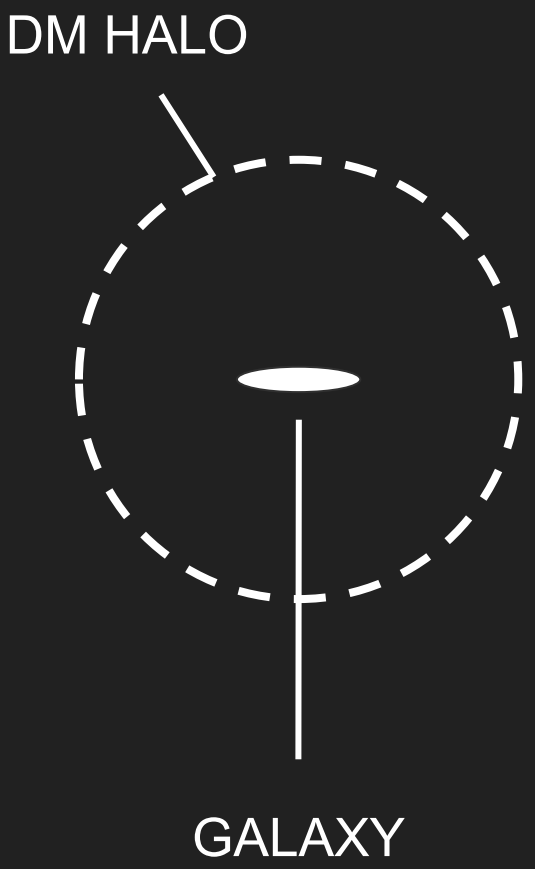
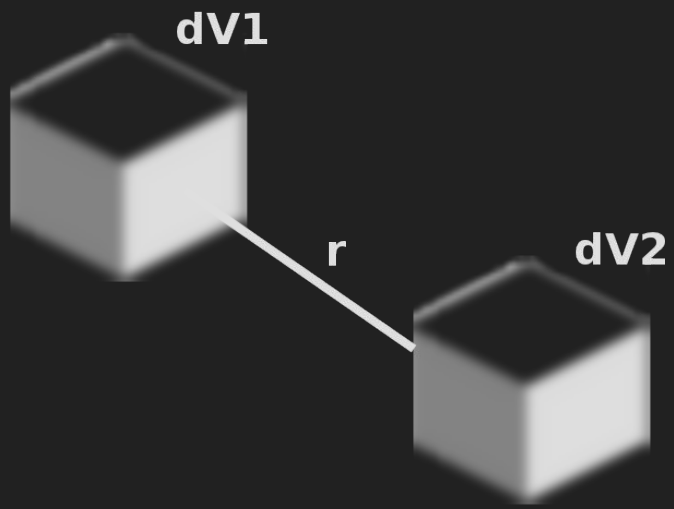
HALO ASYMMETRY AND GALAXY CLUSTERING



Author: Anna Durkalec anna.durkalec@ncbj.gov.pl **PAiP-2025, 20.02.2025**

UNDERSTAND THE RELATIONSHIP BETWEEN GALAXIES AND THE UNDERLYING DARK MATTER

GALAXY CORRELATION FUNCTION



Excess number of pairs separated by r over the random distribution

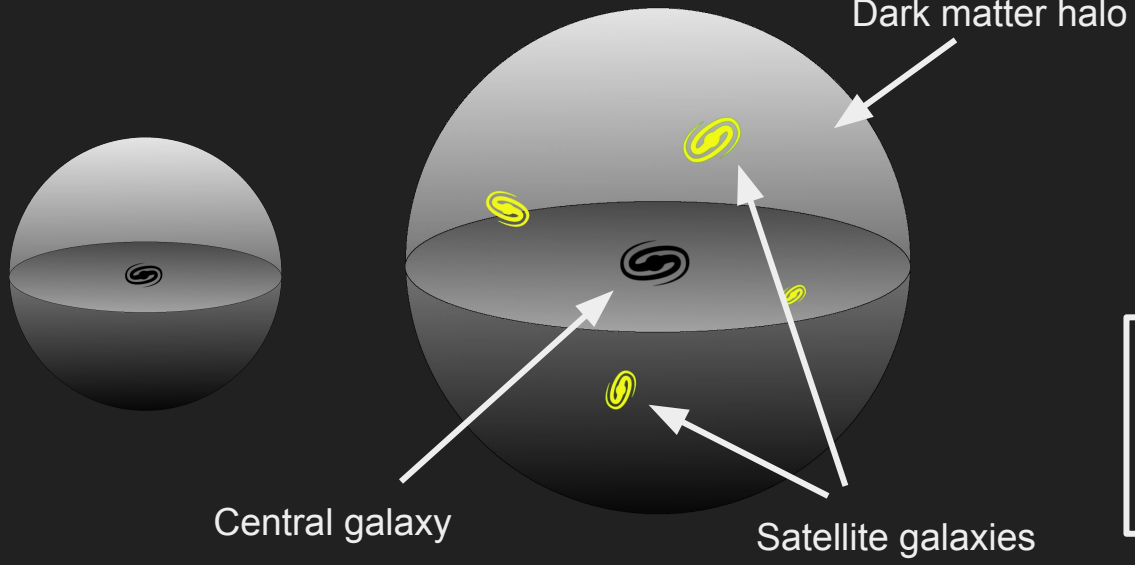
BUT IT HAS REQUIREMENTS

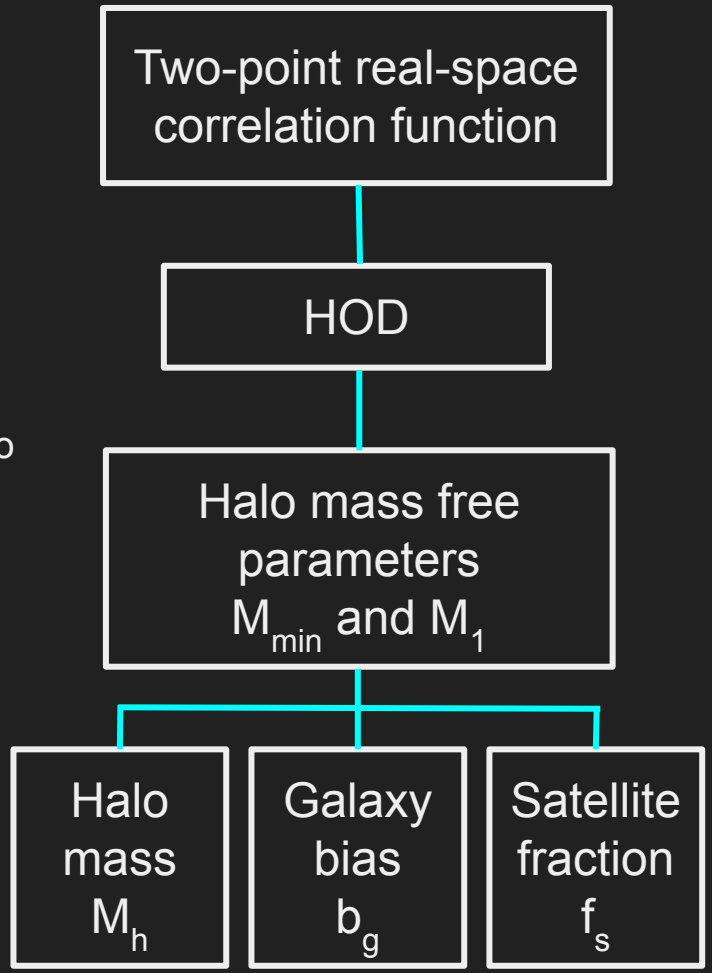
HALO OCCUPATION DISTRIBUTION MODELLING (HOD)

