Galaxy Bias and Its Effects on Baryon Acoustic Oscillations Measurements

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Abstract

We use high force resolution simulations and a variety of Halo Occupation Distributions (HODs) to analyze the effects of galaxy bias on the measurements of the BAO signal. We investigate whether galaxy bias changes the non-linear shifts on the acoustic scale relative to the underlying dark matter distribution presented by Seo et al. (2009). For the less biased HOD models ($b < 3$), we do not detect any shift in the acoustic scale relative to the no-bias case, typically $0.10\% \pm 0.10\%$. However, the most biased HOD models ($b > 3$) show a shift at moderate significance ($0.79\% \pm 0.31\%$ for the most extreme case). A one-step reconstruction scheme (Eisenstein et al 2007) increases the correlation between the initial and final ($z = 1$) density fields achieving an equivalent level of correlation at nearly twice the wavenumber after reconstruction. Reconstruction reduces the shifts and errors on the shifts. We find that after reconstruction the shifts from the galaxy cases and the dark matter case are consistent with each other and with no shift. The 1σ systematic errors on the distance measurements inferred from our BAO measurements with various HODs after reconstruction are about $0.07\% - 0.15\%$.

Baryon Acoustic Oscillations (BAOs)

- Imprint of acoustic waves onto matter distribution.
- Robust standard ruler.
- Measured via damped harmonic series in power spectrum or peak in correlation function.

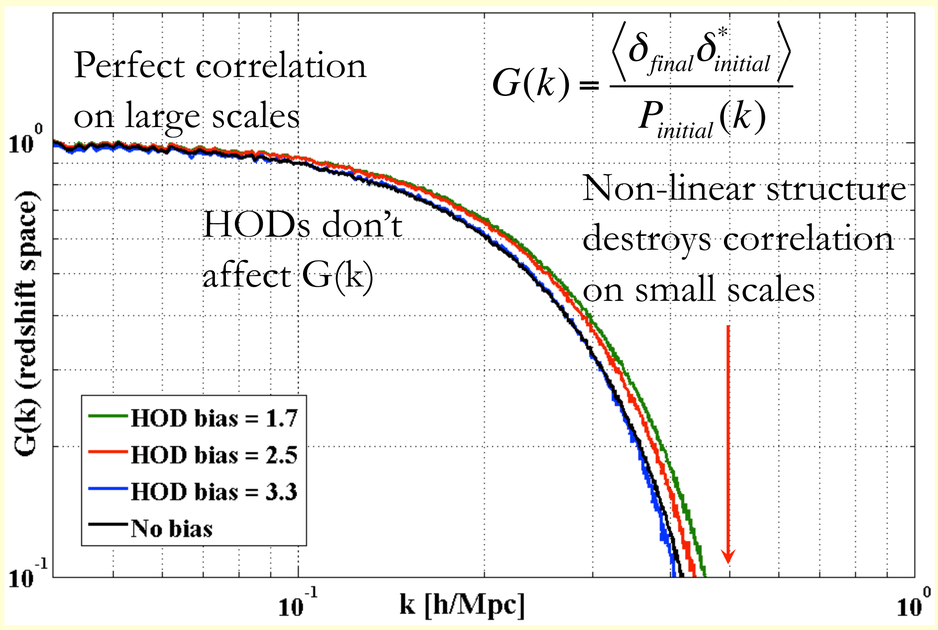
Halo Occupation Distributions (HODs)

- 12 HOD models to explore a range of galaxy biases
- Populate dark matter halos with "galaxies"
- Vary halo mass thresholds to hold central and satellite galaxies

