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Investigating the environmental effects on the evolution of galaxies in groups and clusters

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ABSTRACT: The Undergraduate ALFALFA Team (UAT) Groups Project is investigating the influence of the environment on galaxies in group environments. Galaxies in clusters show evidence for a variety of environmental effects. The UAT team has chosen groups from the RASSCALS sample (groups defined using the Rosat X-ray satellite, Mahdavi et al. 2000). Galaxies within 2 degrees of the group center and 3 sigma of the central velocity of the group were targeted for H α observations. We cross-matched the 52 RASSCALS groups and clusters the UAT has observed to the Tempel et al. (2017) group catalog based on Sloan Digital Sky Survey observations, finding 26 that matched within 10 arcminutes of the RASSCALS group. Here we compare properties of these groups.

Undergraduate ALFALFA Team (UAT)

- NSF-sponsored consortium of 24 undergraduate-focused institutions engaged in undergraduate research and faculty development within the Arecibo Legacy Fast ALFA (ALFALFA) survey and followup projects
- ALFALFA: Blind HI survey of Arecibo sky (7074 deg²) for extragalactic HI sources (Giovannelli et al. 2005, $z < 0.06$, $0 < \text{Dec} < 32$ deg)
- Observations and analysis carried out by undergraduates at UAT Institutions

UAT Groups and Poor Clusters Project

- Star formation and gas content in clusters affected by environment through processes such as ICM-ISM and galaxy-galaxy interactions (e.g., review by Boselli & Gavazzi 2006)
- What effect(s) dominant? Is there pre-processing in groups?
- UAT H α Imaging Project: quantify star formation rates and distributions in groups with wide range of properties, compare to cluster studies

UAT Sample Selection and Properties

- HI ALFALFA (Giovannelli et al. 2005)
- RASSCALS (Mahdavi et al. 2000) or ACCEPT (Cavagnolo et al. 2009) X-ray observations
- Spring (9h-16h) and Fall (22h-3h; Pisces-Perseus Supercluster) skies
- 67 total groups/clusters to date, including 52 RASSCALS groups, 34 in Spring Sky

Sloan Digital Sky Survey (SDSS)

- Imaging and spectroscopic redshift survey (York et al. 2000)
- 2.5-m telescope at Apache Point Observatory in New Mexico
- Imaging one third of the sky and spectra for more than three million sources
- Several group catalogs derived from SDSS including Tempel et al. (2014, 2017)

