Spatially Resolved Spectroscopy of Lensed Galaxies in the HFF

Tucker Jones (UCSB/CGE) & the GLASS team

Yale Frontier Fields Workshop, 12 November 2014
Frontier Field goals:

“These Frontier Fields will combine the power of HST with the natural gravitational telescopes of high-magnification clusters of galaxies. Using both the Wide Field Camera 3 and Advanced Camera for Surveys in parallel, HST will produce the deepest observations of clusters and their lensed galaxies ever obtained, and the second-deepest observations of blank fields (located near the clusters). These images will reveal distant galaxy populations ~10-100 times fainter than any previously observed, improve our statistical understanding of galaxies during the epoch of reionization, and provide unprecedented measurements of the dark matter within massive clusters.”

At intermediate redshifts ($z \approx 1-3$):
1. Detailed structure of massive galaxies ($>10^9 \, M_\odot$)
2. First glimpse of dwarf galaxy properties
1. Galaxies at the epoch of reionization
   - Observing Lyα at $5.5 < z < 13.0$

2. How gas and metals cycle in and out of galaxies
   - Emission line ratio maps of 100s of galaxies at $1.3 < z < 2.3$

3. Galaxy evolution in dense environments
   - Spatially resolved star formation in cluster cores and outskirts

4. Super Novae for cosmology etc.
   - SN discoveries in up to 4 epochs of imaging per cluster
Complete wavelength coverage from 0.8–1.7 µm
Strehl ≈ 1, resolution ≤ 0.13 arcsec, no sky lines, no telluric absorption
Emission line maps with GLASS
System of 3 galaxies at z=1.855

TJ et al. 2014
Source plane reconstruction

Gravitational lensing model:
5% error in deflection angle
13% error in magnification

Lensing correction: apply additional external shear and convergence to align images in the source plane.
→ Higher SNR in faint regions
(TJ et al. 2014, Wang et al. in prep)

See Xin Wang’s poster!
Emission line maps with GLASS

System of 3 galaxies at z=1.855

TJ et al. 2014

Source plane

Metallicity gradient

TJ et al. 2014
Metallicity gradient evolution

Mergers flatten metallicity gradients (Rupke et al. 2010; Rich et al. 2012)
Strong feedback/outflows flatten metallicity gradients (Gibson et al. 2013; Angles-Alcazar et al. 2014)

\[ \text{Gradient} \approx 0 \]

Gradient < 0

Merging, strong feedback

TJ et al. 2013, 2014
Metallicity gradient evolution

Mergers flatten metallicity gradients (Rupke et al. 2010; Rich et al. 2012)
Strong feedback/outflows flatten metallicity gradients (Gibson et al. 2013; Angles-Alcazar et al. 2014)

→ Gradient evolution is sensitive to galaxy evolution processes

TJ et al. 2013, 2014
GLASS/HFF data c.f. field surveys at z=2

GLASS data in the Frontier Fields probe an order of magnitude lower stellar mass compared to field surveys.
→ Increased dynamic range
→ Probes the mass range of local group dwarf progenitors at z~2

Mass-metallicity(-SFR) relation:
consistent with previous data, possible steep slope at low mass

GLASS initial results reveal a dwarf galaxy progenitor at z=1.85 with very high specific SFR. Can possibly explain:
- The “cusp-core” problem
- The “too big to fail” problem
- The “missing satellites” problem
GLASS/HFF data c.f.

“Main sequence”

Mass-metallicity relation

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Bottom line

Detailed structure of massive galaxies at $z > 1$
($M_* \sim 10^9 \ M_\odot$)
- Emission line maps for 100+ galaxies
- Resolved $M_*$, SFR, metallicity
- Metallicity gradient evolution

Properties of dwarf galaxy progenitors at $z > 1$
- GLASS probes down to $M_* \sim 10^7 \ M_\odot$ at $z \sim 2$
- Will address whether feedback can resolve tension between observed dwarf galaxies and $\Lambda$CDM theory
The GLASS Team

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