THE HOD FRAMEWORK

Assumptions:

1. Galaxies reside in dark matter halos.
2. Number of galaxies inside the halo is the function of the mass of the halo.





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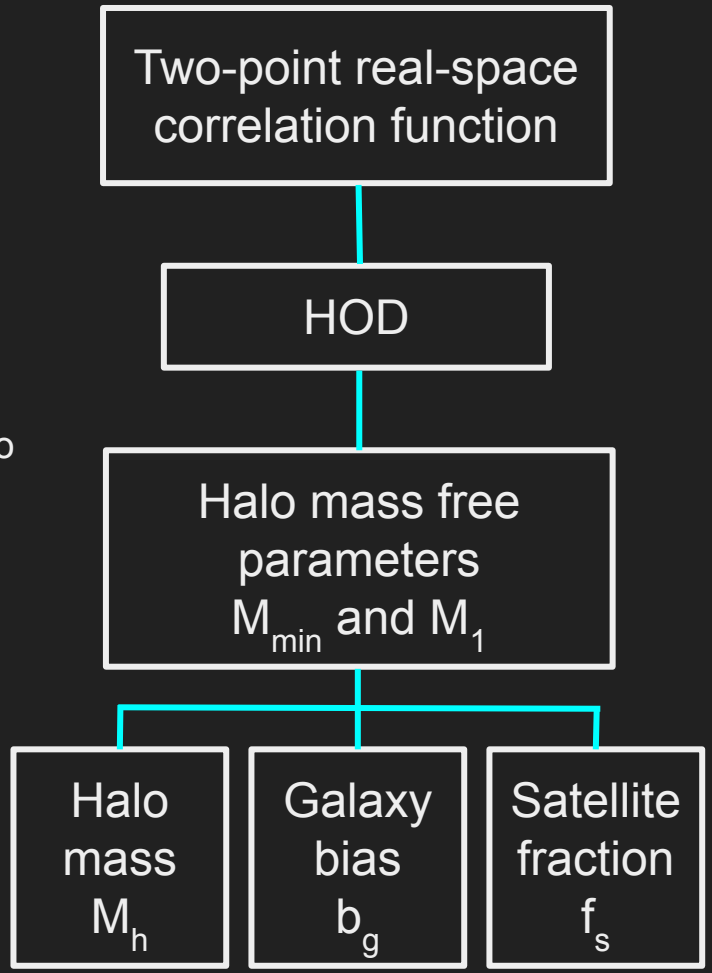
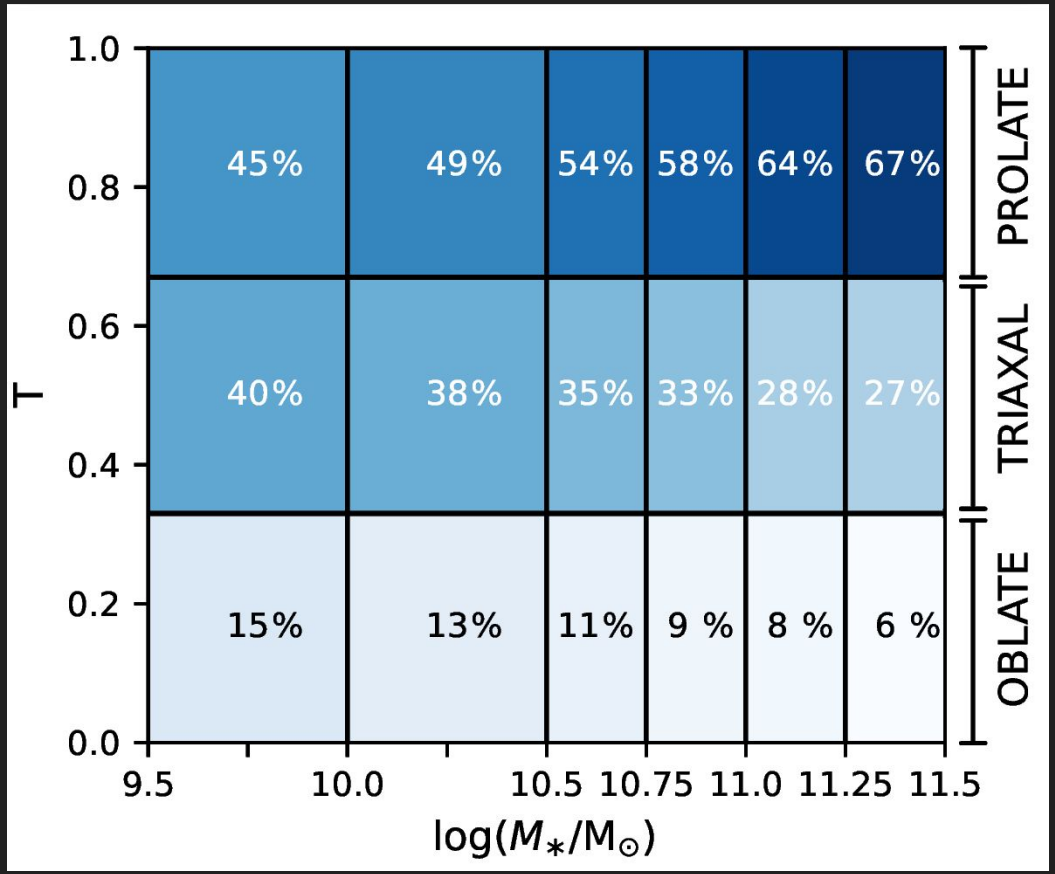