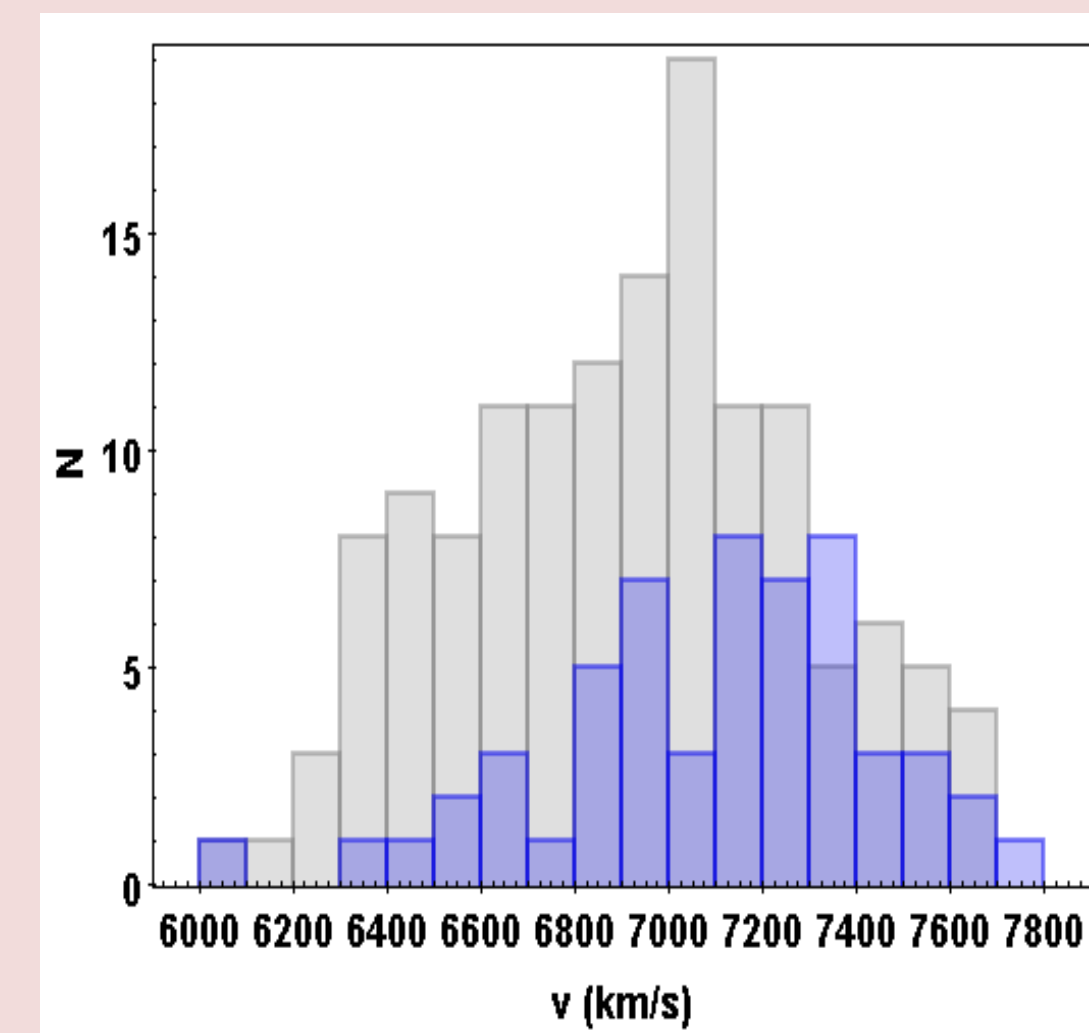
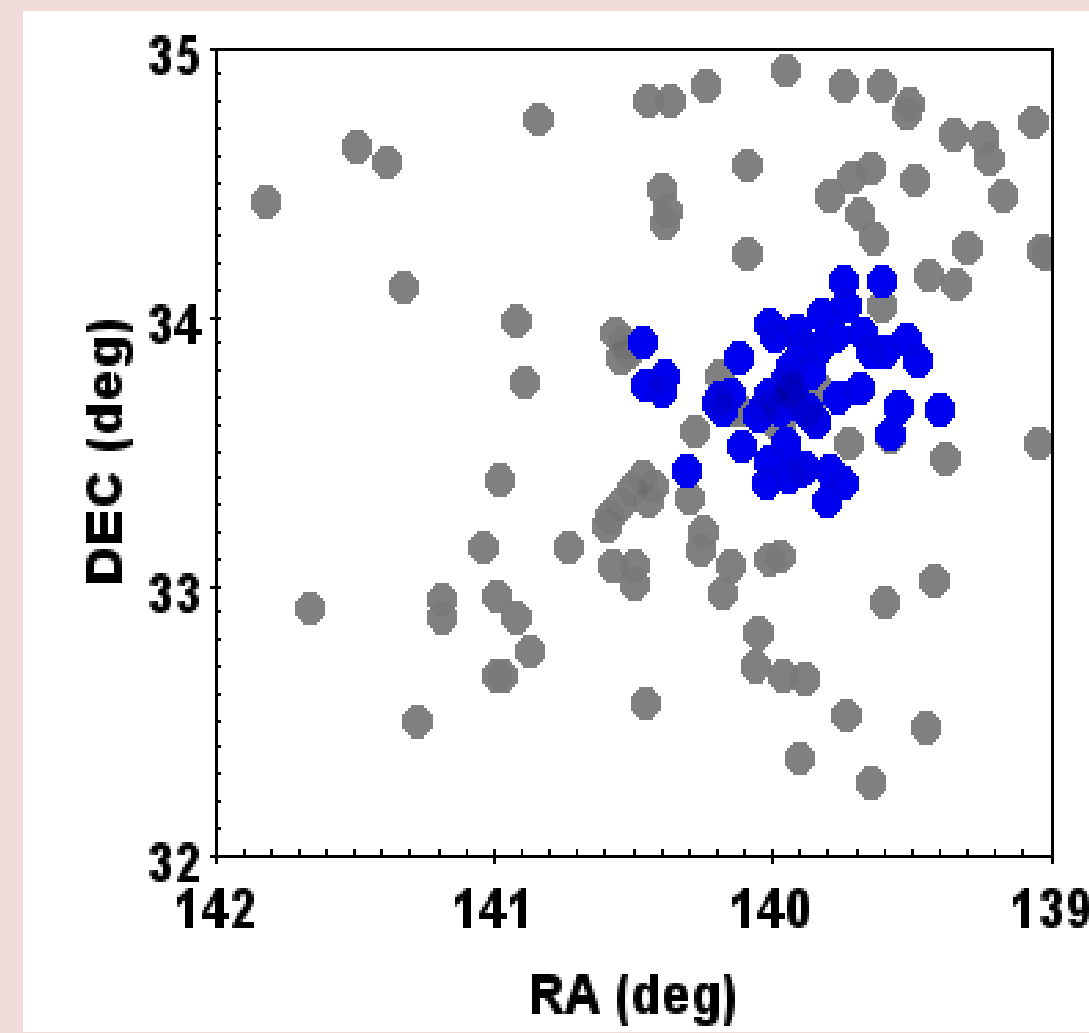
Acknowledgements

