Why Does Environment Matter?

An Incomplete & Biased Guide

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Redshift Surveys

Center for Astrophysics Redshift Survey (1980s)
First observational evidence of Large-Scale Structure
Davis, Huchra, Geller, Latham, Tonry

Galaxies are not distributed randomly

First CfA Strip
$28.5 \leq \delta < 32.5$
$m_B \leq 15.5$
LSS: Local Universe

2dF Galaxy Redshift Survey

6dF, SDSS
Hierarchical Formation

Primordial fluctuations to collapsed, bound structures (Peebles 1972):
Galaxies, Galaxy Groups, Galaxy Clusters
Defining Environment

**Group:**

~10 L* Galaxy/Mpc\(^3\)

\(\delta(\text{velocity}) \approx 200-300 \text{ km/s}\)

**Field:**

~1 L* Galaxy/Mpc\(^3\)

cz=Hubble Expansion

**Cluster:**

~10\(^2\)-10\(^3\) L* Galaxy/Mpc\(^3\)

\(\delta(\text{velocity}) \approx 1000 \text{ km/s}\)
Frei Catalog of Local Galaxies
Observed Environmental Trends

Changes in Morphology

Dressler+1997

55 Cluster Sample – all, with area cut

Changes in Star Formation

Gomez+03

Star Formation Rate (M☉/yr)

log (Surface Density)

Field Cluster

log (Surface Density)

Field Cluster
Observables

Galaxies:
masses (stellar & gas), sizes, luminosities, metallicities, star formation histories (ages), kinematics (scaling relations)

Intra-cluster/group medium:
masses (stellar & gas), sizes, luminosities, metallicities, star formation histories (ages), kinematics, temperatures (X-ray)

Dark Matter:
mass & distribution via lensing & galaxy kinematics
Color-Magnitude Diagram

- Galaxy Mass: Big to Small
- Stellar Population: Young to Old
- Galaxy Color: Bright to Faint
- Luminosity: Single Age to Multiple Ages
#1: Merging & Massive Galaxies

Bryan+08: ENZO AMR, $10^{15} M_{\text{sun}}$ cluster
Galaxy-Galaxy Merging: MS1054

MS 1054–04 (z=0.83, lookback time 7 Gyr)

~16% bound galaxy pairs (spectroscopically confirmed)

Tran+05b
van Dokkum+99
#2: Dynamical Friction & ICL

Bryan+08: ENZO AMR, $10^{15} \ M_{\odot}$ cluster
Intracluster Light: Virgo

Mihos+05
μ > 26.5 mag arcsec²
Intracluster/group Light

Rudick+06 (Models): ICL structure evolves
→ fossil record of cluster assembly
Intracluster/group Light

Build-up of ICM linked to accretion of galaxy groups

Rudick, Mihos, McBride 2006
Summary

Rise of the galaxy group environment
(big shift from even 5 years ago)

Holistic view of galaxy evolution:
Galaxies & Intra-Halo Light/Medium

Synergy between observations & theory
(better translate b/w theory observations, e.g. satellites & centrals)