Halo Assembly Bias
and its Impact on Galaxy Formation

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in collaboration with

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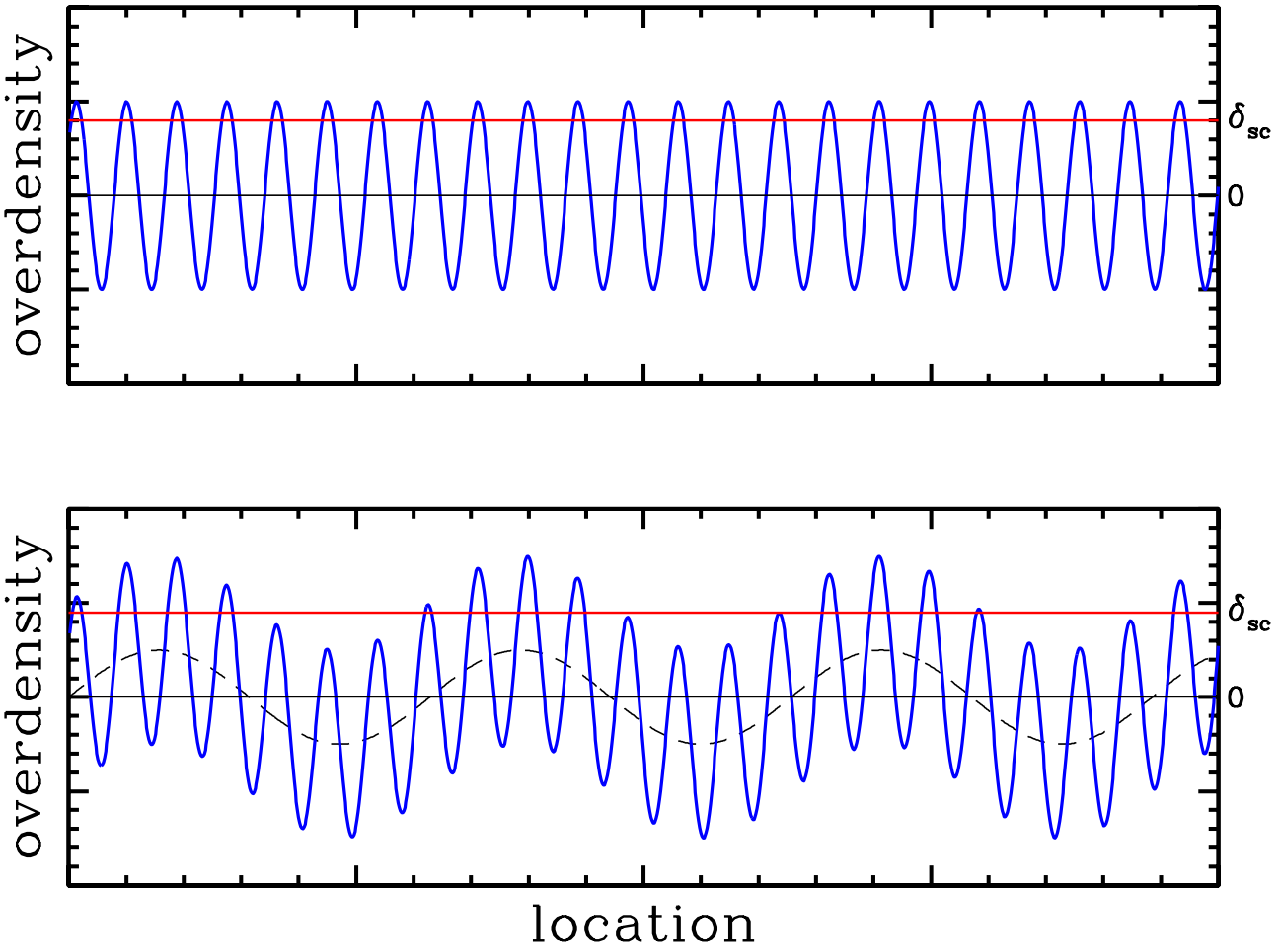
The Origin of Halo Bias