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References

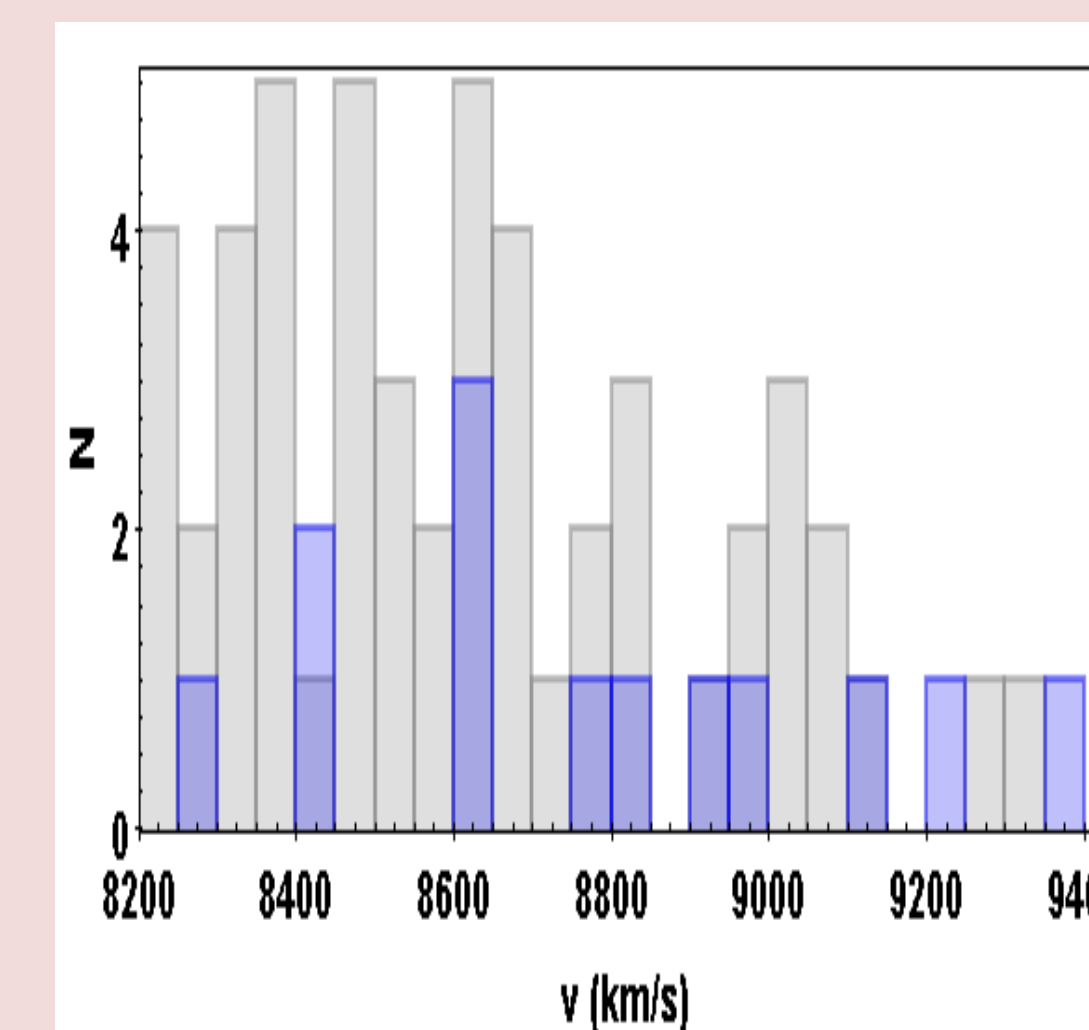
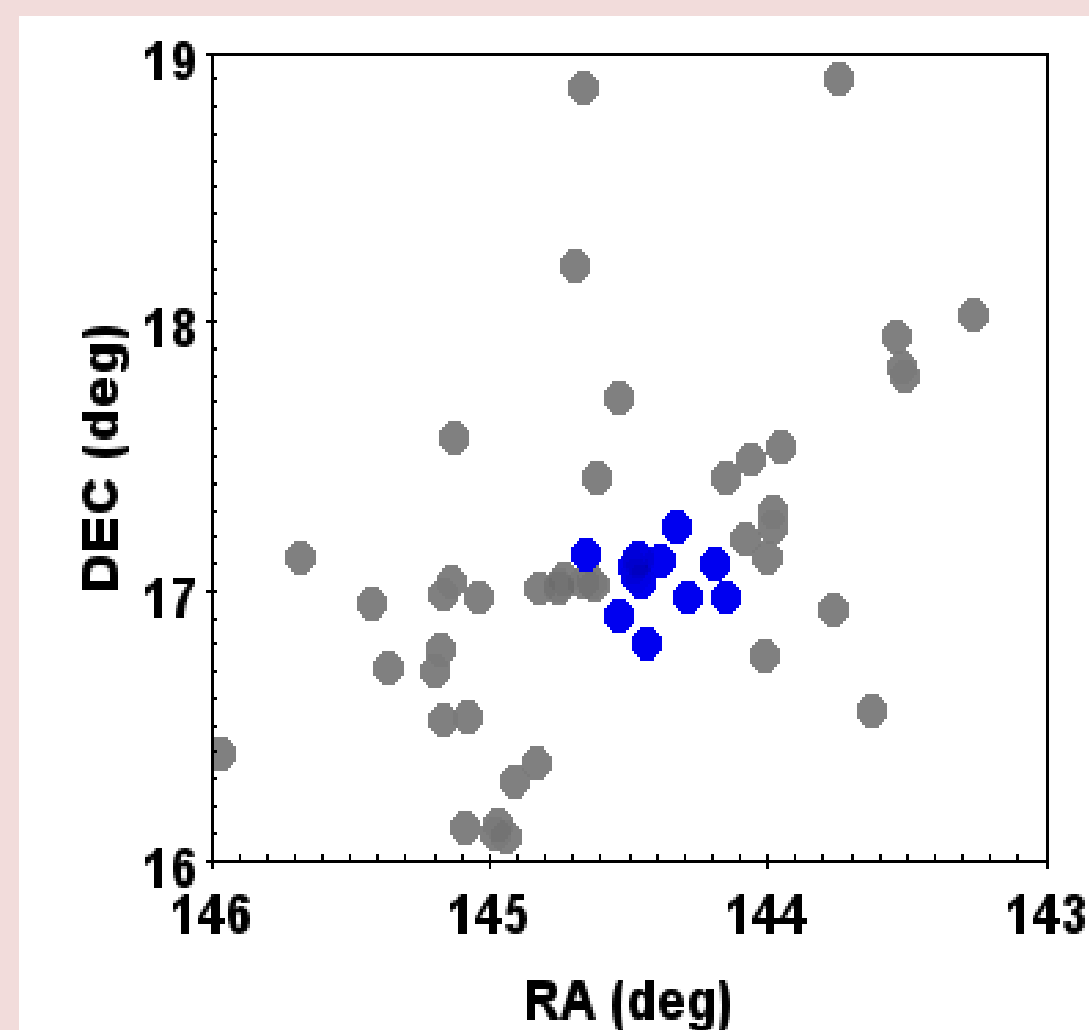
Boselli, A. & Gavazzi, G. 2006, PASP, 118, 517
Giovannelli, R. et al. 2005, AJ, 130, 2598
Mahdavi, A. et al. 2000, ApJ, 534, 114
Tempel, E. et al. 2014, A&A 566, 1
Tempel, E. et al. 2017, A&A 600, L6
York, D.G. et al. 2000, AJ, 120, 1579

