The RCS-Spec Survey of Intermediate Redshift Clusters

Renbin Yan
(University of Toronto)

Collaborators: Howard Yee, David Gilbank, Mike Gladders, Erica Ellingson, I-hui Li, Bau-ching Hsieh, Felipe Barrientos, Tracy Webb, Ashley Faloon, Kris Blindert, Brian Keeney, and RCS Team
Red-sequence Cluster Survey (RCS-1)

- 92 sq. deg. R and z' imaging
  \[ R_{AB} \approx 24.8, \ z_{AB} \approx 23.6 \ (5\sigma) \]

- A survey aimed to find a large sample of galaxy clusters up to \( z \approx 1 \) using the red-sequence technique.

Gladders & Yee (2005)
The Cluster Red-sequence Method

Gladders & Yee (2000)

Uses the early-type (red) galaxies as markers for cluster detection.

Requires only 2 filters: Inexpensive
Red-sequence Cluster Survey (RCS-1)

Gladders & Yee (2005)

- 92 sq. deg. R and $z'$ imaging
  - $R_{AB} \sim 24.8$, $z_{AB} \sim 23.6$ (5σ)
- >600 clusters found with $B_{gcR}>500$, $σ>3.3$, $0.2<z<0.9$
RCS-Spec

RCS-Spec is a spectroscopic follow-up survey in 36 wide fields around 42 clusters found in RCS-1.

Goals of RCS-Spec

- Cluster confirmation
- Cluster dynamics
- Galaxy Evolution in and around clusters
- Multi-waveband studies with Chandra, Spitzer, HST/ACS.
Cluster Sample Selection

42 clusters randomly selected in 2x3 richness and redshift bins

0.2 < z < 0.9
Observations

18 clear nights on Magellan over 3 years
High Multiplexing in Wide Field

27′ wide field
(7Mpc/h at z=0.7)

700 slits/mask
(w/ band-limiting filter)

$R \sim 500$

49,120 spectra in total
Data Reduction

Data are reduced with the Carnegie Observatory COSMOS pipeline and a modified version of the DEEP2 1-d pipeline.

We carefully removed the 0th, 2nd, and 3rd order contamination. The higher order overlaps in the flat frames also cause background level jumps in the spatial direction, yielding large residuals on strong sky lines, which have to be blocked out for redshift fitting.

All spectra are inspected by eye to confirm the pipeline redshifts, with ~850 hours of hard work by team members and trained undergraduate students at U. of Colorado.
Data Summary

- **49,120 spectra** obtained in 6 sq. deg. around 42 clusters.

- **20,930 good redshifts** obtained, the largest dataset of its kind at intermediate redshifts.

- Based on repeated observations, **98% of the redshifts** are robust, with a typical redshift error of $116\,\text{km/s (c}\Delta \text{z)}$.

- Limiting magnitude is about $M^*(z)+1$ in R band.
Sample K+A Spectra

\( Z = 0.701 \)

\( Z = 0.663 \)

\( Z = 0.681 \)
Sample K+A Spectra

$Z = 0.409$

$Z = 0.526$

$Z = 0.588$
Sample K+A Spectra

\[ J_\lambda \]

- \( Z = 0.489 \)
- \( Z = 0.493 \)
- \( Z = 0.574 \)

\[ f_\lambda \]

\[ \lambda \]

\[ 3500 \quad 4000 \quad 4500 \quad 5000 \]
Examples of Cone Diagrams

1107-05

14+0840

NAOC Workshop,
06/2010
Examples of Cone Diagrams
Examples of Cone Diagrams

- 2154-05
- 231953
Pie Diagram
Color-Magnitude Diagram for the Spec Sample
Cluster finding

Cluster finding is done in the spectroscopic catalog using the matched-filter algorithm (Kepner et al. 1999, White & Kochanek 2002), yielding a catalog of 1759 cluster/groups.

Among these, 81 clusters/groups have at least 10 members within $R_{200}$.

Among the 42 primary RCS-1 cluster targets, 39 are confirmed.
Spec-z vs. Red-Sequence-z
Vel. Disp vs. $B_{gcR}$

![Graph showing velocity dispersion ($\sigma$) vs. $B_{gcR}$ from the aug05 catalog.](chart.png)
Cluster/Group Catalog

Number of Groups

\[ \frac{(v-v_0)}{\sigma} \]
Color-dependent Vel. Dist.

![Graph showing the velocity distribution of red and blue galaxies. The x-axis represents \((v - v_0)/\sigma\), and the y-axis shows the number of galaxies. The red line represents red galaxies, and the blue dotted line represents blue galaxies.](image)
Sciences to do

- Butcher-Oemler effect
- SFH vs. environment, redshift, and richness.
- Post-starburst (K+A) galaxies
- Cluster Dynamics
- Evolution in the Color-Magnitude Relation
- Many more ......
Stay Tuned.