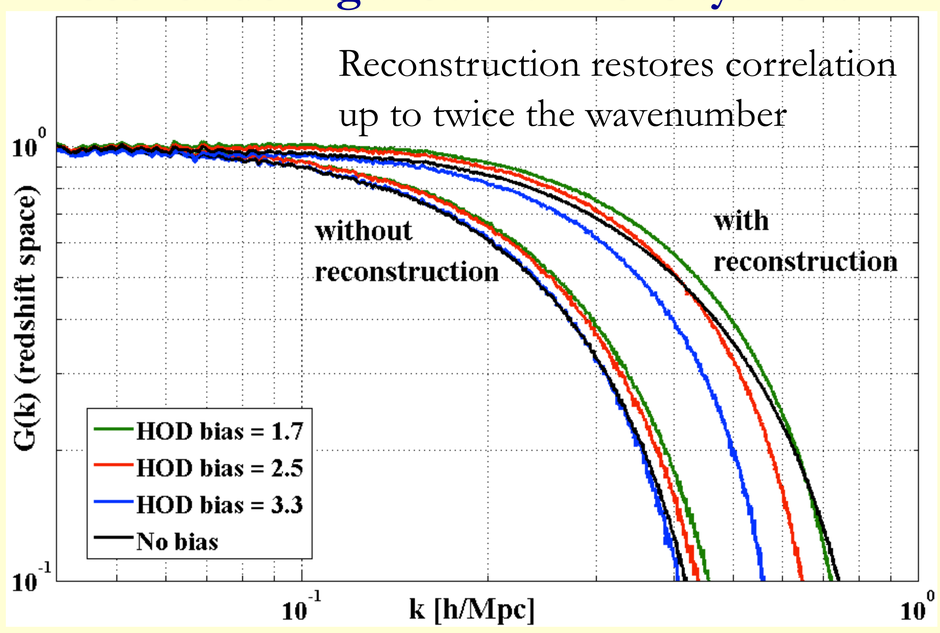
Reconstruction

- Initial matter density field is highly linear.
- Overdensities grow but also attract each other.
- Gravity causes large (few Mpc) scale velocity flows.
- Cause BAO peak to shift and spread, therefore degrading measurements.
- Use final density field to estimate velocity field.
- Undo velocity flows and reconstruct the density field.
- Reconstructed density field is more correlated to initial density field.

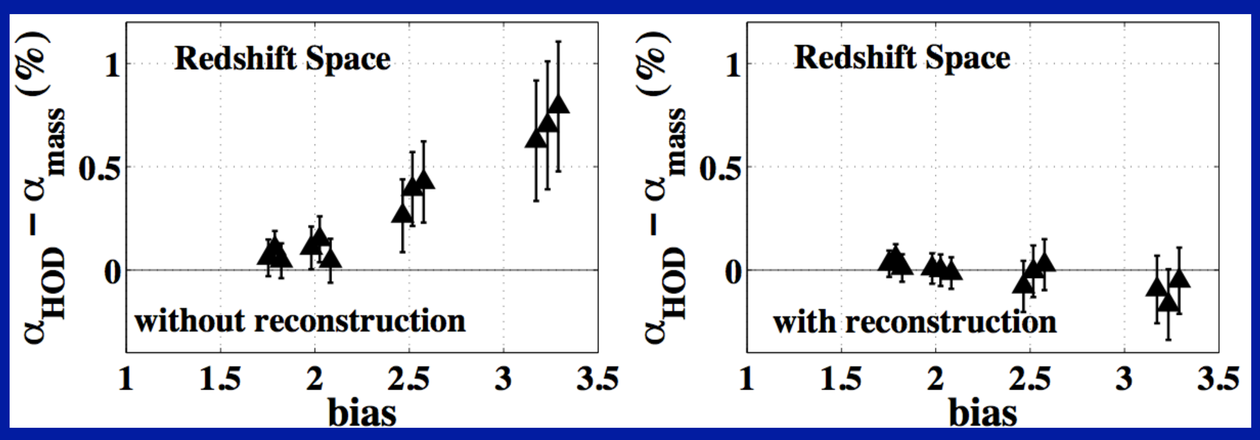
Correlation of Initial and Final Density Fields



Reconstructing the Final Density Field



Comparing Biased and No–Bias Cases



- α is the ratio of the measured acoustic scale to linear theory prediction.
- Acoustic scale is easily measured for the matter field by low resolution simulations.
- Before reconstruction hint of shift in high biased HODs ($\sim 2\sigma$).
- All shifts removed after reconstruction; error bars reduced by factors of 1.5 – 2.0 .