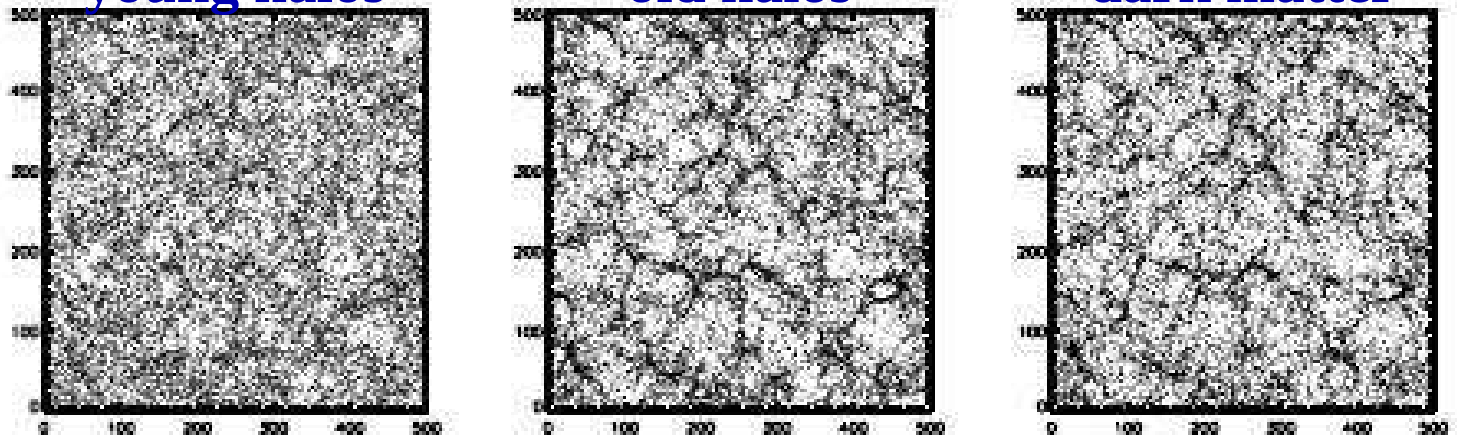


Modulation causes statistical bias of peaks (haloes)

Modulation growth causes dynamical enhancement of bias

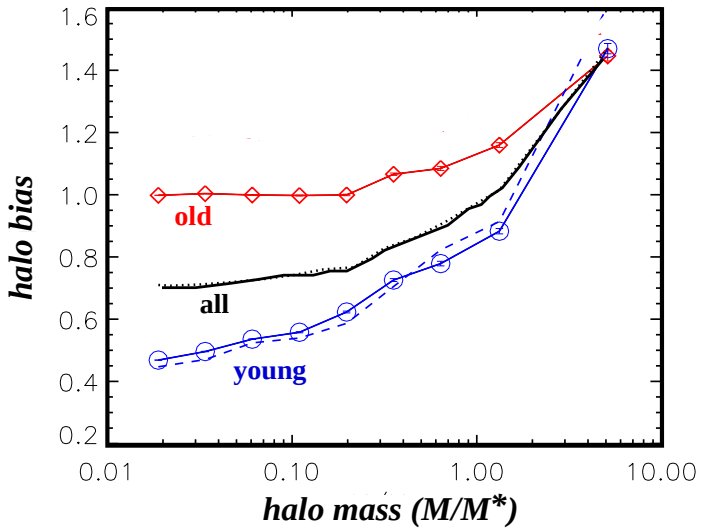
Halo Assembly Bias

young halos | **old halos** | **dark matter**



(Gao, White & Springel 2005)

$$b_{\rm halo}(r) = \frac{\xi_{\rm hm}(r)}{\xi_{\rm mm}(r)}$$



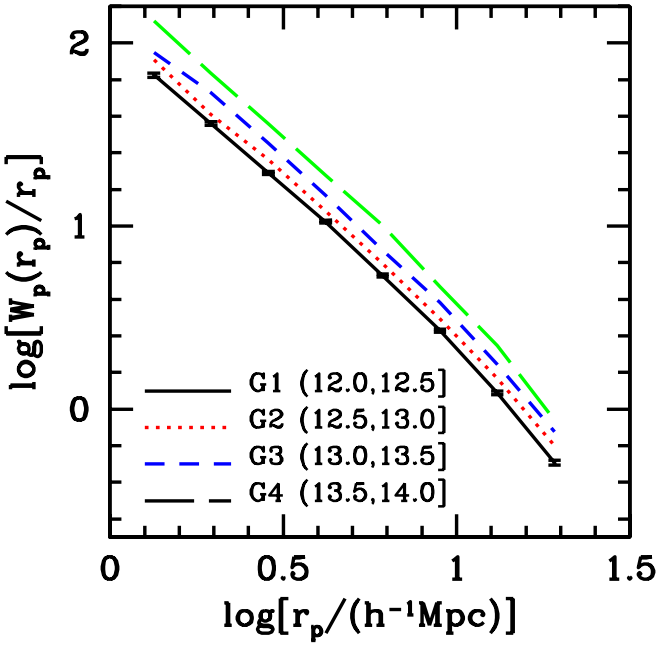
Halos that assemble earlier are more strongly clustered than halos of the same mass that form later.

