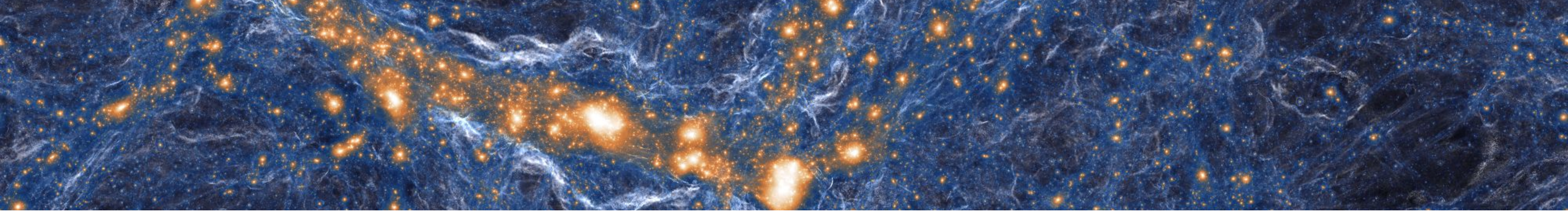

Correlations between galaxy properties and environment in the large scale structure

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From galaxies to cosmology with deep spectroscopic surveys: A tribute to Olivier Le Fèvre
Marseille, France
06 July 2022