Sky plots and velocity histograms for example groups



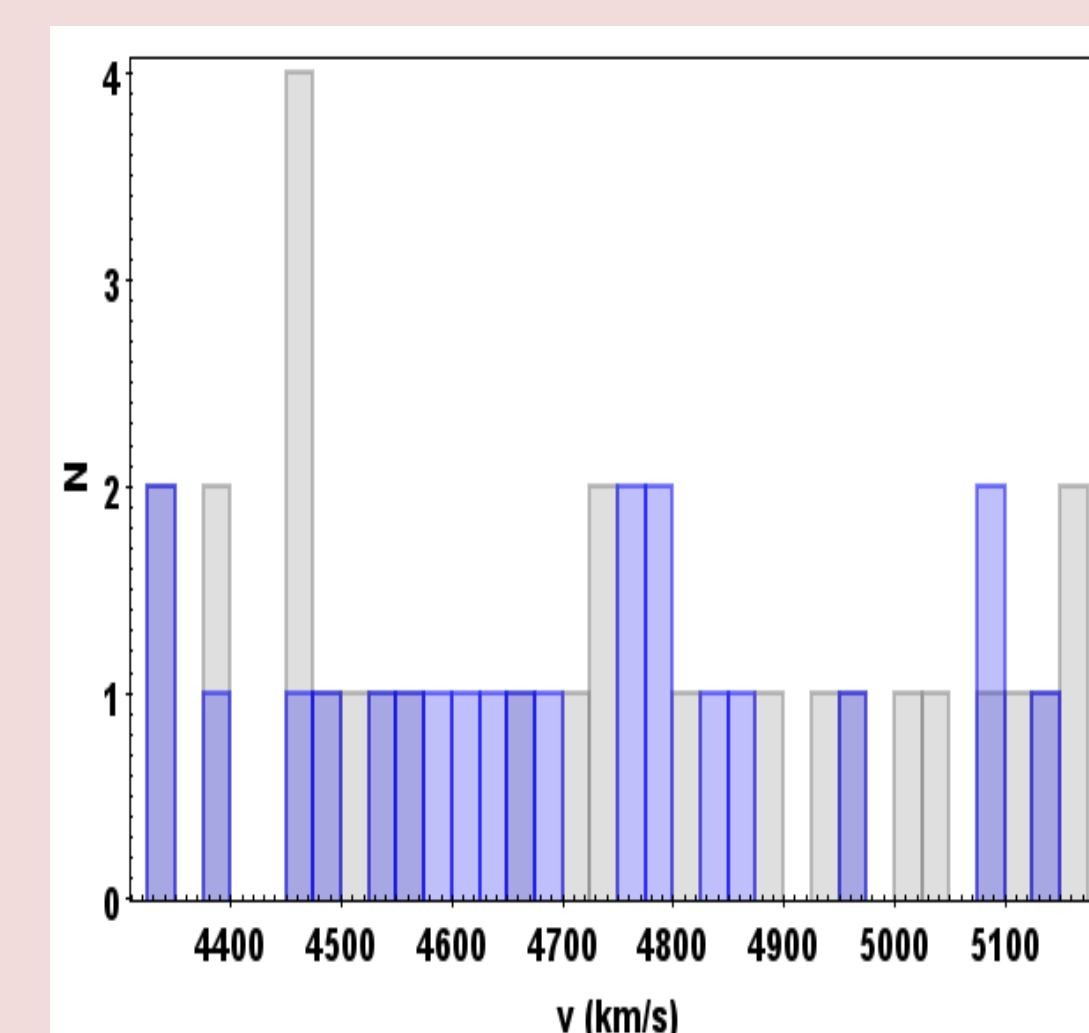
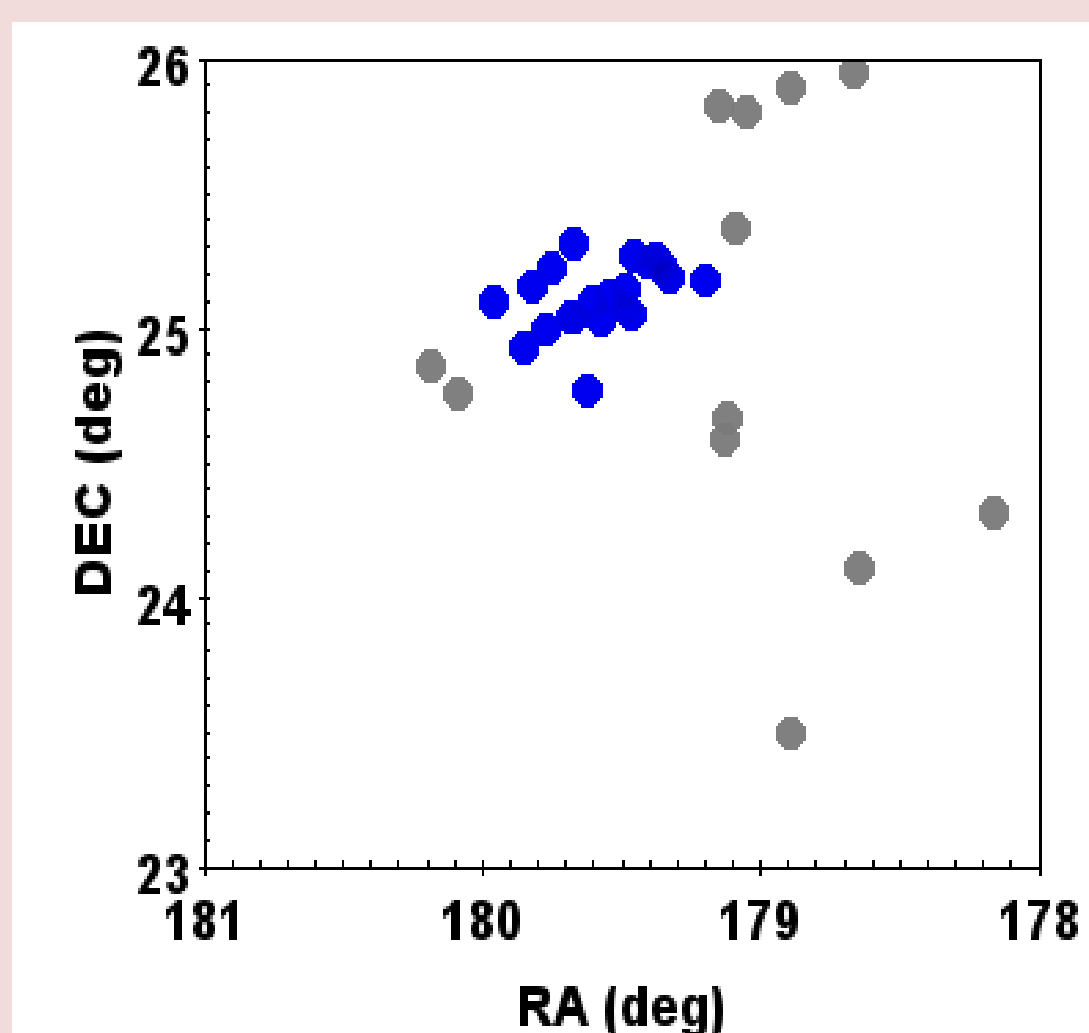
NRGb032 = Tempel Group ID 4245