PROLATE

SPHERICAL

OBLATE



Mock catalogue populated in BolshoiP simulation, Durkalec et al. 2024

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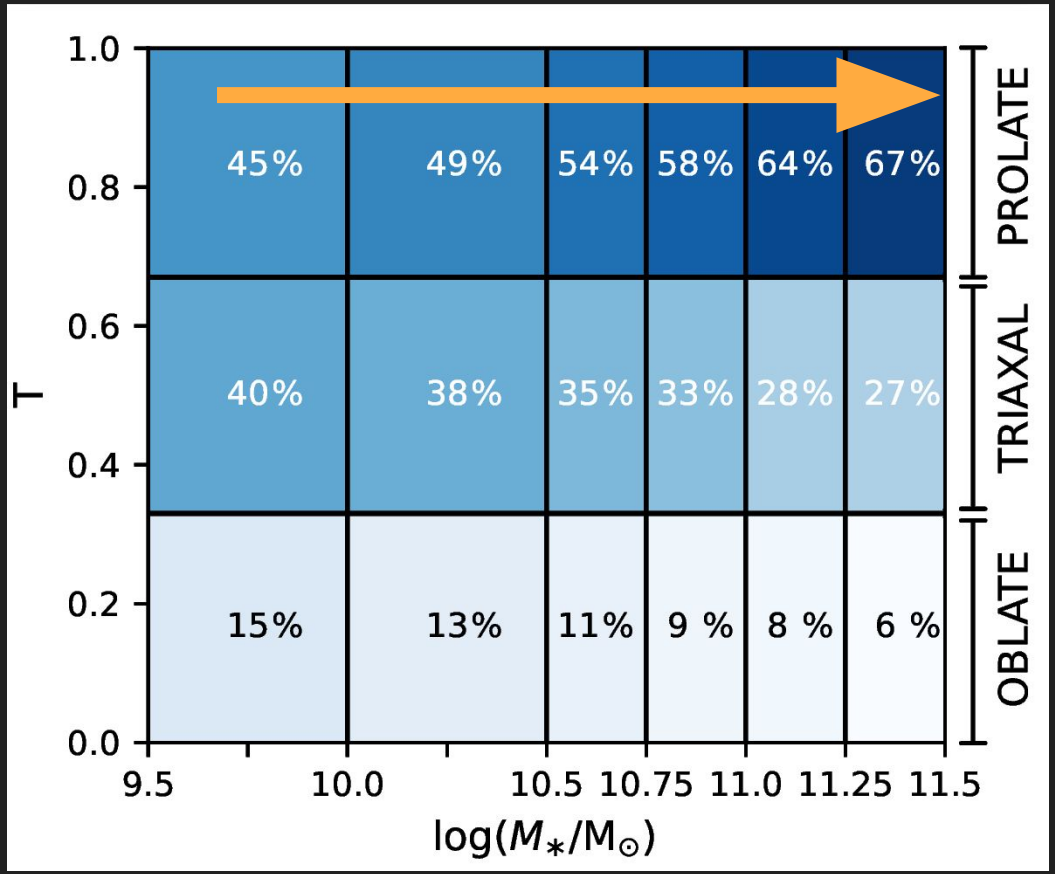
SPHERICAL

OBLATE



Mock catalogue populated in BolshoiP simulation, Durkalec et al. 2024

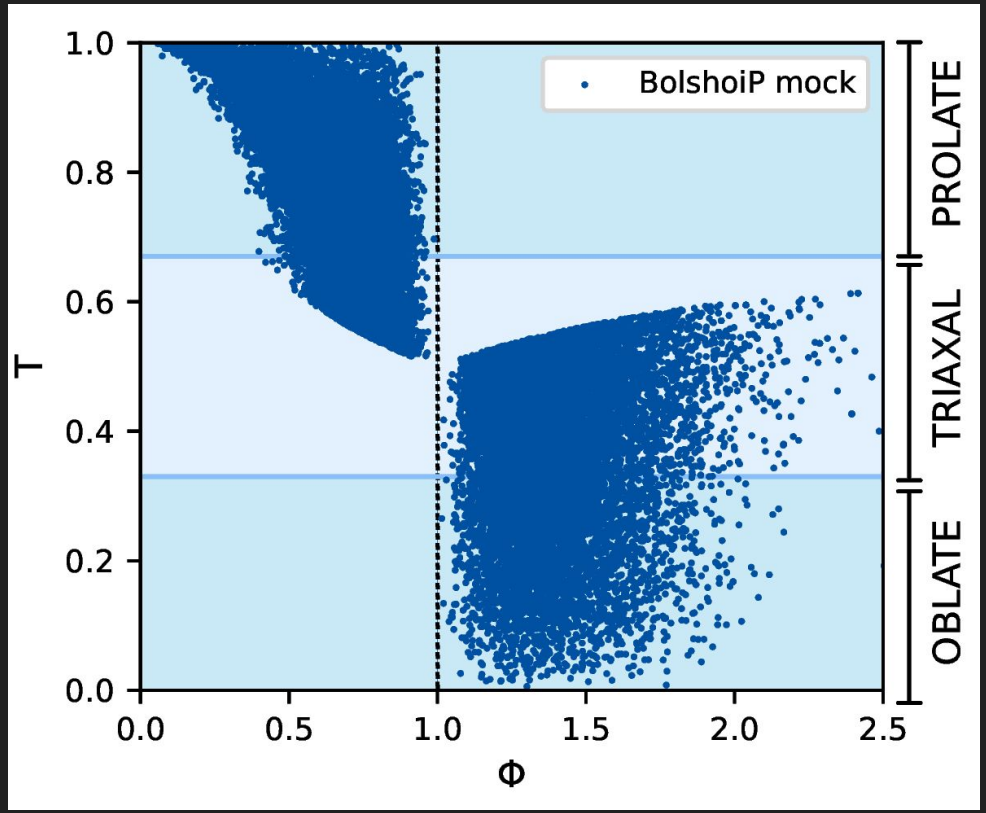
MODIFIED MODEL (6 - PARAMETERS)

Additional parameter ϕ - constructed to measure how strongly the shape of the DM halo deviates from the spherical symmetry.

$$0 < \phi < \infty$$

$$\phi = 1$$

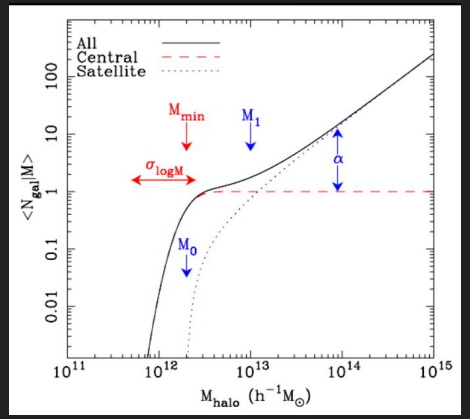
for a spherically symmetric haloes



Mock catalogue populated in BolshoiP simulation, Durkalec et al. 2024

MODIFIED MODEL (6 - PARAMETERS)

The core HOD stays the same:



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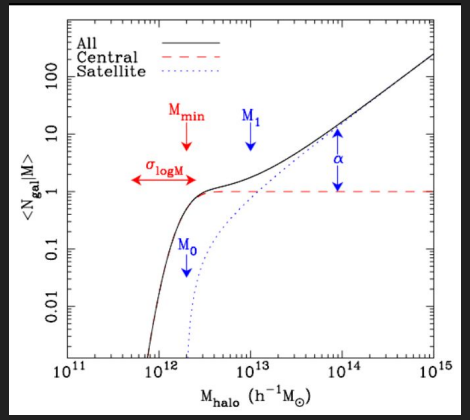
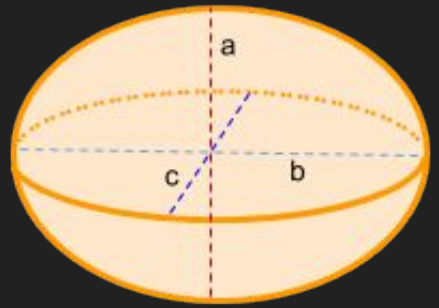


We modify (slightly) NFW profile:

NFW profile

$$\frac{\rho(R)}{\rho_{crit}} = \frac{\delta_c}{\frac{R}{R_S}\left(1+\frac{R}{R_S}\right)^2},$$



Halo radius

$$R = \sqrt{\frac{x^2}{a^2}+\frac{y^2}{b^2}+\frac{z^2}{c^2}}.$$

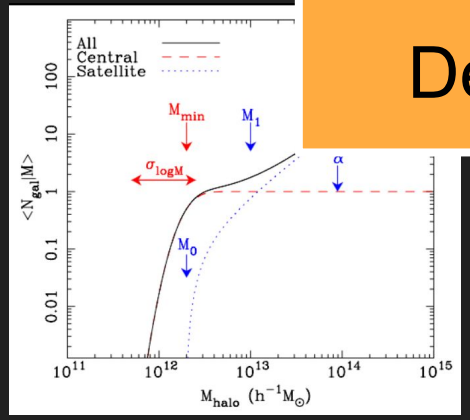
$$R \approx \frac{r}{a}\sqrt{1+\left(\frac{a+b}{2c}\right)^2} \quad \text{if } a = b$$

$$R \approx \frac{r}{b}\sqrt{1+\left(\frac{b+c}{2a}\right)^2} \quad \text{if } b = c$$

$$R \approx \frac{r}{a\sqrt{2}}\sqrt{1+\phi^2} \sim \frac{r}{b\sqrt{2}}\sqrt{1+\phi^2}$$

MODIFIED HOD (6 - PARAMETERS)

The core HOD stays the same:



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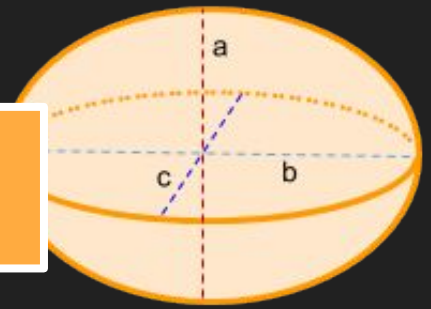
a^2 b^2 c^2



Details in Durkalec et al. 2024

$$R \approx \frac{r}{a}\sqrt{1+\left(\frac{a+b}{2c}\right)^2} \quad \text{if a = b}$$

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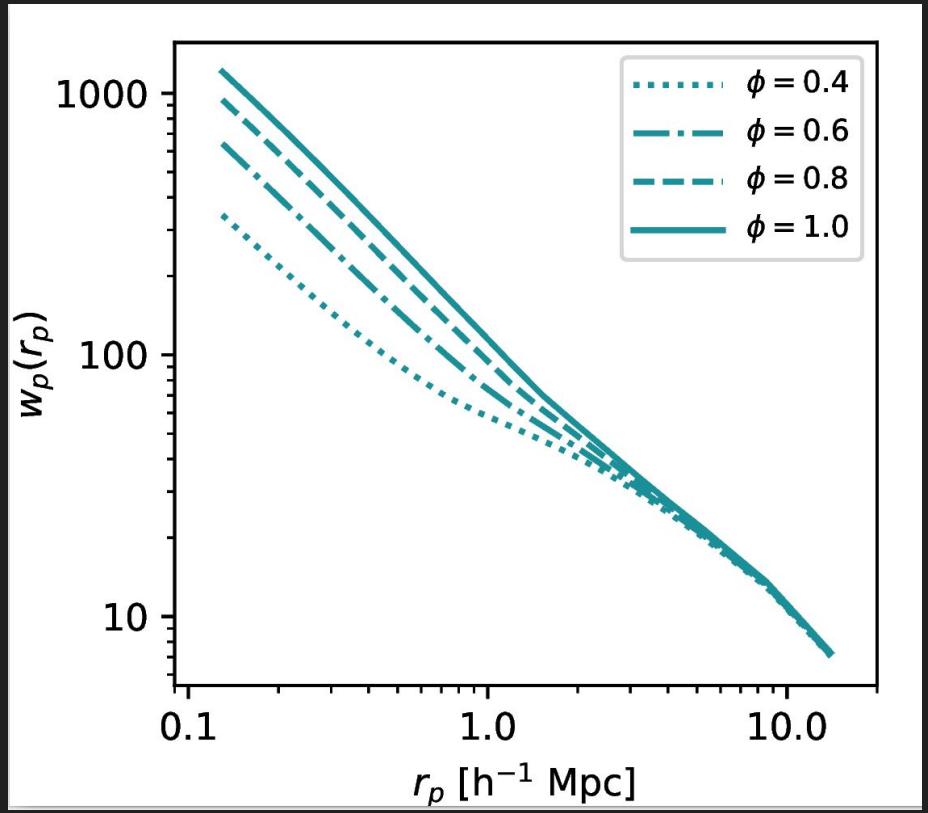
MODIFIED MODEL (6 - PARAMETERS)

Modelled correlation functions for different ϕ and other parameters fixed at the same value

