Probing reionisation with cross-correlations of galaxies and the IGM transmission

KICC 10th Anniversary Symposium
Cambridge - 18 September 2019

Romain A. Meyer (UCL)

Collaborators: K. Kakiichi (UCL), S. E. I. Bosman (UCL), R. S. Ellis (UCL), N. Laporte (UCL), B. Robertson (UCSC), E. Ryan-Weber (Swinburne), K. Mawatari (Osaka/Kashiwa)
We know when reionisation was completed - but we are ignorant about which sources did it.
An idealised view of reionisation: galaxies trace “ionised bubbles”

→ Spectroscopic surveys of field galaxies with background QSO to probe cross-correlations with the IGM transmission
A survey of LBGs and LAEs in 8 $z>6$ quasar fields

MUSE/VLT

DEIMOS/Keck

Meyer et al., in prep
Meyer et al., in prep
The two-point correlation of transmission spikes is better defined than the mean flux around galaxies (at $z>5.5$ with few QSOs).
The **2-point cross-correlation** function of LAEs and transmission spikes reveals association on ~10s cMpc scales!

**LBG - Lyα**

No signal -> cosmic variance?  
(13 LBGs, 3 QSOs)

**LAE - Lyα**

Clear signal  
(22 LAEs, 6 QSOs)

*Meyer et al., in prep*
Modelling the two-point cross-correlation of transmission spikes and galaxies: all galaxies matter!

\[ \langle \Gamma_{HI}(r) \rangle \propto \langle f_{esc} \xi_{ion} \rangle \times \text{(Galaxy abundance: Tracer+Clustering)} \]

\[ \tau_\alpha \approx 11\Delta_b^{2-0.72(\gamma-1)} \left( \frac{\Gamma_{HI}}{10^{-12} \text{ s}^{-1}} \right)^{-1} \left( \frac{T_0}{10^4 \text{ K}} \right)^{-0.72} \left( \frac{1 + z}{7} \right)^{9/2} \]

\[ P(< \Delta_b^{\text{max}}(r)) = \int_0^{\Delta_b^{\text{max}}(r)} P_V(\Delta_b)d\Delta_b \]

We constrain the luminosity-averaged escape fraction and ionising efficiency of all galaxies contributing to reionisation.
Our model captures well the two-point cross-correlation (except on the small scales)

\(f_{esc} = 0.1, M_h = 10^{11} M_\odot\)

\(M_{lim}^{UV} = -12, M_h = 10^{11} M_\odot\)

\(M_{lim}^{UV} = -12, f_{esc} = 0.1, \xi_{ion} = 25.5\)

Meyer et al., in prep
High-z galaxies need large escape fractions to drive reionisation!

$\xi_{ion} = 25.5$
Conclusions

• First detection of LAE-IGM transmission 2 point correlation signal
• Constraint on luminosity-average escape fraction
• “The end of the beginning”: IGM-galaxy/metal absorber correlations will probe different populations of sources
Extra slides
Previous attempts at galaxy-IGM correlations

1 QSO / 5 LBGs / z~5.8

15 QSOs / 37 C IV / z~5.2
Taking into account the enhanced gas overdensities closer to the LAE/LBG host halo center

- Gas overdensity PDF extracted from IllustrisTNG100-2 at z=5.85
- Parametrised following MHR+2000, Pawlik+2009

Meyer et al., in prep