Skyplot (left) and velocity histogram (right) depict galaxies in and near the RASSCALS NRGb032 group in grey and Tempel et al. (2017) group galaxies in blue. The Tempel et al. group is embedded in a larger structure, with velocities tending toward lower values than the main group.



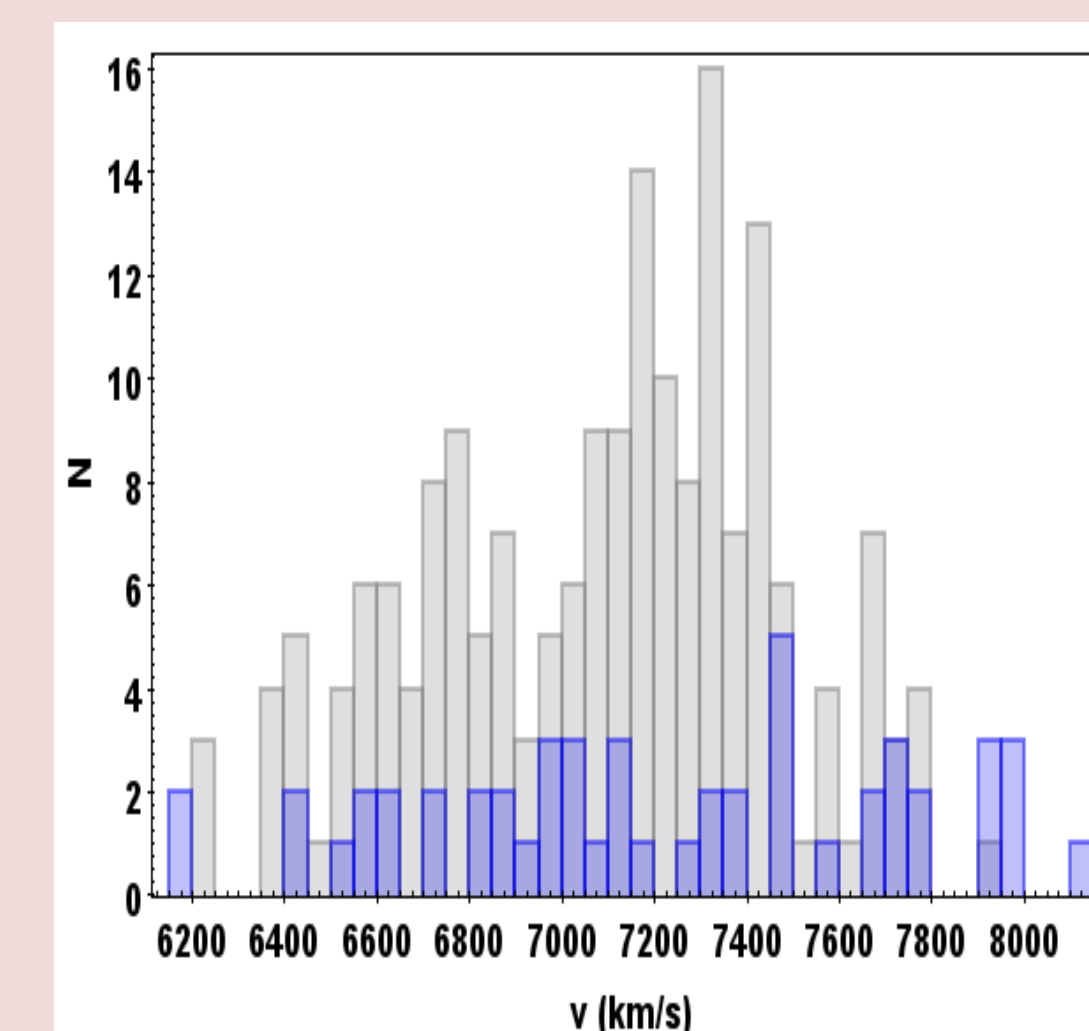
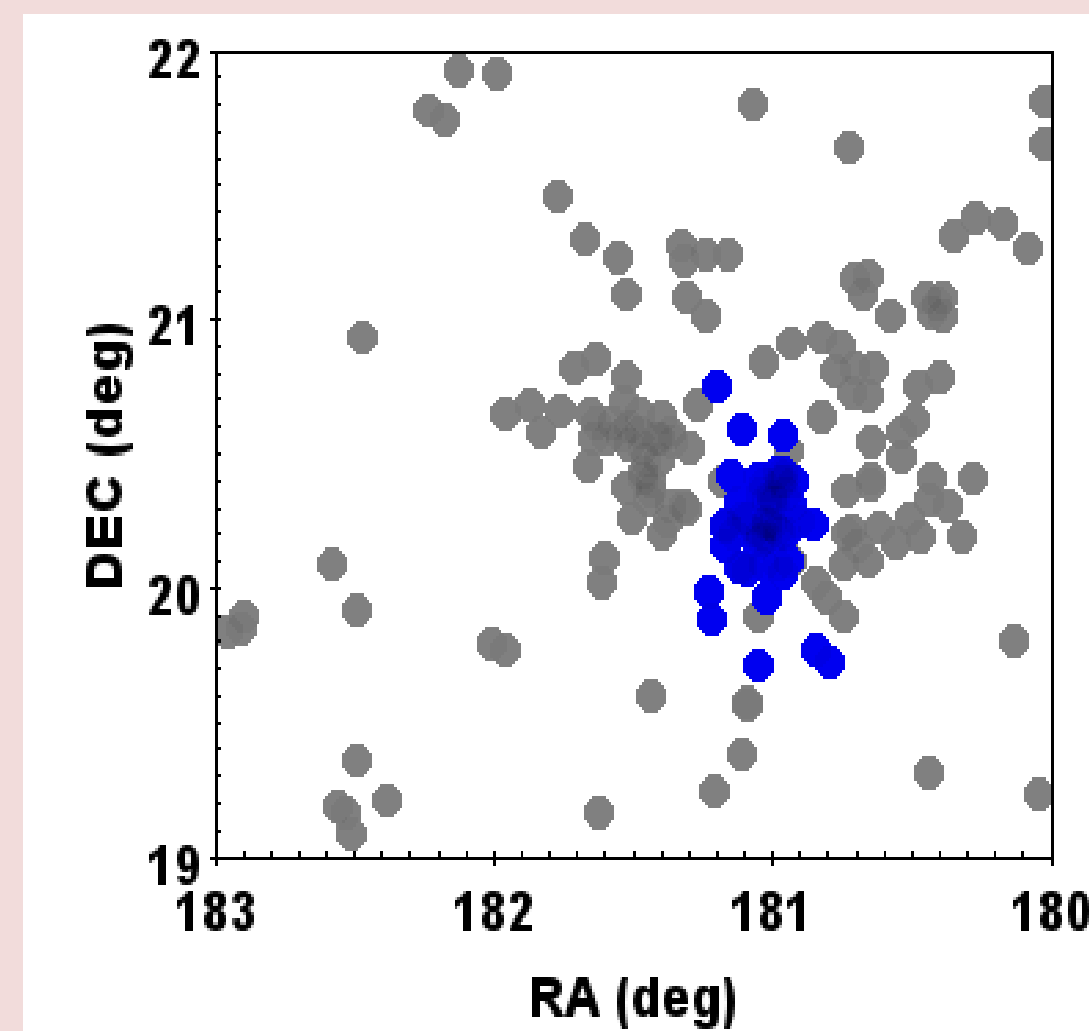
NRGb049 = Tempel Group ID 1876

Skyplot (left) and velocity histogram (right) depict galaxies in and near the RASSCALS NRGb049 group in grey and Tempel et al. (2017) group galaxies in blue. The Tempel et al. group is embedded in a larger structure with velocities spanning a range, but not displaying a Gaussian distribution.