Only one halo term ($r_p < 1\ h^{-1}$ Mpc) is influenced



Durkalec et al. 2024

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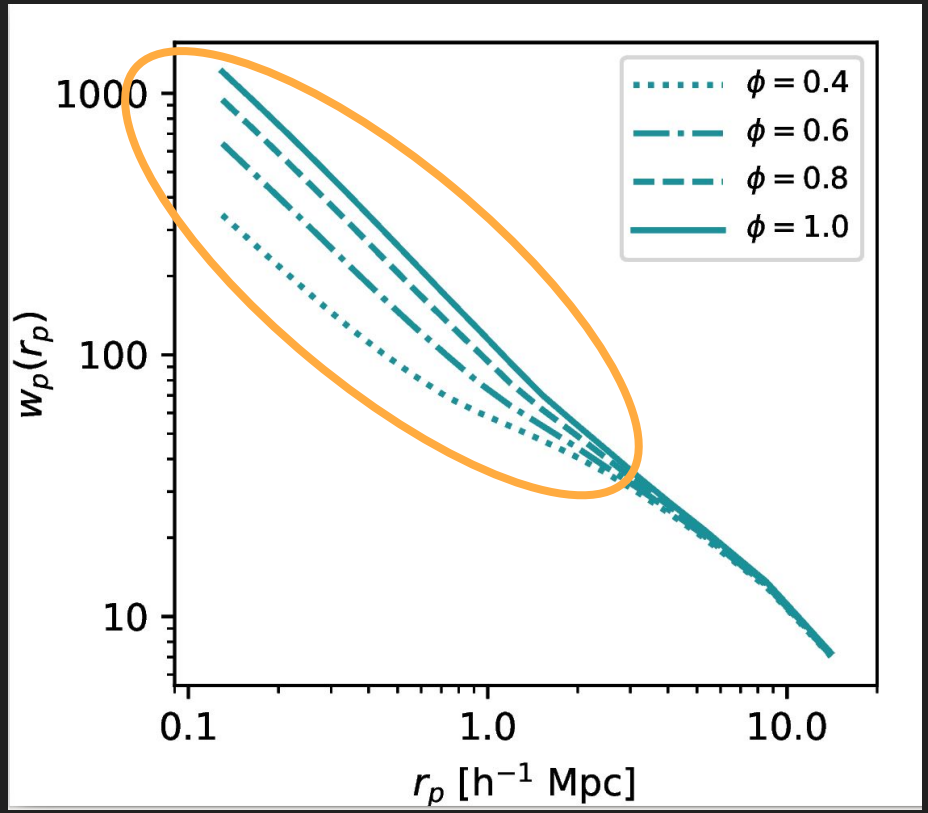

Durkalec et al. 2024

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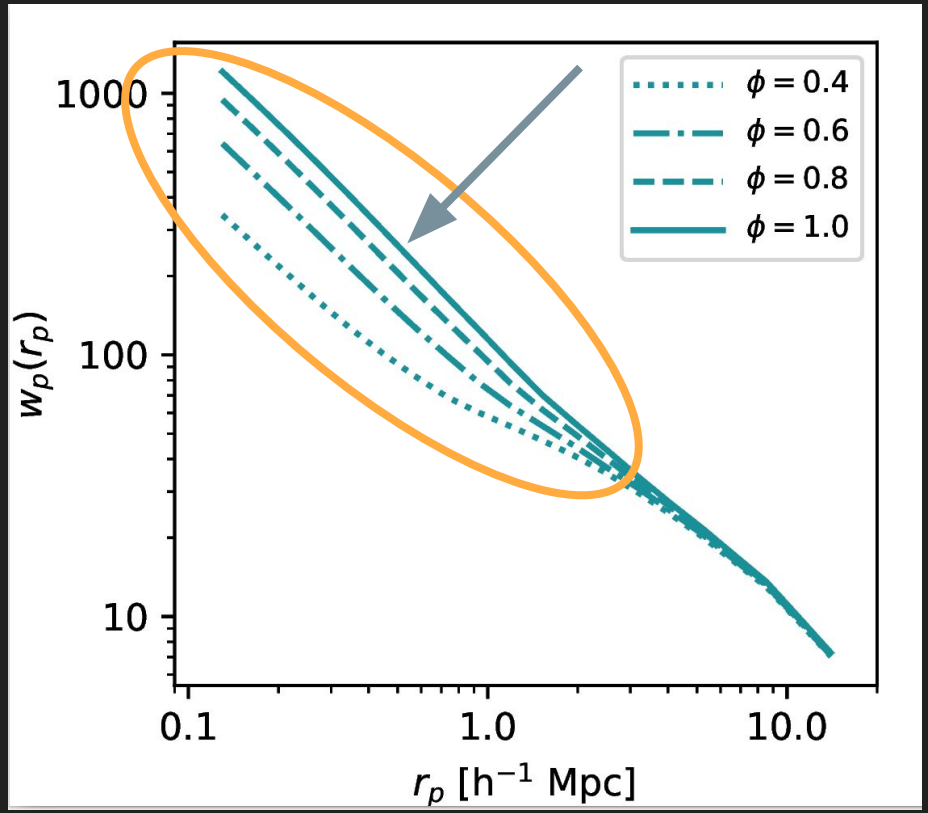

Durkalec et al. 2024

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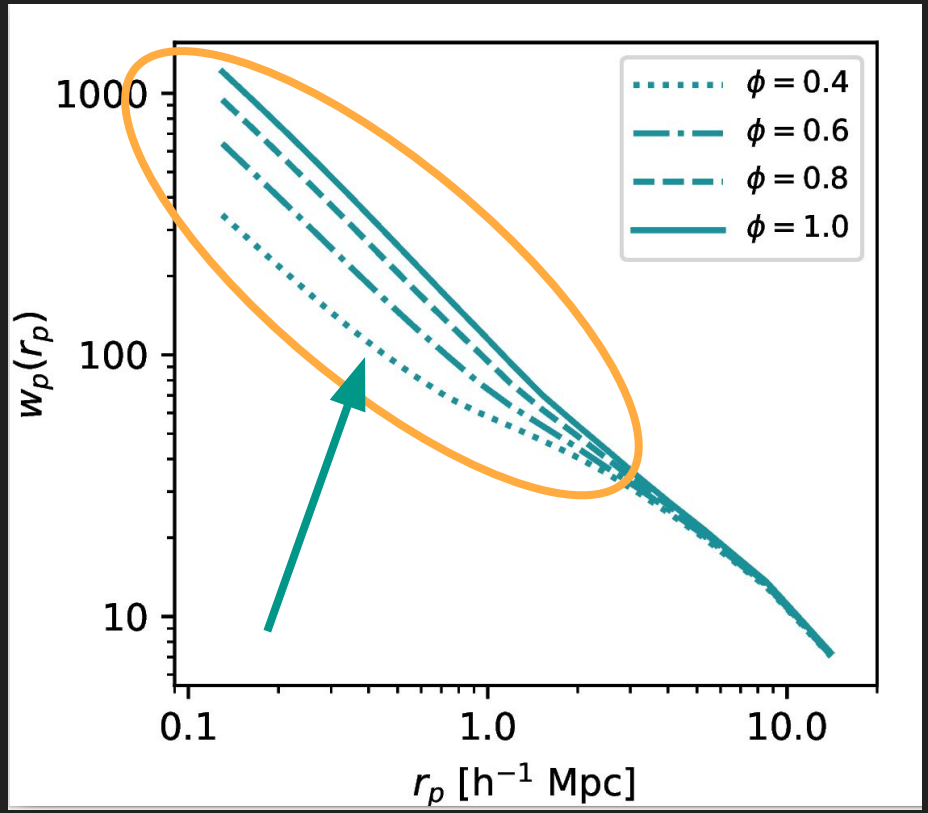