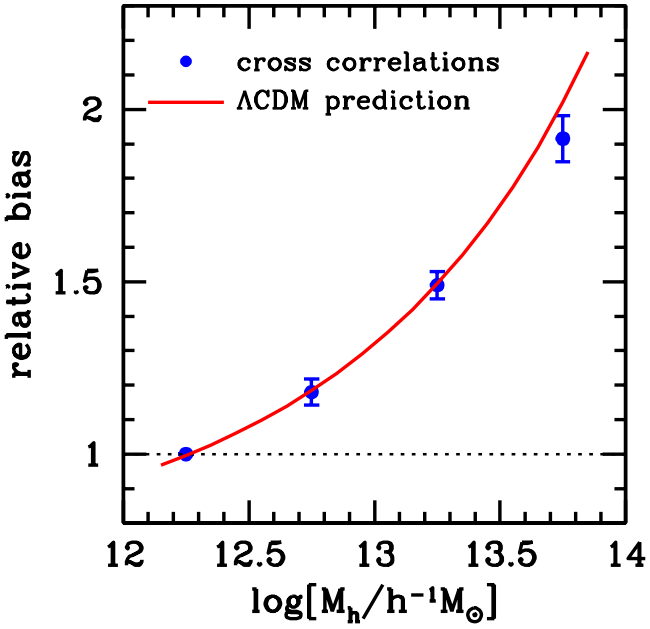
Effect is stronger for less massive haloes

Mass Dependence of Halo Bias

We probe halo bias using SDSS group catalogue of Yang et al. (2007)

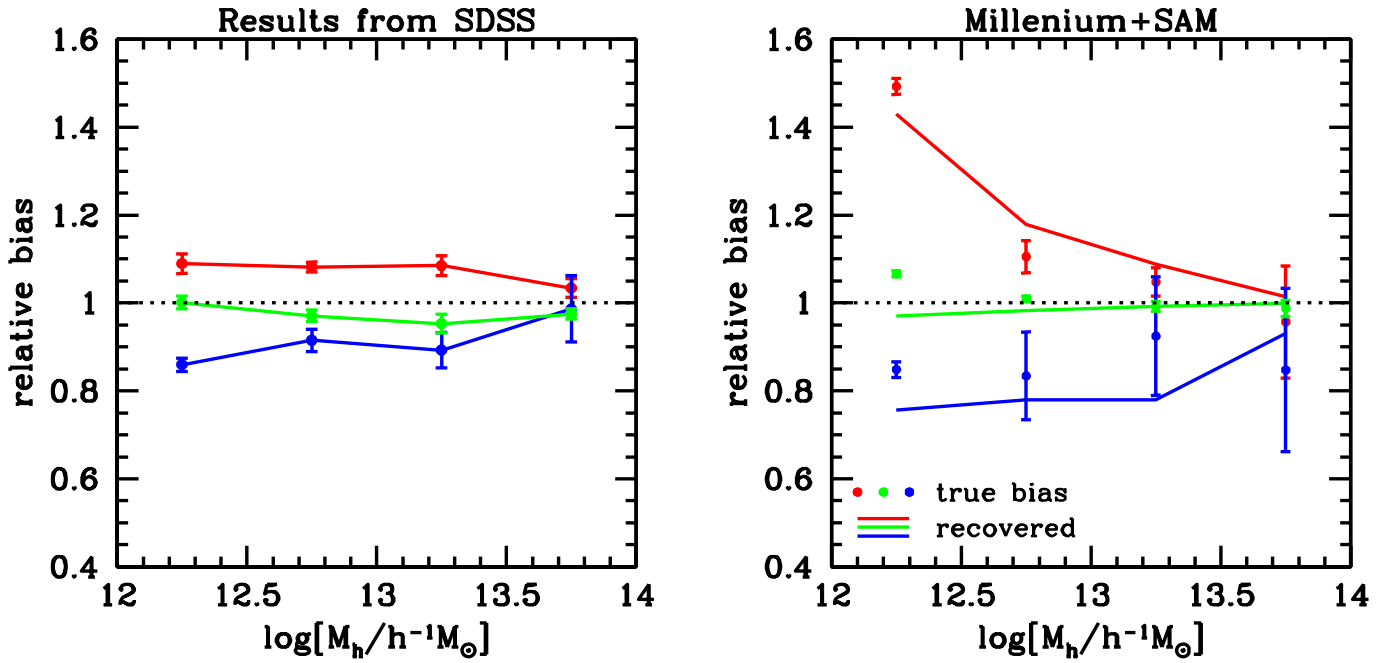
We measure relative bias from Group-Galaxy Cross Correlations





- More massive groups/haloes are more strongly clustered
- Mass dependence in excellent agreement with ΛCDM predictions
- Mass assignment in group catalogue is reliable

Color Dependence of Halo Bias



- We detect weak, but significant color dependence of halo bias
- Groups with red centrals are more strongly clustered that equal mass groups with blue centrals
- Our method can recover true signal from mock redshift survey
- SAM of Croton et al. (2006) 'predicts' similar color dependence, but much stronger for low mass haloes.