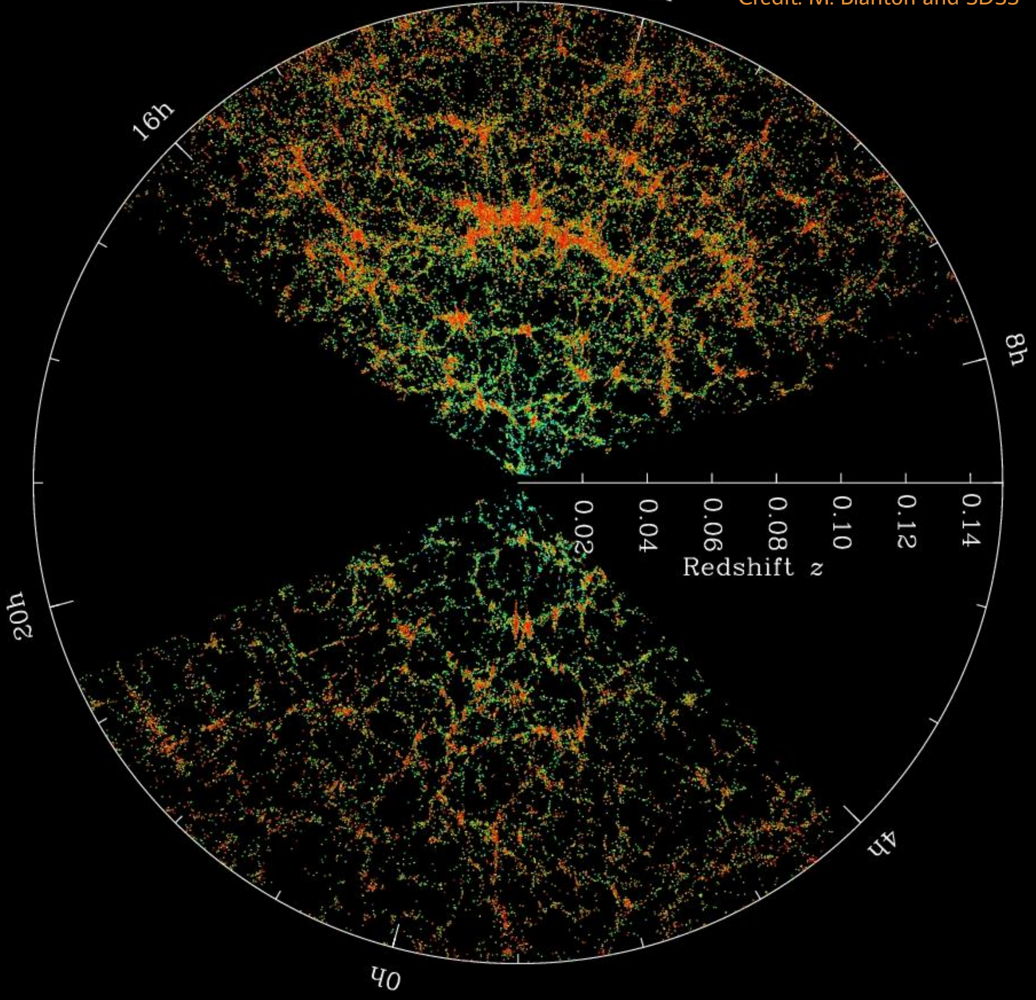
Large scale structure of the Universe

nodes

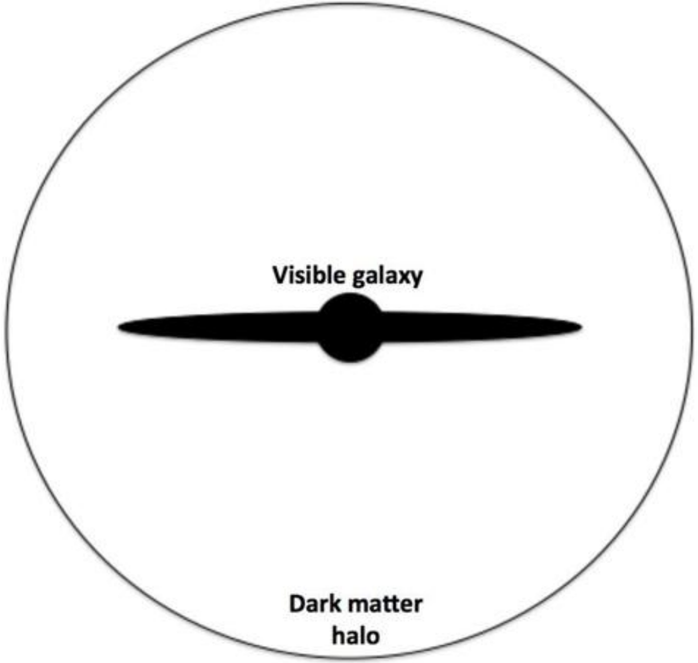
filaments

walls

voids



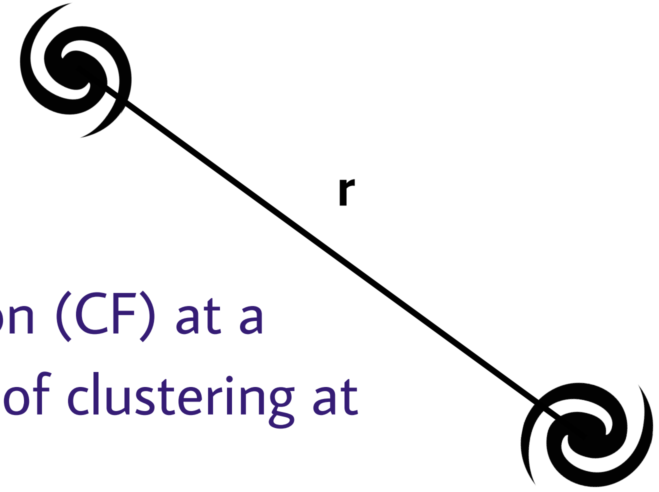
Credit: M. Blanton and SDSS



- ★ Galaxies live in dark matter haloes.
- ★ Galaxy properties are majorly defined by the properties of the DM halo in which they live.
- ★ The properties of DM halo correlate with environment (Sheth & Tormen 2004).
- ★ This prompts a correlation between galaxy properties and environment

Two-point correlation function - ξ(r) or $w_p(r_p)$

Compares the real distribution of galaxies with a random distribution.



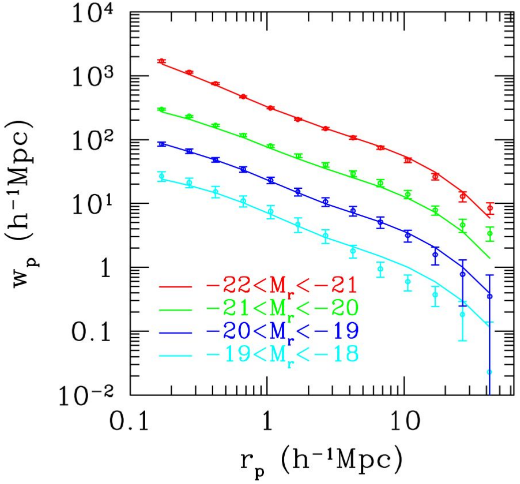
★ Greater the value of correlation function (CF) at a particular scale, greater is the strength of clustering at that scale