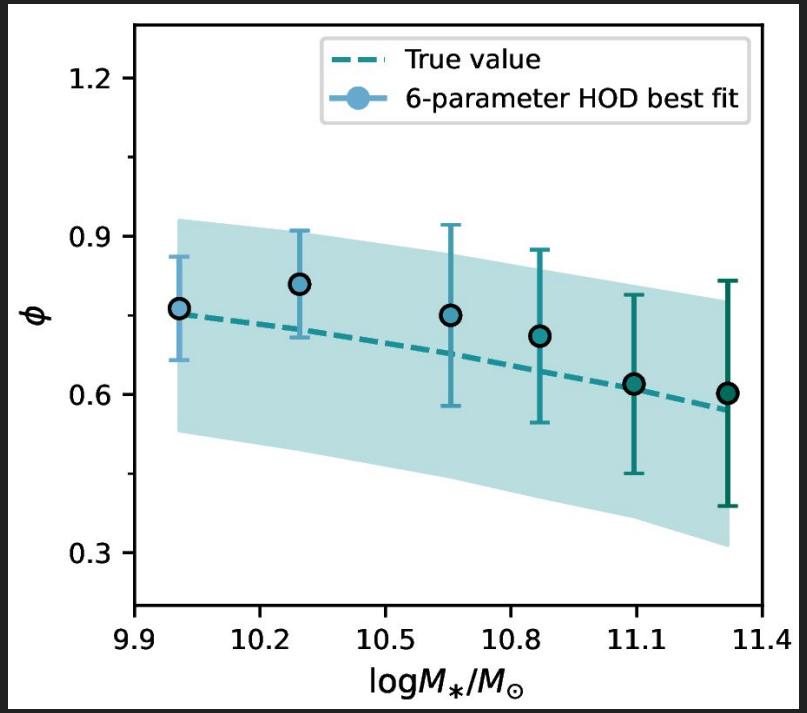
Durkalec et al. 2024

RESULTS BASED ON MOCK DATA

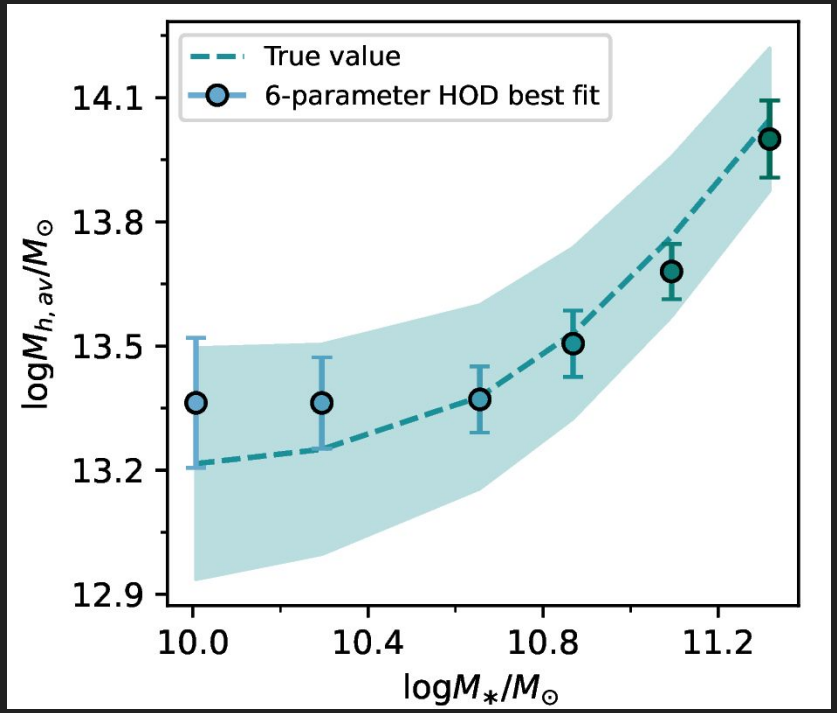
MODIFIED MODEL (6 - PARAMETERS) FITS

BOLSHOIP MOCK RESULTS

ASYMMETRY



HALO MASS



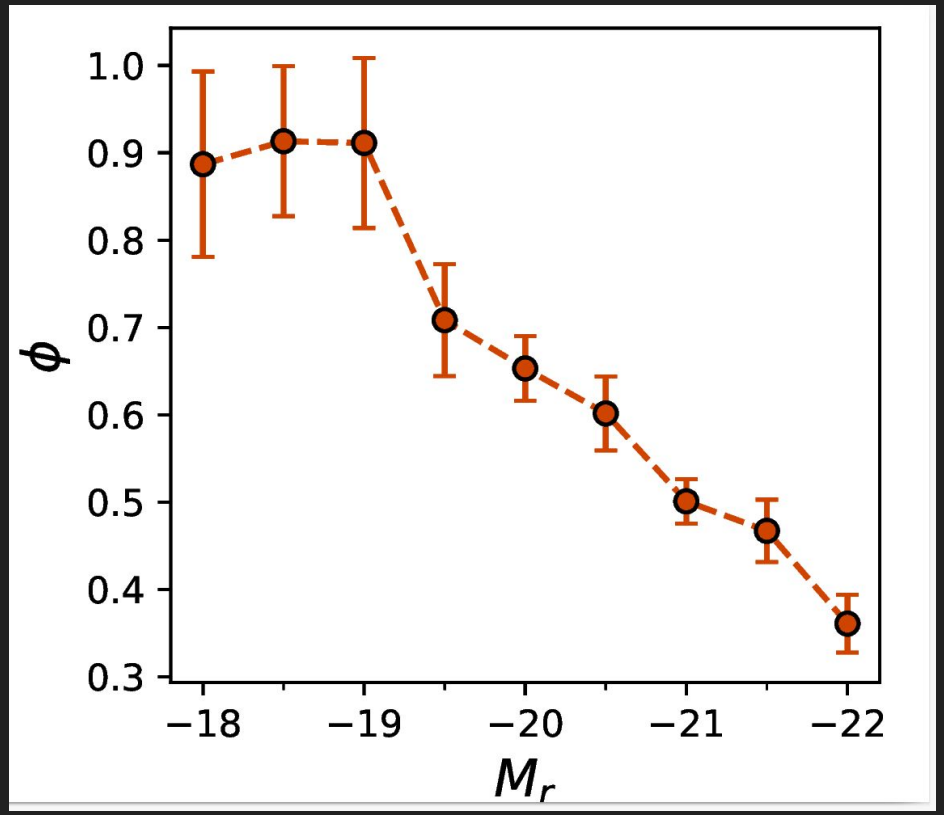
Durkalec et al. 2024

RESULTS BASED ON SDSS OBSERVATIONS

MODIFIED MODEL (6 - PARAMETERS) FITS

MODEL FIT TO ZEHAVI ET AL. 2011 CF RESULTS (SDSS)

Halo asymmetry parameter for different M_r luminosity selected samples from SDSS - correlation function measurements from Zehavi et al. 2011.