Implications for Galaxy Formation

To summarize, at fixed mass:

- **Halos that assemble earlier are more strongly clustered**
- **Groups with redder centrals are more strongly clustered**

The logical inference would be that

Star Formation History traces Mass Assembly History

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But, more massive halos assemble later. These should then host younger galaxies, which is in violent contrast to observations!!

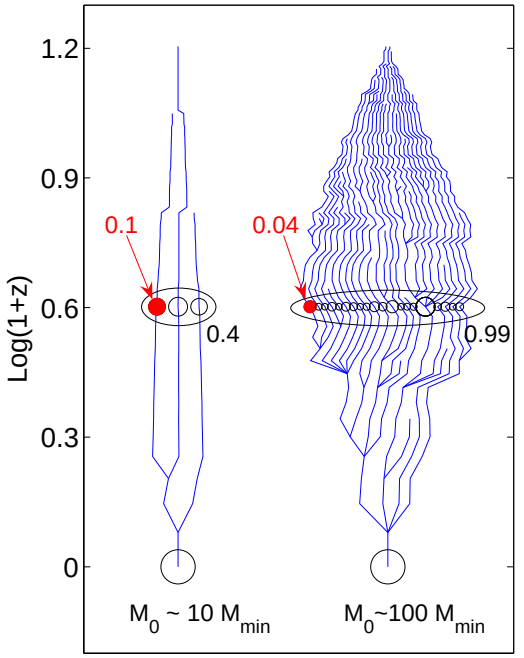
Some people call this "downsizing" or "anti-hierarchical"

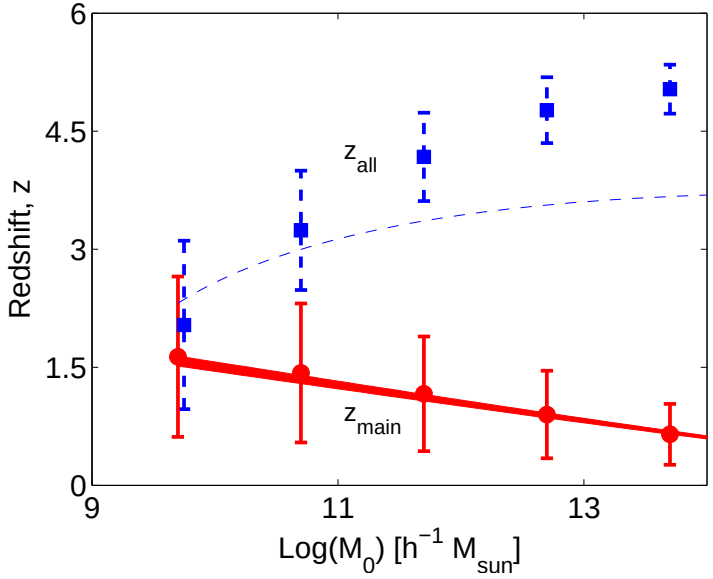
What is really required is

- **Positive correlation between SFH and MAH at fixed mass**
- **Negative correlation between SFH and MAH globally**

Is there a natural explanation for such SFH-MAH correlations?

Halo Formation *vs.* Halo Assembly



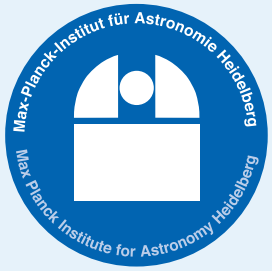


Neistein, vdB & Dekel, 2006

Halo assembly time : time when $M_{\rm mmp} = M_0/2$

Halo formation time: time when $\sum_{i=1}^{N_{\rm min}} M_i = M_0/2$

- More massive halos assemble later, but form earlier
- But at fixed mass, halos that form later also assemble later
- Data suggests that star formation tracks halo formation



Conclusions

- Galaxy Groups reveal mass-dependent bias as expected
- Dark Matter Haloes reveal strong assembly bias
- Galaxy Groups reveal weak color bias
- SFH of galaxies is related to halo formation history
- There is nothing ‘anti-hierarchical’ about downsizing