RESOLVING IONISATION AND METALLICITY ON PARSEC SCALES ACROSS PRIMORDIAL ANALOGUES WITH HST-WFC3

My questions/themes:
★ What can we learn from metal-poor galaxies?
★ Spatially resolving metal-poor galaxies at different redshifts
★ What’s the most efficient way of detecting and studying them?
What are the effects of stellar feedback in metal-poor environments?

Did dwarf galaxies play a role in cosmic reionization?

Madau & Dickinson 2014
Are star-forming galaxies chemically homogeneous?

How is star-formation triggered?

- Accretion
- Galaxy Evolution
- Outflows
- Star-Formation
- Metal Distribution

Metallicity

Surface Gas Density

Star-formation efficiency

Metal Distribution

Outflows

Accretion

Galaxy Evolution

Star-Formation

Metal Distribution

Star-formation efficiency

Metallicity

Surface Gas Density

Shi+ 2014

Sextans A (7% solar metallicity; region radius: ~0.15 kpc)

ESO 146-G14 (9% solar metallicity; region radius: ~1 kpc)

Yuan+ 2011

z ~ 2, clone arc

z ~ 1.5, Sp1149

local early-type

local late-type

r1, r2, r3

Yuan+ 2011

Shi+ 2014

Surface Gas Density

0.5 1.0 1.5 2.0 2.5 3.0
NEARBY ANALOGUES TO THE FIRST GALAXIES

z~10 candidate XDFj-38126243 (Oesch+ 2013)

 Mostly blue compact dwarf galaxies (BCDs)

Metal poor  
+  
(often) starbursting  
≈ High-z galaxies

Credit: J. MacKenty et al. 2000

Credit: A. Aloisi et al. 2007

Credit: B. James
MAPPING STELLAR FEEDBACK IN MRK 71

11 filters: 7 emission lines: HST-WFC3
10 orbits, 2 BCDs, PI: James

[@James2016a](#)

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**[OII]**  
**HeII**  
**Hβ**  
**[OIII]**  
**Hα**  
**[SII]6716**  
**[SII]6732**

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**Stellar:** b=U, g=V, r=I  
**Gas:** b=[OII], g=[OIII], r=Hα

D=3.44 Mpc, 0.04”/pixel, ~0.7 pc/pixel

Metal-poor galaxies: exploring low-z, high-z, uncovering

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*(Image of the map of MRK 71 showing emission lines and clusters.)*
EMISSION LINE DIAGNOSTIC IMAGING

Cluster A
Cluster B
Path of blowout
Shock front?

\( \Delta \delta \) (arcsec)

\( \Delta \alpha \) (arcsec)

\[ [\text{OIII}] / H\beta \]
\[ [\text{SII}] / H\alpha \]

Shock-Ionized
Photoionized

Need velocity information (e.g. Ho+, 2014)

James et al., 2016a, ApJ

put in spare slide with models
[OIII]/[OII]+ HeII Contours

Blowout from winds of Wolf Rayet cluster?

HeII $\lambda 4686 = $ WR + nebular HeII

Strongest peak aligns with highly ionised gas

STELLAR FEEDBACK IN MRK71

(Ionisation parameter image)
“FEEDBACK IMAGING”

James et al., 2016a, ApJ
What are the effects of stellar feedback in metal-poor environments?

- Feedback mechanisms create gas cavities: suppress star-formation …and dwarf galaxy evolution? (but can also trigger SF)
- Stellar super winds transport photons: reionization of the IGM
- Shock-excitation: very difficult to detect…large consequences?
METALLICITY “IMAGING” OF MRK 71

Decrease in O/H surrounding main super star cluster:
- Blow-out of primordial gas?
- Pollution from young clusters hasn’t mixed?
- Has the R$_{23}$ diagnostic broken down?…

HeII emission from Wolf Rayet stars <1Myr old

Metallicity, 12+log(O/H)

Kewley & Dopita 2002

Decrease in O/H is consistent with:
- Blow-out of primordial gas?
- Pollution from young clusters hasn’t mixed?
- Has the R$_{23}$ diagnostic broken down?…
Do emission-line diagnostics have a minimum spatial scale?

HST-WFC3 dataset: (0.04″/pixel)
Structure observed <50 pc scales

The era of 30/40m telescopes is approaching…
Each one will have an IFU.

e.g. E-ELT Harmoni
0.04″/spaxel (5″x10″ FoV)
0.02″/spaxel (2.5″x5″ FoV)
We will probe <50pc scales at z=2
CHEMICAL MAPPING @HIGH-Z: DEPENDENCE ON SCALE

Are gradients evolving? or Discrepancy due to resolution?

Scales <1 kpc are needed for a reliable gradient (Yuan+ 2013)

Although ΔZ is lost, <Z> (usually) remains
Are star-forming galaxies chemically homogeneous?

➡ Not always!
➡ Environments affect mixing timescales & star-formation, + evidence for accretion
➡ Spatial scales play a big role - at both low-z & high-z.
EMISSION-LINE MAPPING: FUTURE PATH

Pin-down shocks at low-z with IFUs

Assess how LyC photons escape

Ionisation Parameter Mapping
12 HST-WFC3/ACS orbits, PI: Oey
LyC emitters: Haro 11, Tol 1247-232

Stellar Feedback at z=2.4 with HST

Simulated 3 Orbits
HST-WFC3 F167N
Metal-poor galaxies are key in understanding galaxy evolution.

Stellar feedback: suppresses star-formation & transports photons...shocks?

Star-forming galaxies are not chemically homogeneous: effects?

IFS studies of nearby systems allow extended insight into the 'realistic' ISM of star-forming galaxies at all redshifts → constrain high-z galaxy evolution. A major scientific objective of all future observatories.