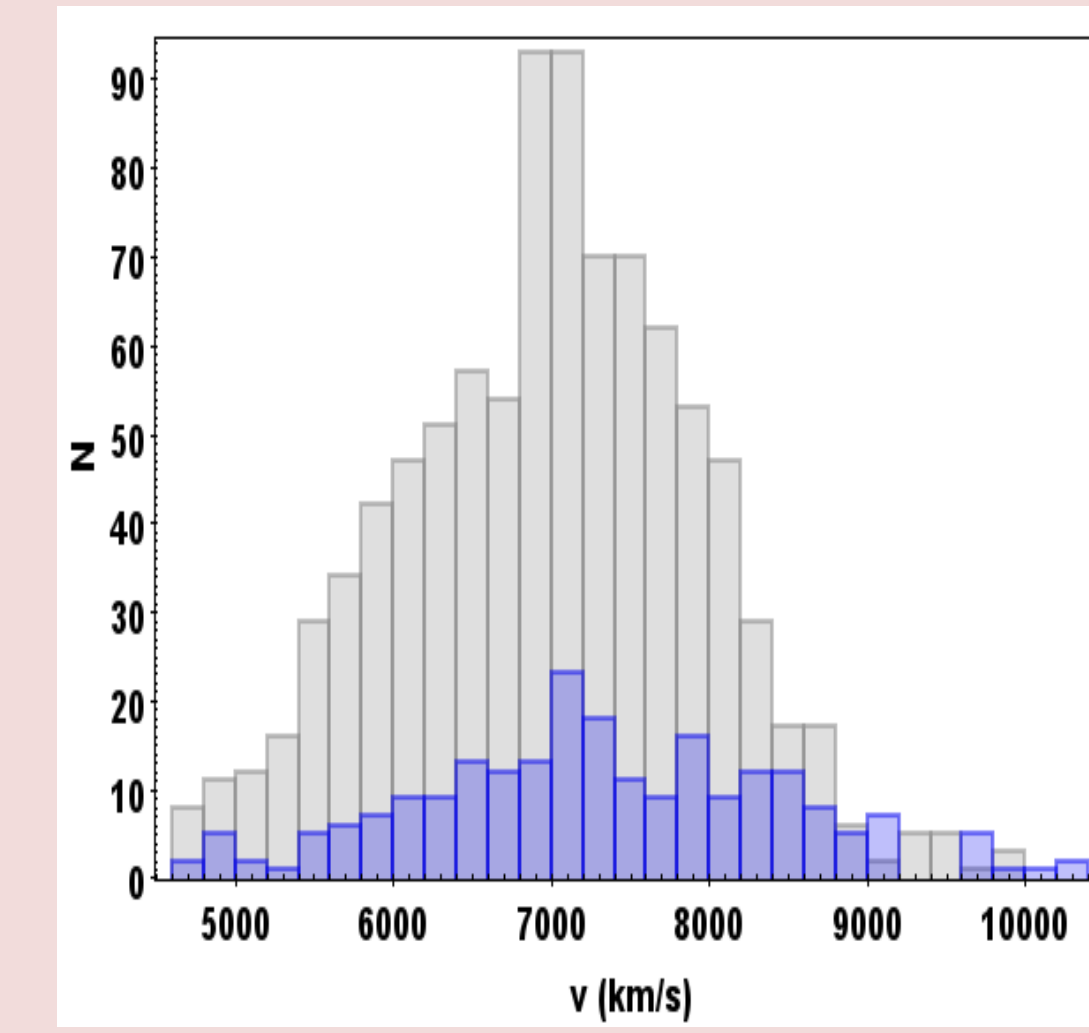
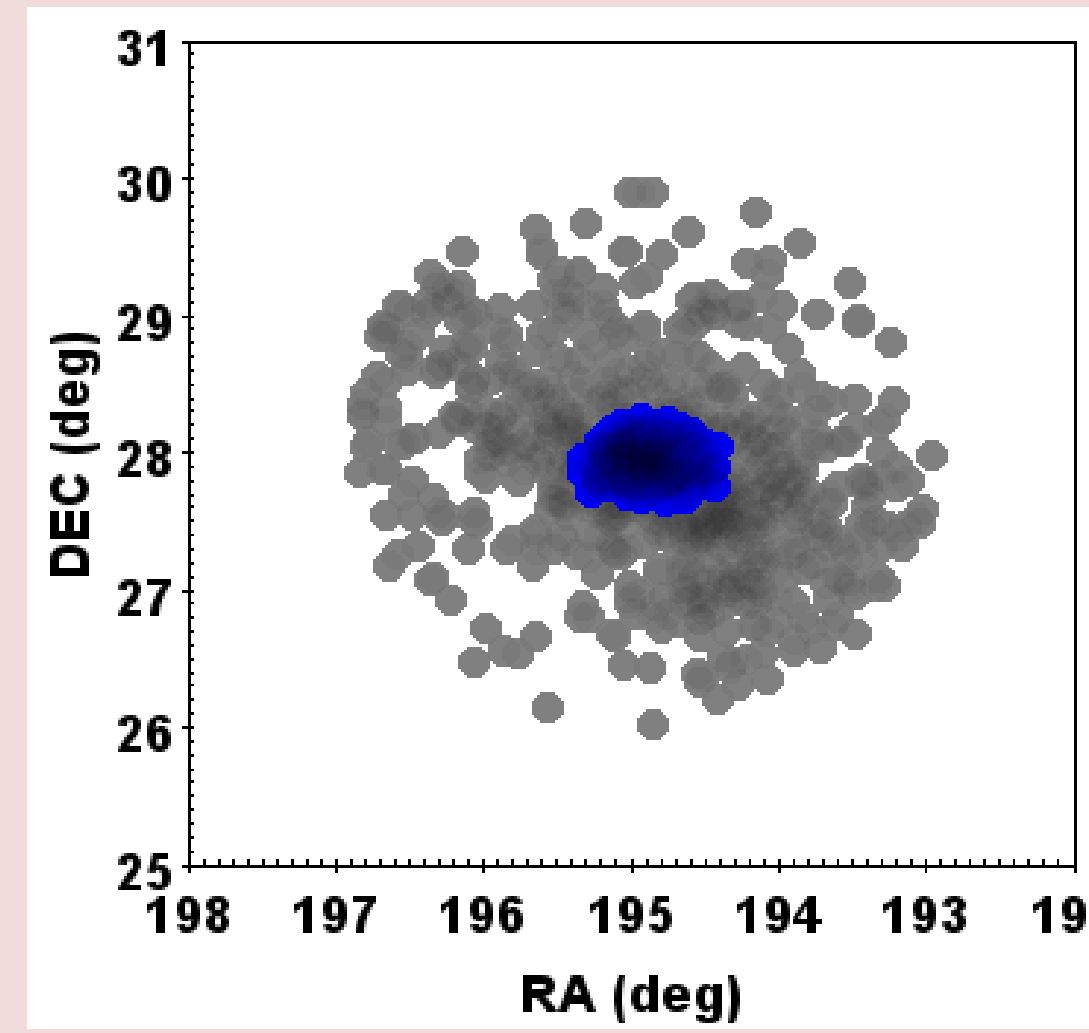
NRGb168 = Tempel Group ID 65990

Skyplot (left) and velocity histogram (right) depict galaxies in and near the RASSCALS NRGb168 group in grey and Tempel et al. (2017) group galaxies in blue. The Tempel et al. group is more isolated than the others displayed here, with fewer galaxies in an extended structure.



