The assembly history of galaxies and their environment

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on GAMA data.
Outline

• Background and motivation:
  • the expectations and observations of halo assembly times - assembly bias;
  • simulations and observations.

• This work:
  • tools and data: geometric environment, VESPA and GAMA;
  • some estimators, plots and preliminary words.

• On-going and future work.
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- Very successful at describing the clustering of galaxies of different luminosity, colour or environment.

- However, simulations show that the clustering of DM halos depends not only on their mass but also - often in a complex way - on their \textit{assembly history}. I.e. halos of the same mass cluster differently according to how long ago they assembled their mass: \textit{assembly bias}. 
Simulations and observations
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- **Halo assembly bias detected in simulations** [Gao, Springel & White 2005; Wechsler et al. 2006; Gao & White 2007; Croton, Gao & White 2007; Li, Mo & Gao 2008], usually by studying clustering strength as a function of halo assembly time at fixed halo mass.
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- **Results are less clear in data.** Using galaxy clustering amplitude some have found evidence on galaxy properties that is consistent with assembly bias [e.g. Yang, Mo & van den Bosh 2006, Wang et al. 2008, 2013], but using different techniques others have not [e.g. Blanton & Berlind 2007; Tinker et al. 2008].
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- Recently Zentner et al. 2014, for example, showed that ignoring halo assembly bias results in a systematic bias of the inferred galaxy-halo relationship from clustering in simulations.
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- Ultimately, we look for a better way to re-parametrise halo-galaxy relation models.
The GAlaxy and Mass Assembly Survey

- A multi-wavelength, spectroscopic survey of the low redshift Universe (z < 0.5).
- Fibre spectroscopy using AAT/2dF+AAOmega
- Area: ~290 deg$^2$ split over 5 regions
- Main sample: ~300k galaxies to r < 19.8 mag
- $\langle z \rangle \sim 0.27$
- $R = 1300$, $370 < \lambda < 880$ nm
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GAMA Spectroscopy

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![Graphs showing rescaled spectra](image-url)
The fossil record of galaxies using VESPA

[Tojeiro et al. 2007, 2009]

Figure 9: Example fits to the optical spectrum of a quiescent and a star-forming galaxy with VESPA (Tojeiro et al. 2009). The SFHs are estimated non-parametrically with an age binning that is adaptive depending on the S/N and information content of the spectrum. The upper panels show the best-fits (red line is the model, black line is the data; emission lines have been excluded from the fits); lower panels show the recovered SFHs plotted as the mass fraction formed within each age bin. Figure courtesy of R. Tojeiro.
We can reconstruct the **star-formation history** of a galaxy from the fossil record.
Estimators of stellar-mass assembly time

(a) $t_{0.85}$ - time in Gyrs at which 85% of stellar mass had assembled.

(b) Mass-weighted age in Gyrs.

(c) fraction of young stars (age < 275 Myrs).

-> each computed from the full SFH from each galaxy.
Environment classifications (more of Lizzie’s work)

• **VOIDS**
• **SHEETS**
• **FILAMENTS**
• **KNOTS**

**Tidal Tensor Prescription:**

\[ T_{ij} = \frac{\partial^2 \phi}{\partial q_i \partial q_j} \]

Second derivative of gravitational potential indicates whether point is near a potential minima or potential maxima.

Eigenvalues of \( T_{ij} \) determine geometrical nature of each point in space.

Number of positive eigenvalues corresponds to the dimension of the stable manifold.
Application to GAMA (still Lizzie’s work)

a) Galaxies

b) Smoothed density contrast
\[ \sigma_s = 10h^{-1}\text{Mpc} \]

c) Environments
\[ \lambda_{th} = 0.1 \]
Application to GAMA (still Lizzie's work)

σ = 4.00h⁻¹ Mpc, \( \lambda_{th} = 0.40 \)

- Voids
- Sheets
- Filaments
- Knots
- Total

\( \sigma_s = 10h^{-1}\text{Mpc} \)
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c) Environments
Stacked spectra

- Geometric environment classifications from Lizzie Eardley.
- Group masses from $G^3$ Cv1 group catalogue from Robotham et al. 2011
EnvClassifications/GAMA_G3CFoFGroupv06_0.10t_10.00s.dat

Ungrouped (18442)  11<logM<12 (3260)
8<logM<11 (1337)   12<logM<15 (6121)
$10.0000 < \log M < 11.0000$

- Void (734)
- Sheet (1794)
- Filament (2382)
- Cluster/Knot (853)

$11.0000 < \log M < 11.5000$

- Void (785)
- Sheet (2258)
- Filament (2853)
- Cluster/Knot (1014)
11.5000 < logM < 12.0000

- Void (896)
- Sheet (3173)
- Filament (4156)
- Cluster/Knot (1668)

12.0000 < logM < 12.5000

- Void (834)
- Sheet (3397)
- Filament (5311)
- Cluster/Knot (2269)
SFHs and assembly times

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- Group masses from $G^3Cv1$ group catalogue from Robotham et al. 2011.
- SFHs and assembly times from VESPA.
Tentative statement:
at fixed group/halo mass, we find no dependence of the stellar assembly time on geometric / global environment.
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• Do our estimators trace halo assembly times?

  • Hard to imagine a scenario where they don’t *to some extent*. We are sourcing suitable *simulations* with which to study this in detail.

  • Even if so, can we assign all effects of global environment on galaxy properties to assembly bias? What about super-halo interactions?
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  - Sample to increase by a **factor of 5 + photometry**.
  - (Important) technicalities: robustness to env classifications, SSP models, group masses.
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- What about galaxy assembly bias? Coming next!
Thank you.

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