The Gemini Cluster Astrophysics Spectroscopic Survey (GCLASS)

A multi-wavelength survey of galaxy clusters at $z = 1$

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# The GCLASS Collaboration

## PIs
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- Howard Yee (Toronto)

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## Spectroscopy
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## X-Rays
- Erica Ellingson (Colorado)
- Douglas Burke (Chandra)
- Amalia Hicks (Michigan)
- Paolo Tozzi (Trieste)
- Piero Rosati (ESO)
Motivation

Why study high-redshift clusters?

**Talks by:** Poggianti, Bundy, Smith, Wilman, Papovich, Rosati, Overzier, Tanaka, Brodwin, Martini, Lubin, Kodama, Koyama, Yan, Valentuzzo

**Posters by:** Giodini, Rettura, Gobat, Hatch, Ideue, Kocevski, Galametz, McGrath, Sanchez-Blazquez, Vulcani
The GCLASS Survey

Gemini-South
Cerro Paychon, Chile

- Spectroscopic survey of 10 rich clusters $z = 1$ with Gemini/GMOS
- Low-res: $R=450 = 17\text{Å} = 400\text{km/s}$
- 4 to 6 masks per cluster (45 total)
- 3 hrs integration per mask
- Nod + Shuffle mode with microslits

Gemini-North
Mauna Kea, Hawaii

- Observational goal: Spectroscopy of 50 members in each cluster(!)
- 222 hr (25 night) project over three years with Gemini/GMOS

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The SpARCS Survey

- Spitzer Adaptation of the Red-sequence Cluster Survey
  - Uses the now “canonical” red-sequence method of Gladders+Yee (2000) shifted into the IR

- Deep-wide z’-band survey combined with SWIRE 50 deg survey
  - Clusters are select based on z’-3.6μm red-sequence to z = 1.6
    - 400 cluster candidates z > 1 with estimated M > 1e14 M$_{sol}$

Muzzin et al. (2009), Wilson et al. (2009), Demarco et al. (2010)
The GCLASS Sample

Richness-limited, IR-selected sample with \( z\)-phot > 0.9

<table>
<thead>
<tr>
<th>Name</th>
<th>Redshift</th>
<th>Velocity-Disp</th>
<th>Members</th>
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<tbody>
<tr>
<td>SpARCS J003645-441050</td>
<td>0.867</td>
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<td>SpARCS J003550-431224</td>
<td>1.335</td>
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</tbody>
</table>
Slits are prioritized based on IRAC magnitude + color = stellar mass. Completeness is very good for L > 0.5L* galaxies, particularly the cores.
Spectroscopic Completeness+Selection

Slits are prioritized based on IRAC magnitude + color = stellar mass
Completeness is very good for $L > 0.5L^*$ galaxies, particularly the cores

Cluster Core

Cluster Virial Radius

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Current Status of GCLASS

35/45 Masks observed (185.3 hrs), ~400 cluster galaxy spectra

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Early Science

Stellar populations of $z = 1$ cluster galaxies from a stacking analysis of spectra

Muzzin et al. (2010), prep
Stacking as a Function of Environment/Mass

Both mass and environment play a role in shaping stellar populations.
Star Formation vs. Environment/Mass

Both mass and environment affect specific star formation rates

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How does this compare to lower-z clusters?

Poggianti et al. (2008)
How does this compare to lower-z clusters?

- Star forming fraction is similar to $z = 0.5$, overall SSFR of field scaled up
- Highest density regions approximately equally dead over redshift range
Both mass and environment affect D4000 and rest-frame color.
Stellar Population vs. Environment/Mass

Appears that the effects of mass and environment mimic each other, especially over the mass/environment range considered here.

Are they related?
Covariance of Mass/Environment

Mass Segregation: Massive galaxies live in the highest density environments
Covariance of Mass/Environment

Mass Segregation: Massive galaxies live in the highest density environments
With the GCLASS sample we have the statistics to isolate each variable and ascertain which dominates the evolution...
Separation of Environmental/Mass Evolution

To be continued....
Conclusions

- Both galaxy mass and environment affect the evolution of galaxy stellar populations at $z = 1$
- Galaxies in higher density environment are older and less star forming
- More massive galaxies are older and less star forming
- Fraction of star forming galaxies in $z = 1$ clusters is similar to lower redshift clusters, but with SSFRs dramatically scaled up
- Evidence for mass segregation of the satellite galaxies
- We need to untangle the covariance of mass/environment to understand which is most important in shaping the $z = 1$ cluster galaxy population (come talk to me if you want the answer...)