$$\xi(r) = \left(\frac{r}{r_0}\right)^{-\gamma}$$

Correlation length

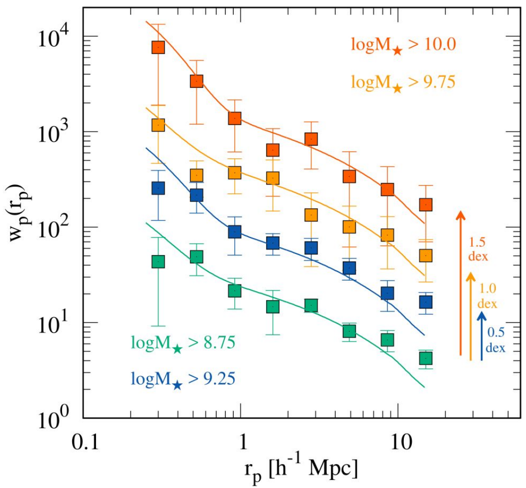
Dependence of clustering on galaxy properties

Zehavi et al. 2011



Norberg et al. 2001
Le Fèvre et al. 2005
Pollo et al. 2006
Zehavi et al. 2011
Farrow et al. 2015
Skibba et al. 2015
Durkalec et al. 2018
...

Durkalec et al. 2018

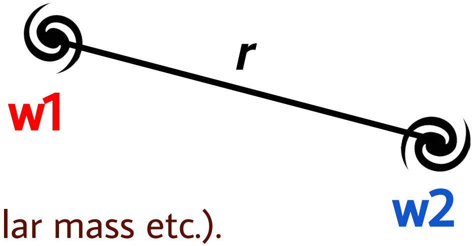


Luminous, massive, red and evolved galaxies tend to live in the denser regions of LSS than fainter, less massive, blue and young galaxies

(Anna Durkalec's talk)

HOW DIFFERENT ARE THE CORRELATIONS BETWEEN DIFFERENT GALAXY PROPERTIES AND THE ENVIRONMENT?

Marked Correlation Function (MCF)



- ★ We mark all galaxies with the property of interest (eg: luminosity, stellar mass etc.).
- ★ The mark is used to weight the galaxies while computing the correlation function

