THE EFFECTS OF HALO ALIGNMENT AND SHAPE ON THE CLUSTERING OF GALAXIES

arXiv: 1203.5335

Marcel van Daalen,
Raul Angulo & Simon White

CosmoComp Workshop, September 2012
THE EFFECTS OF HALO ALIGNMENT AND SHAPE ON THE CLUSTERING OF GALAXIES

arXiv: 1203.5335

Marcel van Daalen, Raul Angulo & Simon White
CosmoComp Workshop, September 2012
THE CORRELATION FUNCTION

- A measure of the amount of structure that has formed on a given scale/separation $r$

- Definitions:
  - Density fluctuations: $\delta(x) \equiv \frac{\rho(x) - \bar{\rho}}{\bar{\rho}}$
  - Galaxy correlation function: $\xi_g(r) = \langle \delta_g(r_1) \delta_g(r_2) \rangle \quad (r = |r_2 - r_1|)$
  - Galaxy-DM cross-correlation function: $\xi_{gm}(r) = \langle \delta_g(r_1) \delta_m(r_2) \rangle$
Haloes and galaxies are biased tracers of the underlying mass density field.

Linear halo bias factor (large scales): $\delta_h(M, z) \approx b_1(M, z)\delta_m$

Calculated here as: $b = \frac{\xi_{hm}}{\xi_{mm}}$ (alternatively: $b^2 = \frac{\xi_{hh}}{\xi_{mm}}$)

Here we consider the range $6 < r < 20$ Mpc/h
• Haloes can be strongly ellipsoidal

• Shape parameter: \( s = \frac{c}{a} \)

• However: the shape is measured from a distribution of points (dark matter or galaxies)

• What happens when the shape is not sampled sufficiently?
HALO SHAPE

• Say we only have a few galaxies in a perfectly spherical halo

1 galaxy:

\[ a = b = c = 0 \]
• Say we only have a few galaxies in a perfectly spherical halo

1 galaxy:
\[ a = b = c = 0 \]

2 galaxies:
\[ a > 0, \ b = c = 0 \]
• Say we only have a few galaxies in a perfectly spherical halo

1 galaxy:
\[ a = b = c = 0 \]

2 galaxies:
\[ a > 0, \; b = c = 0 \]

3 galaxies:
\[ a > 0, \; b > 0, \; c = 0 \]
HALO SHAPE

- Say we only have a few galaxies in a perfectly spherical halo

  1 galaxy:
  \[ a = b = c = 0 \]

  2 galaxies:
  \[ a > 0, b = c = 0 \]

  3 galaxies:
  \[ a > 0, b > 0, c = 0 \]

  10 galaxies:
  \[ a > b > c > 0 \]
SHAPE-DEPENDENT HALO BIAS

$N_{dm} \geq 700$

Peak height, scales with $M \rightarrow \nu = \delta_c/\sigma$

Faltenbacher & White (2010)
SHAPE-DEPENDENT HALO BIAS

Do we see the same in the galaxy distribution?

Peak height, scales with $M \rightarrow \nu = \delta_c/\sigma$

Faltenbacher & White (2010)
HALO SHAPE

Most-pronounced substructure

All galaxies

$s = c/a$ (DM)

$s = c/a$ (galaxies)

$N_{sat}$
HALO SHAPE

Most-pronounced substructure

Only galaxies within $R_{\text{vir}}$

$s = c/a$ (DM)

$s = c/a$ (galaxies)

$N_{\text{sat}}$
SHAPE-DEPENDENT GALAXY BIAS

• Can this form of assembly bias be seen by observing galaxies?

• First ask: do the galaxies trace the halo shape well enough?

• If so, is the shape the galaxies themselves define good enough?

• We divide the haloes up by shape and then measure the bias as a function of mass or number of galaxies
SHAPE-DEPENDENT GALAXY BIAS

The graph shows the shape-dependent galaxy bias ($b_{gal}$) as a function of some parameter $\nu(M)$. Different shapes (Most aspherical 20%, Middle 60%, Most spherical 20%) are represented by different colors and symbols. The shape is measured from the galaxy distribution.
SHAPE-DEPENDENT GALAXY BIAS

Shape measured from galaxy dist.
SUMMARY

• Haloes and galaxies are biased tracers of mass

• This bias depends on the shape of the (relaxed) halo, which is a form of assembly bias

• The galaxies trace the halo well enough to reflect this shape-dependent bias

• With galaxy redshift surveys it may therefore be possible to observe this assembly bias
THE CORRELATION FUNCTION

\[ M_* > 10^9 \, h^{-1} M_\odot \]

- Galaxy–galaxy correlation function
- CDM–CDM correlation function

Graph showing the correlation function \( \xi(r) \) as a function of \( r \) in Mpc/h.
ALIGNMENT

25 realisations

\[ \frac{[\xi_i(r) - \xi_{\text{orig}}(r)]}{\xi_{\text{orig}}(r)} \]

vs.

\[ r \ [\text{Mpc/h}] \]

vs.

\[ r \ [\text{Mpc/h}] \]