HST Grism Spectroscopy of the HFF with GLASS: Ly$\alpha$ Emitters at z>6

Kasper B. Schmidt
UC Santa Barbara

The GLASS Team
GLASS

THE GRISM LENS-AMPLIFIED SURVEY FROM SPACE

- P.I. Tommaso Treu (UCLA)  glass.physics.ucsb.edu
- HST Grism Spectroscopy of 10 massive clusters (Cycle 21)

- Investigate the gas and galaxies at the EoR
  - 2nd part of this talk

- Describe how metals cycle in and out of galaxies
  - see Jones’ talk in 12+3 minutes

- Support SN searches in the HFF
  - see Rodney’s talk tomorrow

- Assess the environmental dependence on galaxy evolution
Grism (slitless/3D) Spectroscopy

- Spectra of *everything* in the field-of-view
- Spatial information to create resolved EL and metallicity maps

- Emission Line redshift precision $Δz\sim0.005$
  - e.g. Brammer et al. 2012
• Spectra of $\sim$10000 ($m_{F140W} < 24$) with spectroscopic limits $\lesssim 1e-18$ erg/s/cm$^2$; Schmidt et al. 2014a
The epoch of reionization is where neutral hydrogen was (re-)ionized by radiation from the first astronomical sources, cf. talks by Bullock, Oesch, Coe, Atek, Livermore, Huang.
**Potential Lyα in GLASS Spectra**

- Multiple imaged source behind RXJ2248 at $z = 6.11$
  - Boone et al. (2013) and Balestra et al. (2013)

- **GLASS** observes each Cluster at 2 PAs $\sim 90^\circ$ apart
  - Minimizes contamination and strengthens line recognition

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Lyα @ $z = 6.11$  
C = Contamination  
Lyα @ $z = 6.11$
Potential Ly$\alpha$ in GLASS Spectra

- 6/10 Clusters have complete GLASS data
  - A2744, MACS0717, MACS1423, MACS2129, RXJ1347, RXJ2248

- ~20 LBGs per cluster selected via:
  - Color selections: $i, z, Y, J, JH$ dropouts
  - Photo-z: BPZ (Benitez 2000) and EAZY (Brammer et al. 2008)
  - Literature samples from e.g. Atek et al. (2013), Zheng et al. (2014), Ishigaki et al. (2014), Bradley et al. (2014), Karman et al. (2014)

- 20-30% of LBGs show ‘line-features’ in the GLASS spectra
Potential Ly$\alpha$ in GLASS Spectra

Ly$\alpha$ @ $z = 6.90$

Ly$\alpha$ @ $z = 6.79$

Ly$\alpha$ @ $z = 6.35$

Ly$\alpha$ @ $z = 7.08$

Ly$\alpha$ @ $z = 6.35$

Ly$\alpha$ @ $z = 6.32$
GLASS EoR Inference at z > 7

- Collected all z > 7 galaxies in completed GLASS clusters
- Selected spectra for objects with low contamination level
- Estimated Ly\(\alpha\) EW limits based on grism spectra
  - Conservatively ignoring the potential Ly\(\alpha\) detections for now
- Apply Bayesian EoR inference from Treu et al. (2012)
EoR State at z > 7: Upper Limits
(If none of the Ly$\alpha$ detections are confirmed)

See also Treu et al (2013; z~8), Pentericci et al. (2014; z~7) and Tilvi et al. (2014; z~8)
**GLASS**

- Well underway (6/10 completed clusters)
- Spectra of *everything* in the WFC3/ACS FoV

**Lyα at z > 6**
- 100s of spectra of LBGs resulting in EW limits
- 10s of confirmed/candidate Lyα emission lines
THE GLASS TEAM

glass.physics.ucsb.edu

- Tommaso Treu, PI (UCLA)
- Marusa Bradač (UCD)
- Gabriel Brammer (STScI)
- Mark Dijkstra (UoO)
- Alan Dressler (Carnegie Obs.)
- Adriano Fontana (INAF Rome)
- Raphael Gavazzi (IAP)
- Alaina Henry (NASA Goddard)
- Austin Hoag (UCD)
- Kuang-Han Huang (UCD)
- Tucker Jones (UCSB)
- Patrick Kelly (UCB)
- Matt Malkan (UCLA)
- Charlotte Mason (UCSB)
- Laura Pentericci (INAF Rome)
- Bianca Poggianti (INAF Padova)
- Kasper Schmidt (UCSB)
- Massimo Stiavelli (STScI)
- Michele Trenti (Cambridge)
- Anja vd Linden (DARK/Stanford)
- Benedetta Vulcani (KIPMU Tokyo)
- Xin Wang (UCSB)
HST spectroscopy of clusters.

No atmosphere

No skylines

Extensive HST imaging of clusters

Atmospheric absorption and skylines

Similar to synergy between 3D-HST and CANDELS
EoR State at z > 7: Upper Limits

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