$$M(r) = \frac{1 + W(r)}{1 + \xi(r)}$$

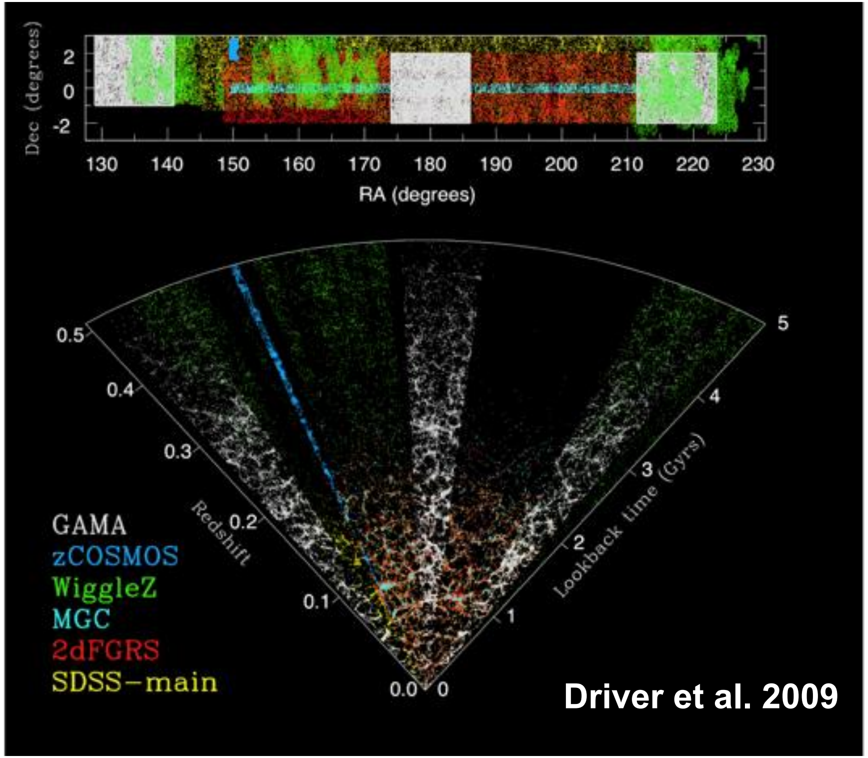
$1 + W(r)$ ← Weighted 2pCF

$1 + \xi(r)$ ← Unweighted 2pCF

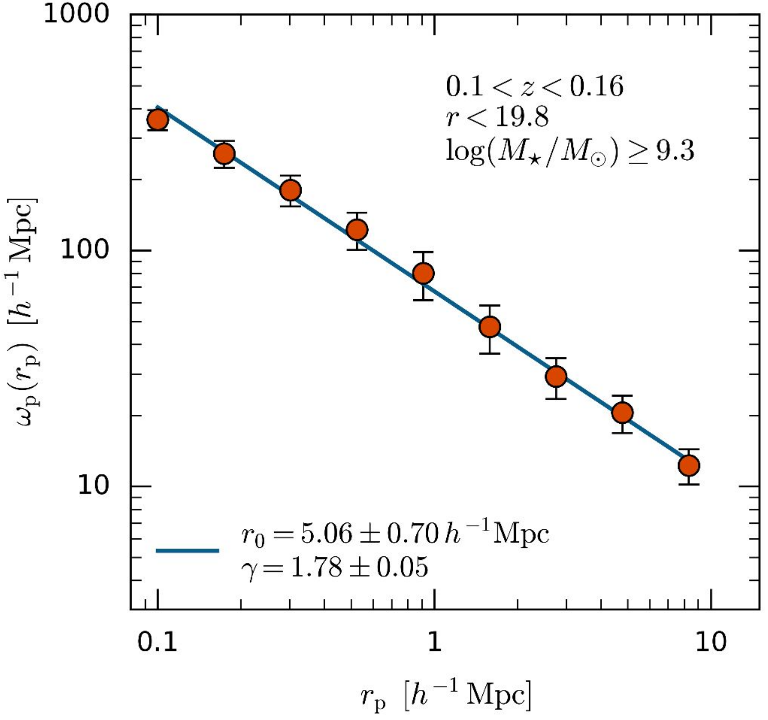
- ★ MCF = 1 : lack of correlation, MCF > 1 : correlation, MCF < 1 : anti-correlation
- ★ Strength of MCF for a property shows strength of the correlation between that property and the environment.
- ★ MCF computed using different properties can be compared to say which property is strongly correlated with the environment.

Galaxy and Mass Assembly (GAMA)

- spectroscopic multiwavelength galaxy survey
- Redshift z_{median} ~ 0.2
- flux limit : r < 19.8 (2 mag fainter than SDSS main galaxy sample)
- covers 5 sky regions of 60 deg^2 each: G09, G12, G15 (equatorial) and G02, G23 (southern)
- we make use of r-band limited data from GAMA II equatorial regions