Durkalec et al. 2024

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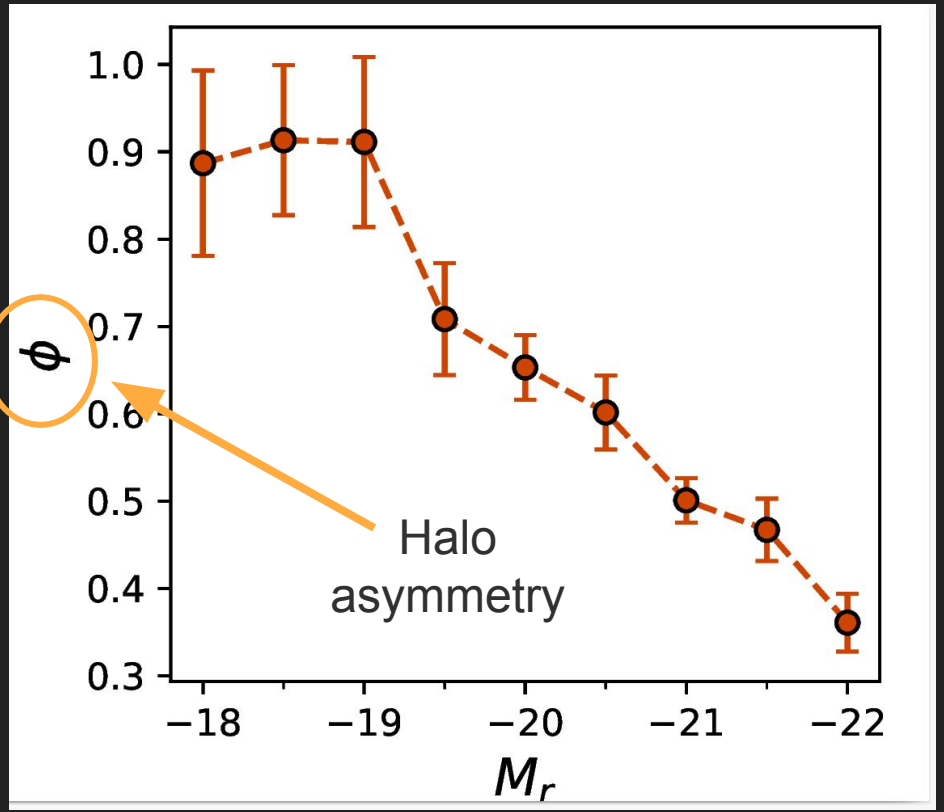

Durkalec et al. 2024

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MODEL FIT TO ZEHAVI ET AL. 2011 CF RESULTS (SDSS)

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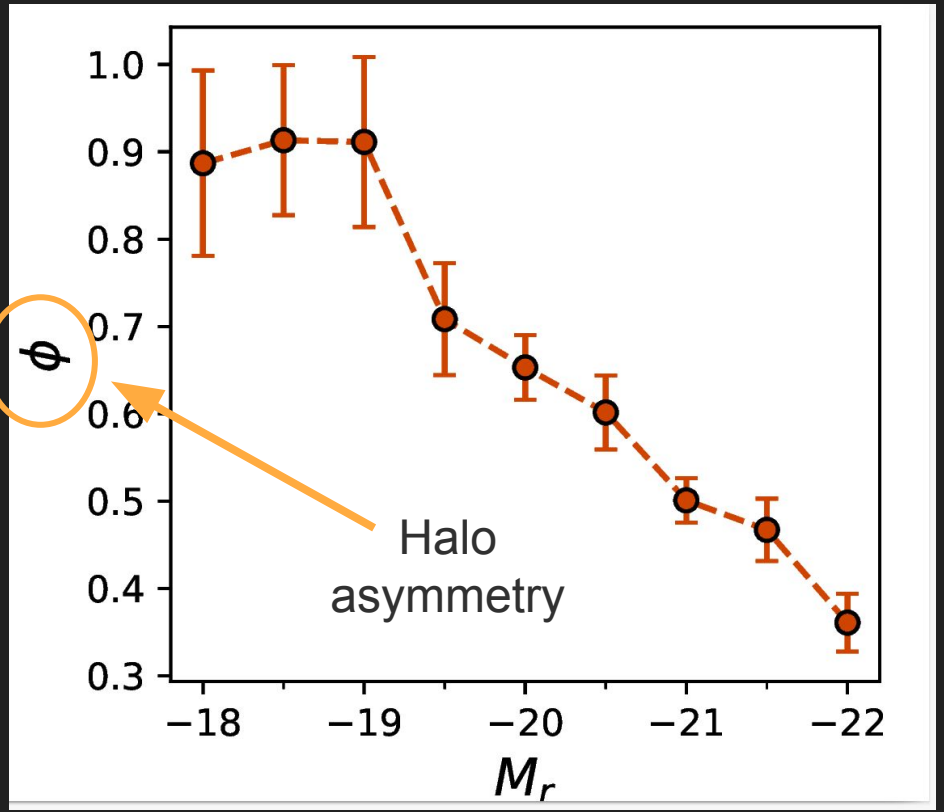
Halo asymmetry increases with luminosity of hosted galaxies. More luminous galaxies occupy more prolate DM haloes.

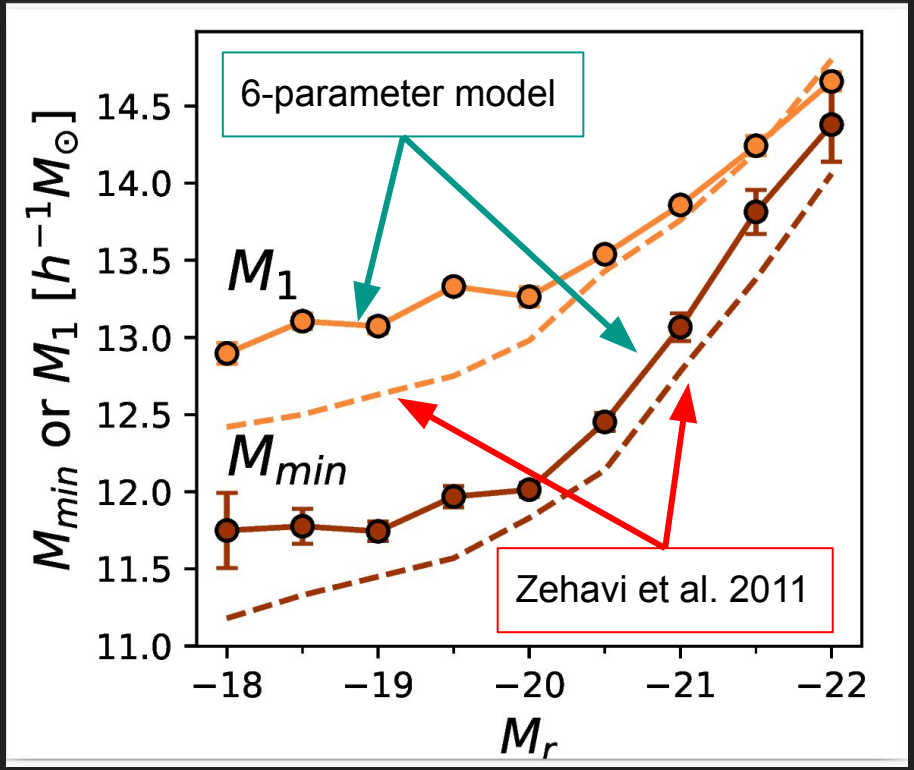


Durkalec et al. 2024

MODIFIED MODEL (6 - PARAMETERS) FITS

MODEL FIT TO ZEHAVI ET AL. 2011 CF RESULTS (SDSS)

As expected characteristic halo masses increase with increasing luminosity of galaxies.



