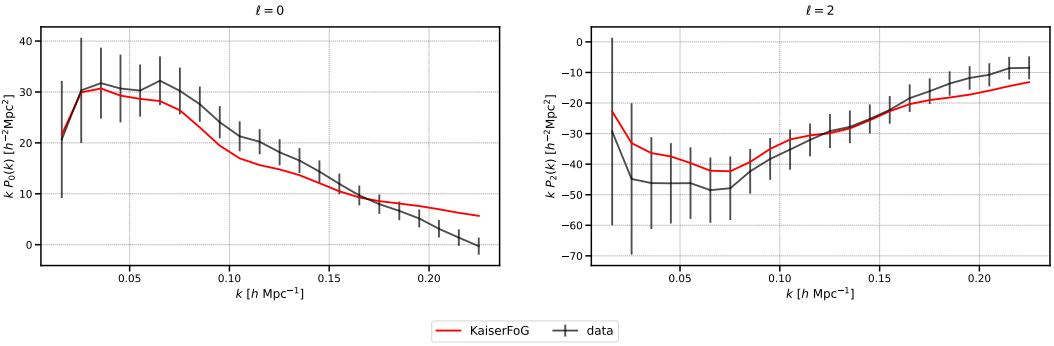


**Figure 3:** Data and model prediction for $0^{th}$ density bin

# Conclusion

**Summary**

i) KaiserFoG model is insufficient for precision cosmology

ii) Regions of extreme density troublesome

**Future Work**

i) Negative quadrupole of $0^{th}$ density bin

ii) Repeat analysis with more sophisticated model

# Backup

# More on Density Splits

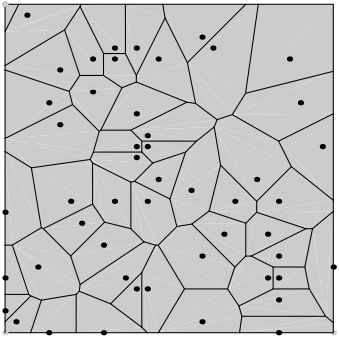

**Figure 4:** 2D Voronoi Tessellation. Taken from [3].

**Alternative to Higher Order Statistics [1]**

i) cross-correlate density bins with galaxy field to capture non-Gaussianities

**Sample Variance Cancellation [2]**

i) density field is biased but not stochastic

ii) testing primordial non-Gaussianity

# Effect of FoG term: Residuals for Lowest Density Bin

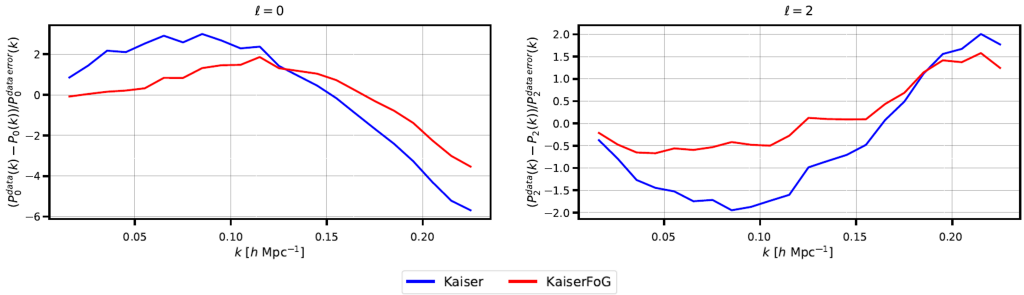


**Figure 5:** Residuals of model predictions for $0^{th}$ density bin

# KaiserFoG Model $f\sigma_8$ Prediction

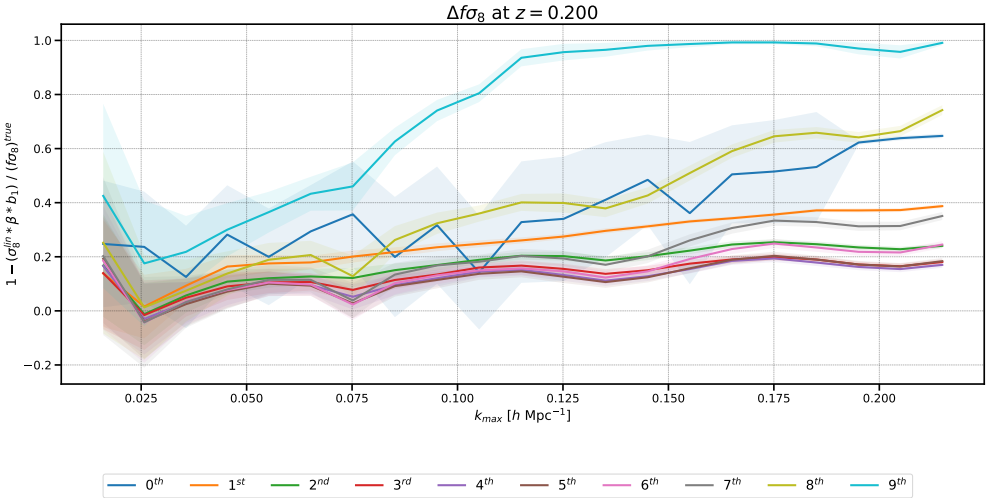


**Figure 6:** Relative difference between true and inferred fs8

# References


[1] Enrique Paillas et al. 'Redshift-space distortions with split densities'. In: *Monthly Notices of the Royal Astronomical Society* 505.4 (June 2021), pp. 5731–5752. DOI: 10.1093/mnras/stab1654.

[2] Uroš Seljak. 'Extracting Primordial Non-Gaussianity without Cosmic Variance'. In: *Physical Review Letters* 102 (Jan. 2009). URL: https://arxiv.org/pdf/0807.1770.pdf.

[3] Eric W Weisstein. 'Voronoi diagram'. In: *MathWorld–A Wolfram Web Resource.* (2000). URL: https://mathworld.wolfram.com/VoronoiDiagram.html (visited on 12/08/2022).