Environmental Dependence of Dark Matter Halo Abundances

Maria Chira

Supervisor: Manolis Plionis
Aristotle University of Thessaloniki

FoF Meeting,
Friday, April 7th 2017,
Cordoba, Argentina

Outline

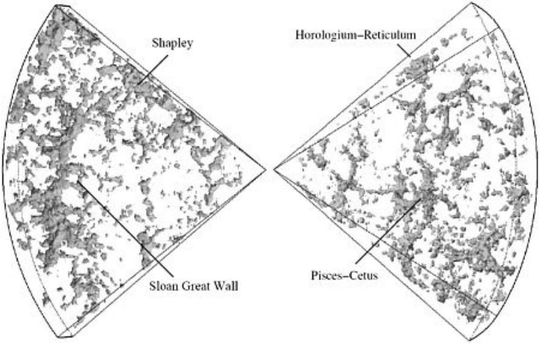
Environment

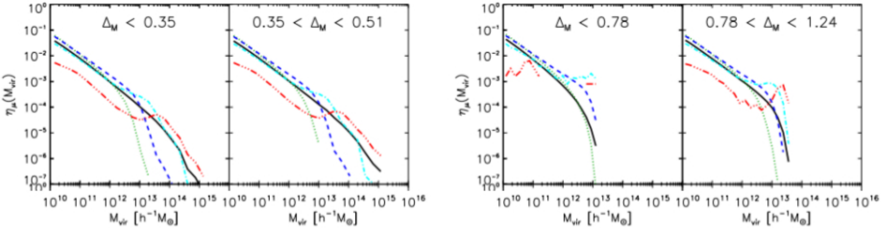
Methods used to define environment

- **Nearest-neighbour approaches:** using the scale that corresponds to the distance to a certain neighbour
- **Fixed-aperture approaches:** counting the number of neighbours within the area or volume set by a fixed aperture

Web-element types

- Knots
- Filaments
- Sheets
- Voids





Mass functions for the different web elements calculated using an adapted aperture (left frame) and a fixed aperture (right frame) smoothing kernel (Metuki et al. 2016) .

Our project

- Different way of defining environment:
  Isolation criterion $\rightarrow$ the isolation radius($R_{\rm isol}$).
  - Especially appropriate for the identification of highly isolated halos.
  - Second parameter is required for the identification of halos residing in dense regions.
- We examine the behavior of halo abundance function for halos of different isolation status.

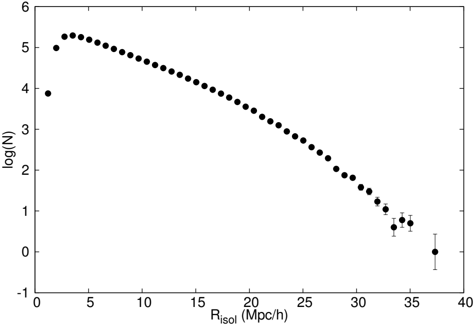
Simulation Data

Light-cone data generated on flight during the realization of a subset of N-body simulations from the "Dark Energy Universe Simulation" (DEUS) project.

- 2592 Mpc h^{-1} boxlength
- 2048^3 particles
- standard ΛCDM model with : $\Omega_m = 0.26, \Omega_b = 0.044$ $h = 0.72$
- full sky cover for $0 < z < 0.65$
- halos containing more than 100 particles
- mass resolution of $m_p = 1.5 \times 10^{11}\, M_\odot/h$
- 3110107 halos of $M(10^{14} M_\odot) \in (0.146, 27.795)$

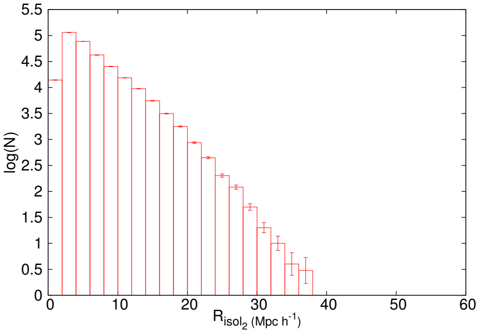
Methodology

- Identification of the nearest neighbor and its 'isolation' radius, $R_{\rm isol}$
- We apply our analysis only on 1595425 central halos with $M \geq 2.5 \times 10^{13} M_{\odot}$ and $z < 0.625$.



- $R_{\rm isol} \in (0.85, 37)$ (Mpc h^{-1})

- Especially for the identification of halos residing in dense regions we need to take into account R_{isol_2} as an isolation criterion of pairs of halos



Halo Abundance Function

- Tool for the quantification of the halo abundance:

$$\Phi(M) = \left[C_1 \left(\frac{M}{M_\star} \right)^\alpha + C_2 \left(\frac{M}{M_\star} \right)^\beta \right] \exp\left(-\frac{M}{M_\star} \right) \qquad (1)$$

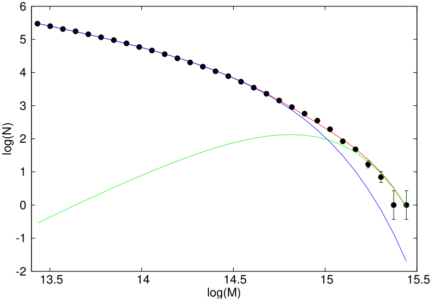
- Mass bins of a width $\delta \log M \simeq 0.0693$
- Fit to the resulting halo abundance: χ^2 minimization procedure.