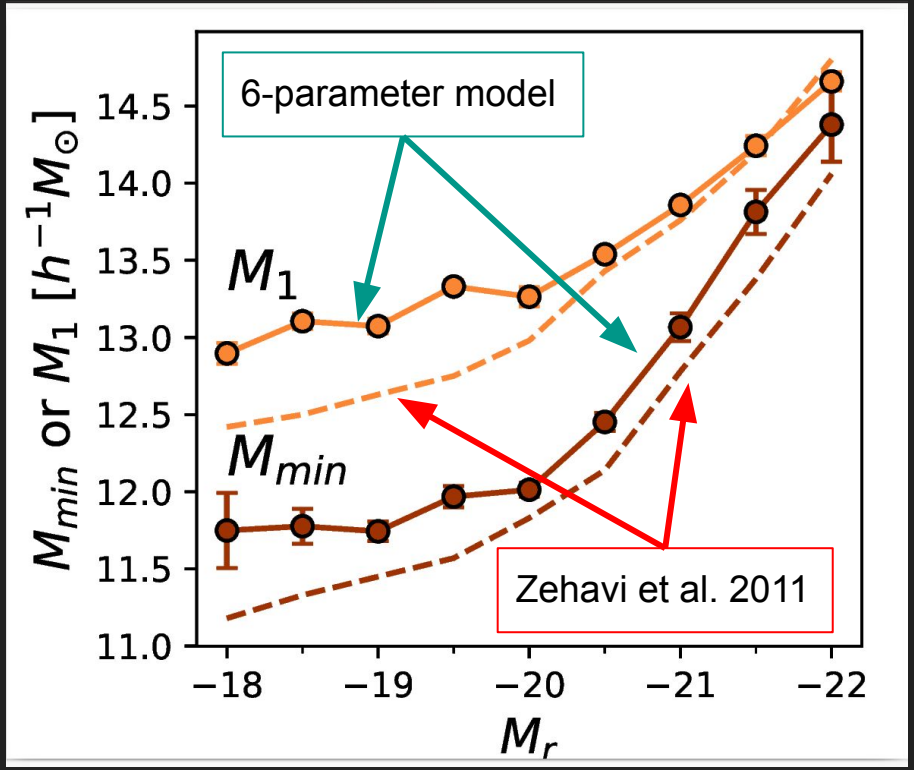
Durkalec et al. 2024

MODIFIED MODEL (6 - PARAMETERS) FITS

MODEL FIT TO ZEHAVI ET AL. 2011 CF RESULTS (SDSS)

As expected characteristic halo masses increase with increasing luminosity of galaxies.

However the minimum halo mass M_{min} obtained using 6-parameter model is slightly higher with respect to the one obtained with the halo spherical symmetry assumption.



Durkalec et al. 2024

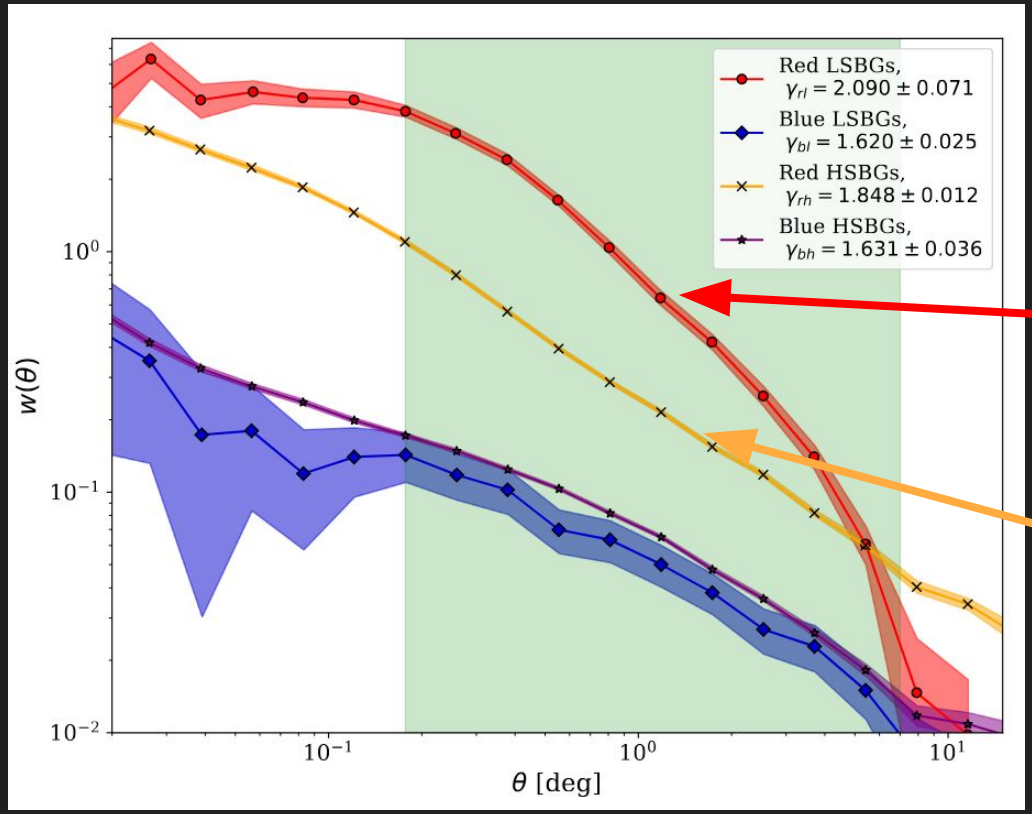
FUTURE PROSPECTS

LOW SURFACE BRIGHTNESS (LSB) GALAXIES

LSB galaxies selected by Thuruthipilly et al. 2024

LSB GALAXY CLUSTERING

WE NEED TO COME BACK TO THE ROOTS



Low Surface Brightness galaxies

"Normal" High Surface Brightness galaxies

Figure from Thuruthipilly et al. 2024