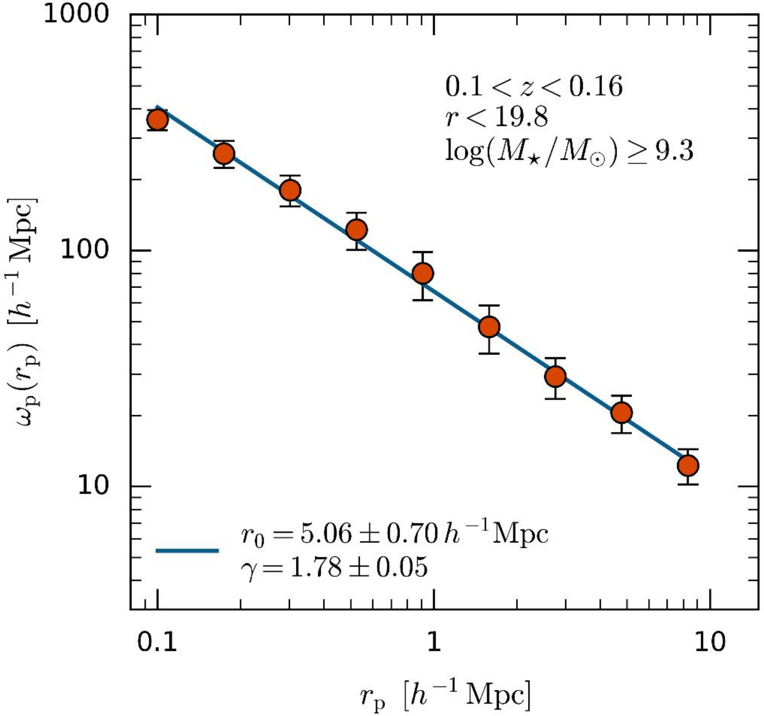


Two point correlation function

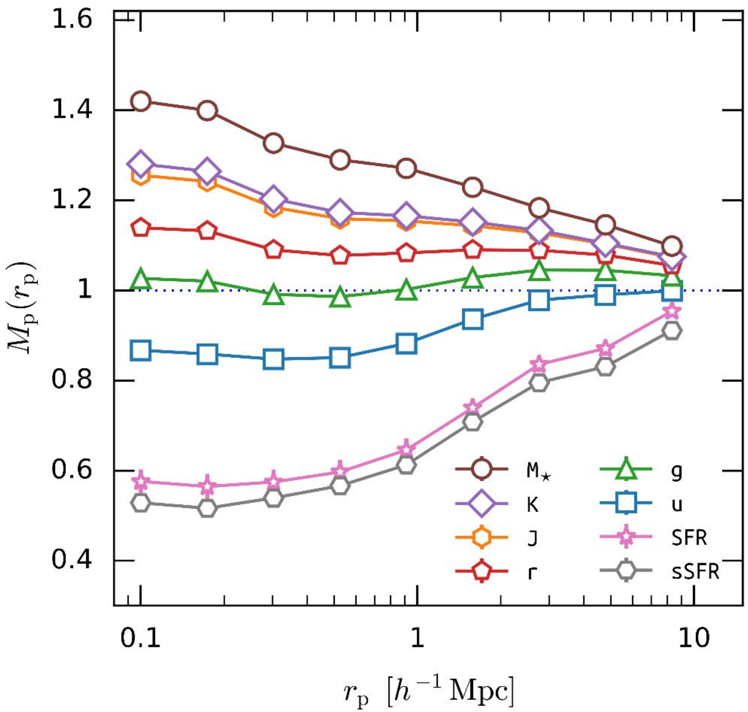


Sureshkumar, Durkalec, Pollo et al. 2021, A&A, 653, A35

Two point correlation function



Marked correlation function



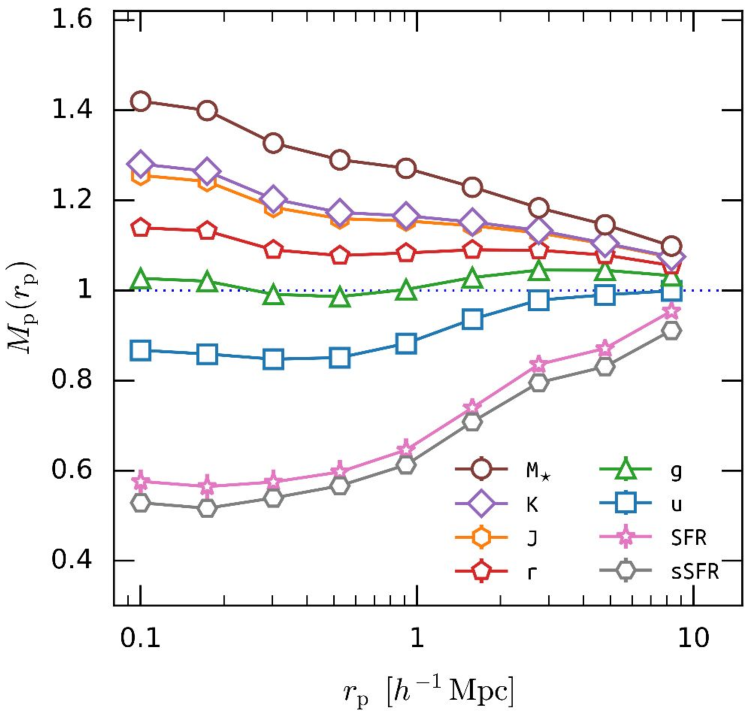
Sureshkumar, Durkalec, Pollo et al. 2021, A&A, 653, A35

★ Stellar mass MCF is stronger than that for other properties ⇒ Stellar mass proves to be strongly correlated with the environment.