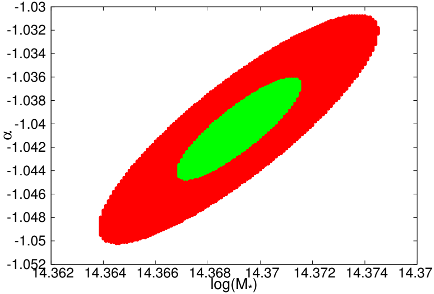
$$\chi^2(\mathbf{p}) = \sum_{i=1}^{N} \frac{(\log N_i(M) - \log \Phi(M, \mathbf{p}))^2}{\sigma_i^2}, \qquad (2)$$

where $\mathbf{p} = (\alpha, \beta, M_*, C_1, C_2)$

Halo Abundance Function

- Uncertainties of the parameters α and $M_\star$ calculated after marginalizing one over the other

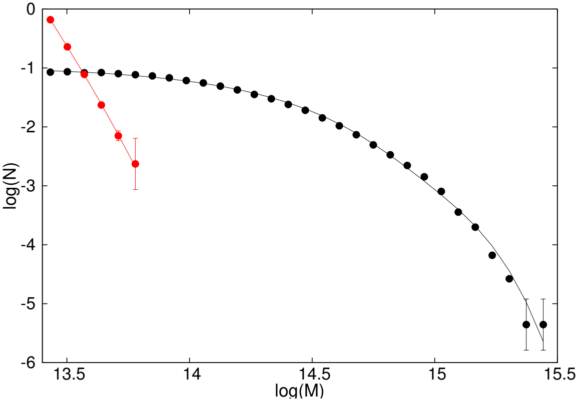




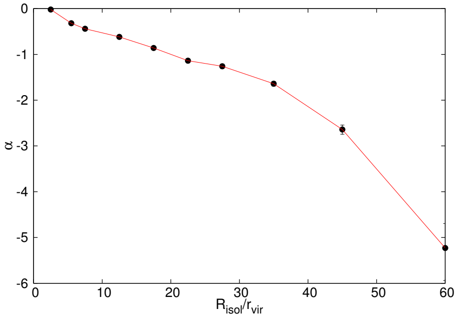
Results

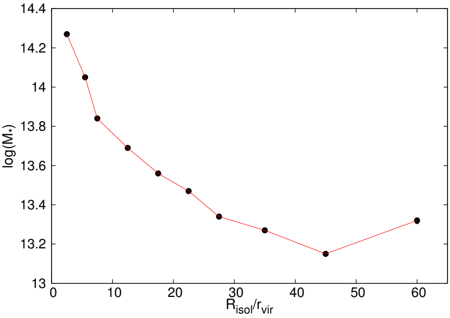
Normalised environmental criterion: $\mathbf{R}_{\mathrm{isol}}/\mathbf{r}_{\mathrm{vir}}$

Abundances of halos of $\mathbf{R}_{\mathrm{isol}}/\mathbf{r}_{\mathrm{vir}} \leq \mathbf{4}$ and $\mathrm{R}_{\mathrm{isol}}/\mathrm{r}_{\mathrm{vir}} \geq 50$ and best fit curves.



Results - Behaviour of the two fitted parameters with isolation defined by the normalized criterion.





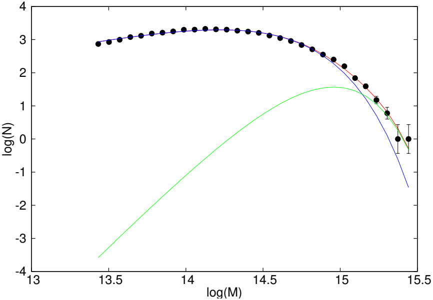
→ α still decreases with isolation.

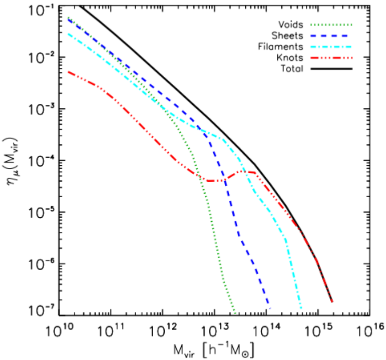
→ $M_\star$ decreases for all isolation status except for the most extremely isolated halos, $R_{\rm isol}/r_{\rm vir} < 50$. ⇒ the largest "void" area halos indeed tend to be relatively more massive than in less extreme isolation cases.

AF for "Knots"

We add a second parameter to our criterion for dense regions and we construct the AF of halos for which we demand that

$$1 < R_{isol}/r_{vir},\ R_{isol_2}/r_{vir} < 4$$





(Metuki et al. 2016)

Conclusions

Regarding our method:

- Our monoparametric estimator is a reliable environmental criterion for the characterisation of the isolation status of a halo. It consists of the normalised distance, $(R_{\rm isol}/r_{\rm vir})$, to the first neighbour and defines a minimum spherical devoided area around each halo.
- Using as a further parameter $(R_{\rm isol_2}/r_{\rm vir})$ we find excellent qualitative agreement of our AF with that of more elaborate but multiparametric methods (Metuki et al. 2016, Alonso, Eardly & Peacock 2015).

Conclusions

Regarding the AF

- the abundance of halos is strongly environment-depended.
- The main slope α, has a systematic decreasing tendency with isolation.
- $M_\star$, does also decrease with isolation, except for the extremely isolated halos for which we see an unexpected upturn which is redshift dependent.
- therefore, there must be a significant evolution of the isolation of the massive most isolated halos, an interesting result that needs further investigation.

Thank you !!!