MUSE+WFC3 STUDIES OF CIII] EMITTERS

Michael Maseda, Jarle Brinchmann, Marijn Franx, Roland Bacon, and the MUSE GTO Team

Leiden Observatory

(A&A accepted; part of forthcoming MUSE UDF Paper Series)
The current state of high-z spectroscopy

- Hundreds of photometric candidates at $z > 5$ from CANDELS, HUDF, BoRG, etc.
- But relatively few spectroscopic confirmations from Ly-α or continuum breaks (a few 10s in MUSE)

\[ Oesch+15,16 \]
What’s going on at high-z?

• Increasingly neutral IGM at $z>6$ leads to increased scattering of Ly-$\alpha$ photons (Stark+11, Pentericci+11, Treu+13, Dijkstra+14, …)
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- (New results indicate that this may not be true around the most extreme galaxies)
CIII: the best thing since Ly-α?

- Up to 10% of Ly-α but is not energetic enough to ionize Hydrogen

Shapley+03 (z~3 LBG stack; ~1000 galaxies)
CII: the best thing since Ly-α?

- Up to 10% of Ly-α but is not energetic enough to ionize Hydrogen

- Photoionization models ➔ “Easier” to interpret than Ly-α

- Doublet (1907/1909 Å) ➔ unambiguous redshift determination at high-resolution

BUT current samples are small and biased

Shapley+03 (z~3 LBG stack; ~1000 galaxies)
Physics with CIII and the rest-UV in general

- CIII doublet sensitive to electron density
- CIII and OIII 1665 (or 5007) can constrain C/O abundance
- These and other lines, like HeII 1640 and CIV 1549 can constrain:
  - Ionization parameter
  - AGN diagnostics
  - Metallicity

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MUSE probes these lines at $1.5 < z < 4$

Shapley+03 (z~3 LBG stack; ~1000 galaxies)
MUSE spectroscopy

- MUSE at the VLT
- R~3000
- 4650-9300 Å
- 1’x1’ Integral Field Unit

- AO system should be online from end of 2017
MUSE spectroscopy

- MUSE at the VLT
- R~3000
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- ~20 hours in the HDFS (Bacon+15)
- Flux limit ~3x10^{-19} erg/s/cm$^2$
MUSE spectroscopy

- MUSE at the VLT
- $R \sim 3000$
- 4650-9300 Å
- 1’x1’ Integral Field Unit
  (a wide-area IFU acts like a MOS)
- ~20 hours in the HDFS
  (Bacon+15)
- Flux limit $\sim 3 \times 10^{-19} \text{ erg/s/cm}^2$
MUSE spectroscopy

- MUSE at the VLT
- R~3000
- 4650-9300 Å
- 1’x1’ Integral Field Unit

- 30+ hours in the UDF (GTO; Bacon+17)
- ~20 hours in the HDFS (Bacon+15)

- Flux limit ~3x10^{-19} erg/s/cm^2
The full MUSE UDF Program

- MUSE UDF program has two components:
  - “Deep” (1x30 h) and “Mosaic” (9x10 h)
  - Matches footprint of deepest HST imaging
17 CIII Emitters (> 3-σ, > 1 Å EW)
Are the CIII emitters intrinsically different?

- Compare e.g. SED-derived quantities (MAGPHYS – da Cunha+08)
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Are the CIII emitters intrinsically different?

- Compare e.g. SED-derived quantities (MAGPHYS – da Cunha+08)
What controls the strength of CIII?
SF or AGN?

- CIII alone cannot constrain the type of ionizing radiation

\[ \text{Feltre+15} \]
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Feltre+15
SF or AGN?

- CIII alone cannot constrain the type of ionizing radiation
- MUSE has coverage of HeII, OIII, SIII…

Feltre+15, Gutkin+16
SF or AGN?

- C IIII alone cannot constrain the type of ionizing radiation
- MUSE has coverage of He II, O III, S IIII...

(Including data from UDF Mosaic; Maseda+ in prep)
MUSE+ WFC3 in the UDF

WFC3 G141 slitless spectroscopy from 1.1-1.7 μm

40ks: Line sensitivity of < 10^{-18} erg/s/cm^2

MUSE UDF-10 is well-matched to deep HST imaging and spectroscopy!

Adapted from Brammer+13
MUSE+WFC3 in the UDF

WFC3 G141 slitless spectroscopy from 1.1-1.7 μm

High-EW optical lines expected to be common at high-z (e.g. Labbe+13)
CIII emitters have strong optical lines

- OIII + Hβ (and OII) for CIII emitters
CIII emitters have strong optical lines

- OIII+Hβ (and OII) for CIII emitters

\[
\text{[O III]} / \text{[O II]} = \frac{\text{EW}_{\text{OIII},0}}{\text{EW}_{\text{OII},0}}
\]

\[
[\text{O III}] = 47.9 \times \text{C III}] + 349
\]

Paalvast+17
In progress: C\textsc{iii}-O\textsc{iii} from full UDF

- UDF-10 (this work; Maseda+17b)
- UDF Mosaic (this work)
- Stark+14
- Maseda+17a
- Fit to MUSE UDF data (this work)
Conclusions

- CIII emitters are, on average, younger, more vigorously star-forming, and bluer than non-CIII emitters.
- High-EW C III] (> 5 Å) only occurs at masses < $10^{9.5} \, M_\odot$ and SFRs < $10 \, M_\odot$/yr.
- Nearly all high-EW OIII emitters (> 250 Å) at these redshifts are CIII emitters.
Bonus: why an IFU is important

- MUSE UDF program has two components:
  - “Deep” (1x30 h) and “Mosaic” (9x10 h)
  - Matches footprint of deepest HST imaging

![Image showing exposure time and flux distributions]
Bonus: why an IFU is important

• No photometric preselection

• Bacon+17: At least 160 sources have MUSE redshifts and no counterpart in the Rafelski+15 catalog
  • Many (> 70) are high-EW LAEs!
HST-undetected LAEs

MAXMAP  |  WHITE  |  HST F775W  |  HST F850LP  |  NB Lyα

10^{-20} \text{ erg s}^{-1} \text{ cm}^{-2} \text{ Å}^{-1}

Lyα

Bacon+17
HST-undetected LAEs

HST_F606W  HST_F775W  HST_F105W  HST_F125W
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