★ SFR is anti-correlated with the environment.

★ K-band luminosity MCF follows stellar mass MCF ⇒ K-band can be a good, but not a perfect substitute for stellar mass in tracing the environment.

★ u-band luminosity can be a good, but not a perfect proxy for star formation rate in the context of galaxy clustering.

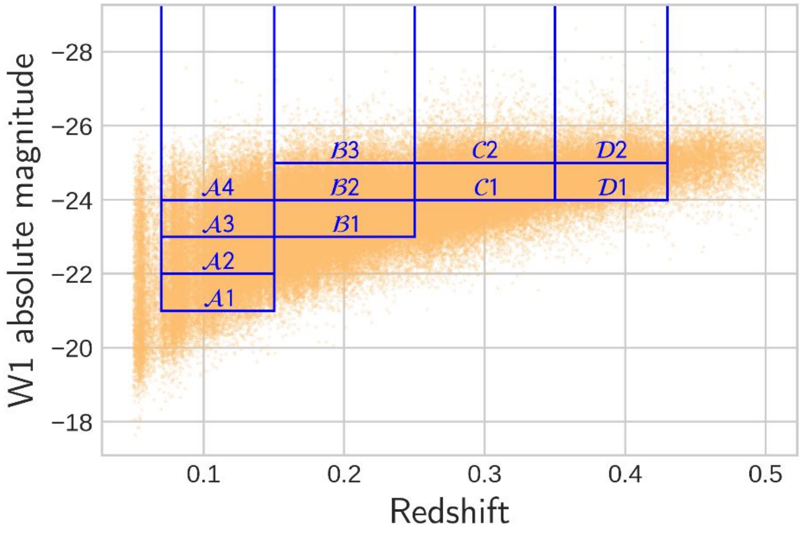


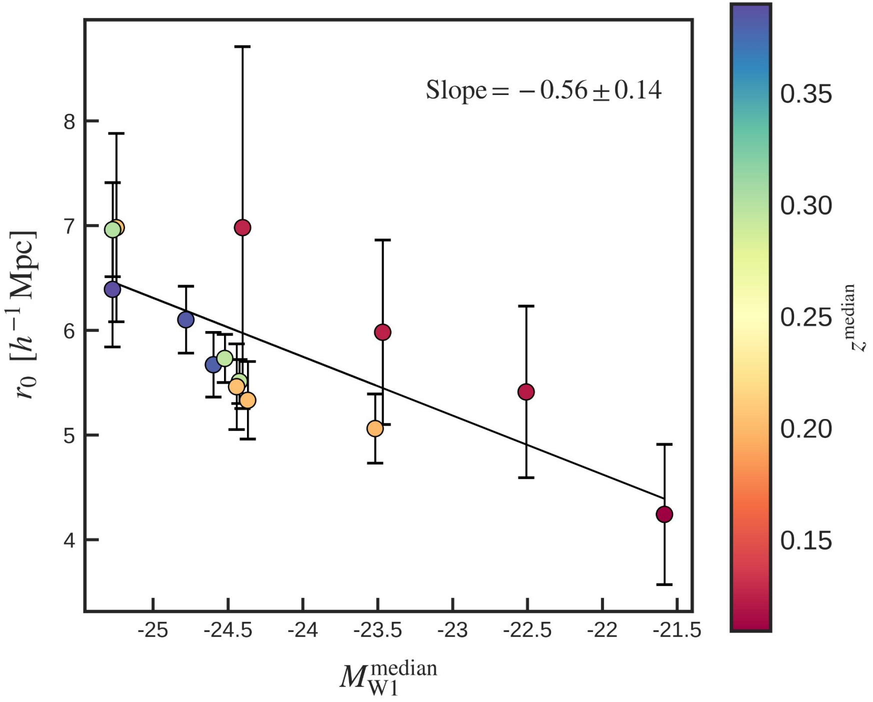
Sureshkumar, Durkalec, Pollo et al. 2021, A&A, 653, A35

HOW ABOUT THE MID-IR PROPERTIES AND THE ENVIRONMENT?