NRGb177 = Tempel Group ID 10680

Skyplot (left) and velocity histogram (right) depict galaxies in and near the RASSCALS NRGb177 group in grey and Tempel et al. (2017) group galaxies in blue. The Tempel group et al. is more compact in the sky, but spans the whole velocity range of the galaxies within the larger structure.



NRGb226 = Tempel Group ID 1539

Skyplot (left) and velocity histogram (right) depict galaxies in and near the RASSCALS NRGb226 group in grey and Tempel et al. (2017) group galaxies in blue. The skyplot depicts a rich cluster called the Coma Cluster. The Tempel group is more compact in the sky, but spans the velocity range a larger extended structure.

What are groups and how are they defined in RASSCALS and Tempel et al. Catalogs?

Galaxy groups and clusters

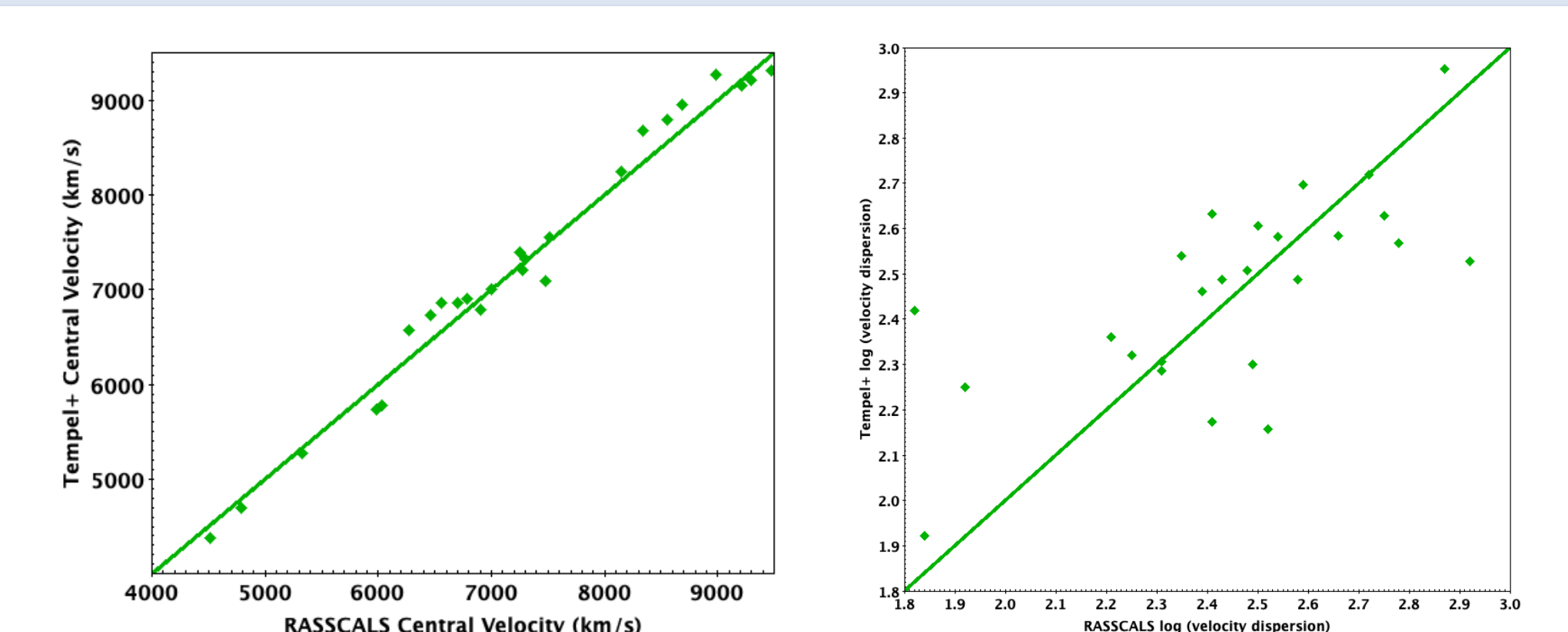
- Galaxies orbit common center-of-mass
- Velocity dispersion is standard deviation of velocities about the mean velocity, estimated using the line-of-sight velocities (assuming Gaussian distribution)

RASSCALS (ROSAT All Sky Survey-Center for Astrophysics Loose Systems, Mahdavi et al. 2000) Group Selection

- Groups selected from Center for Astrophysics and Southern Sky Redshift Surveys (about 1/4 of the sky)
- Friends-of-friends algorithm
- X-ray flux or upper limit from ROSAT

Tempel et al. (2017) Group Selection

- Groups selected from SDSS spectroscopic sample
- Modified friends-of-friends group finder which is designed for flux-limited galaxy surveys.



Comparison of RASSCALS and Tempel et al. group central velocity (left) and velocity dispersion (right). Central velocities are in good agreement, but velocity dispersions are more scattered.

Conclusions

- Comparison of recent group catalogs based on more complete SDSS data will better define the group structures we are studying.
- 26 Spring RASSCALS groups are identified with Tempel et al. (2017) groups and 6 were examined in comparative sky plots and velocity histograms.
- Most of the Tempel et al. groups examined were embedded in larger surrounding structures.
- This analysis will be helpful in refining group membership and detecting environmental processes affecting individual galaxies.

Future Work

- Examine all RASSCALS groups in overlap
- Examine velocities of galaxies in the vicinity as a function of distance from the center of the group
- Compare group membership based on other recent group catalogs
- Refine group membership as defined by RASSCALS criteria and criteria of other group studies