GAMA galaxies with mid-IR properties from WISE

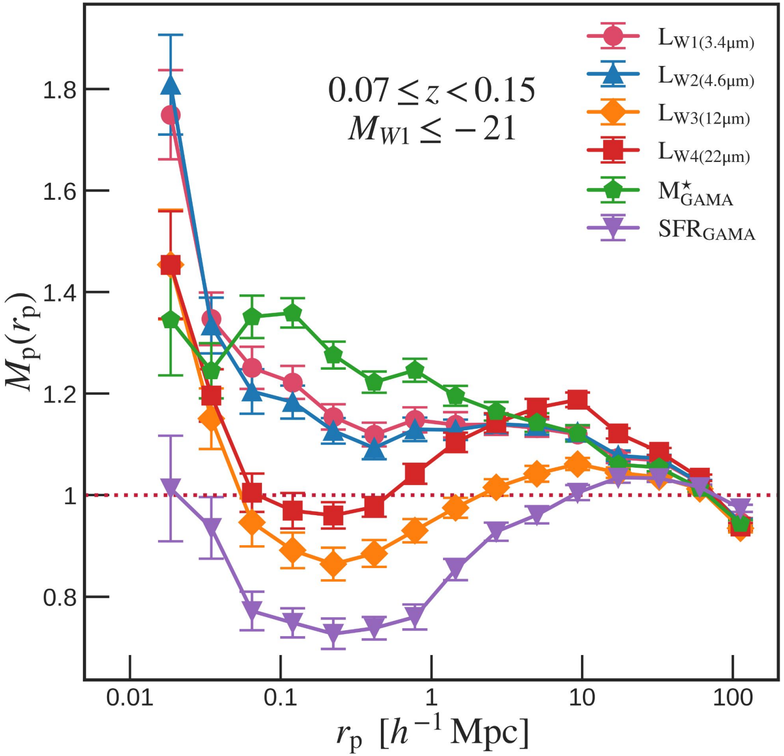
(Cluver et al. 2014)





Sureshkumar, Durkalec, Pollo et al. (submitted to A&A; arXiv: 2201.10480)

Environmental dependence of mid-IR properties



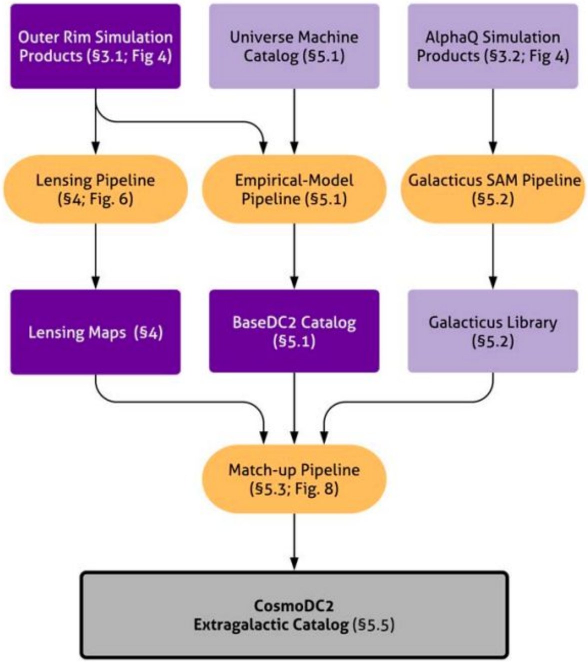
- ★ W1 and W2 bands follow stellar mass in tracing the environment.
- ★ W3 and W4 bands follow SFR.
- ★ Stronger SFR-environment correlation in smaller scales

Sureshkumar, Durkalec, Pollo et al. (submitted to A&A; arXiv: 2201.10480)

HOW WELL DO SIMULATIONS REPRODUCE THE ENVIRONMENTAL DEPENDENCE OF GALAXY PROPERTIES?

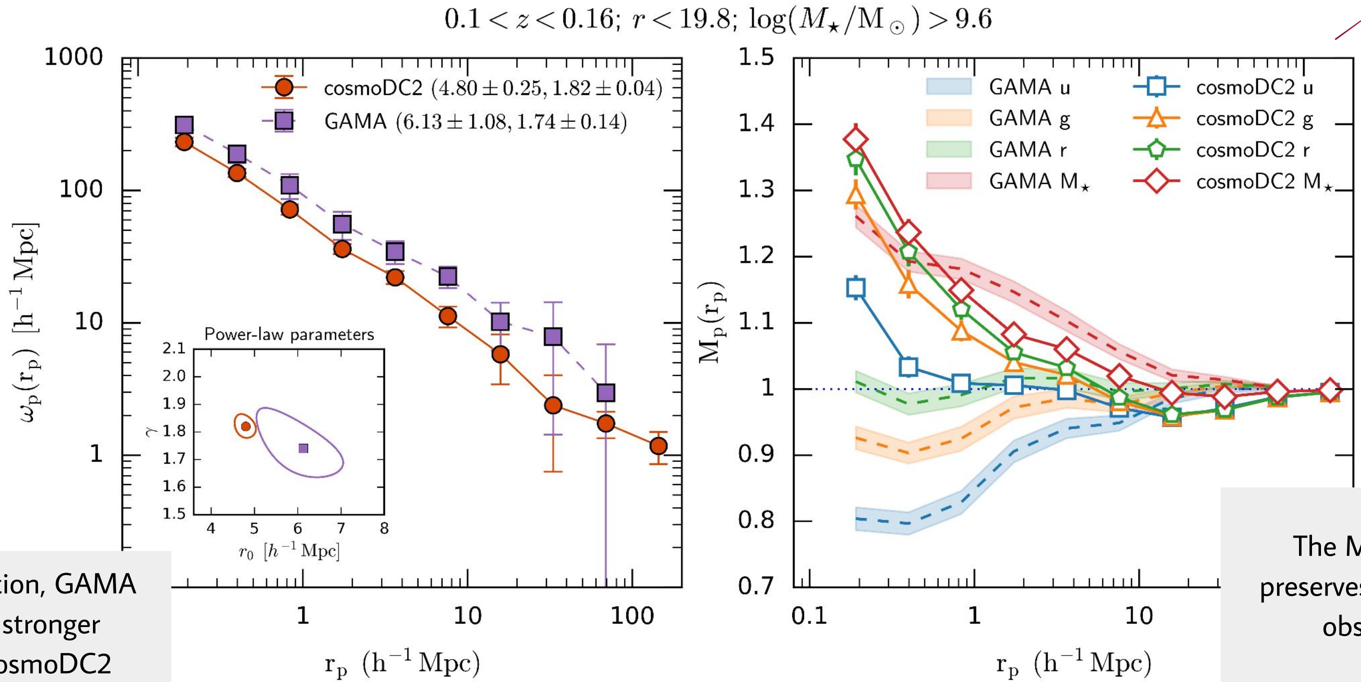
CosmoDC2 catalogue

- LSST Dark Energy Science Collaboration
- Redshift up to 3
- Magnitude depth : r < 28
- Sky area : 440 sq. deg.



Korytov et al. 2019

Measurements in cosmoDC2 catalogue



For the same selection, GAMA sample shows a stronger clustering than cosmoDC2 sample.

The MCFs in cosmoDC2 preserves the hierarchy that is observed in GAMA.

However, MCFs in cosmoDC2 behaves very differently than in GAMA implying that the cosmoDC2 mock catalogue does not perfectly reproduce the environmental dependence in observed data.

Sureshkumar, Durkalec, Pollo et al. (in prep.)

Future plans

Using high redshift surveys (e.g. VIPERS)

- Environmental dependence of properties at high redshift
- Verify proxies for stellar mass and SFR
- Redshift evolution of MCFs (particularly SFR)

Conclusions

- We demonstrated how marked correlation function traces the differences in the environmental correlations of different galaxy properties.
- Stellar mass proves to be the strongest tracer of environment.
- SFR is anti-correlated with the environment.
- Luminosities in different bands form a hierarchy in which K (2.2 μm), W1 (3.4 μm) and W2 (4.6 μm) bands follow stellar mass and u (0.4 μm), W3 (12 μm) and W4 (22 μm) bands follow SFR in tracing the environment.
- CosmoDC2 simulation catalogue does not perfectly reproduce the environmental dependence of galaxy properties observed in real data.

thank you for you attention!

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