Mapping the Star Formation and H I Gas Properties of Galaxies around the Virgo Cluster

Yoon et al., *The Astrophysical Journal*, 986:38 (2025)

1. Objective

This study investigates how galaxies' **star formation activity** and **neutral hydrogen (H I) gas** content vary across large-scale structures — filaments and groups — surrounding the **Virgo Cluster**. The goal is to understand how different **environmental conditions** outside clusters influence galaxy evolution.

2. Data and Methods

- **Data sources:** SDSS (optical), GALEX (UV), WISE (IR), ALFALFA and HyperLeda (H I gas).
- **Structures:** Three filaments (F1–F3), two groups (G1–G2), and a Virgo reference sample.
- **Star formation indicators:**
  - *W3–W1*: traces recent star formation (100 Myr–1 Gyr)
  - *NUV–r*: probes star formation history on a few hundred Myr scale
  - *g–r*: longer timescale tracer (1–10 Gyr)
- **H I gas analysis:** H I-to-stellar mass ratio (log $M_{H\,I}/M_*$); classified as *H I-poor*, *H I-poorish*, or *H I-normal-to-rich*.

3. Key Results

Star Formation & Color Trends:

- Blue, actively star-forming galaxies dominate all structures.
- Filament 2 shows the **highest fraction of red galaxies** (16–25%), including low-mass red systems (log $M_*\approx$8.5).
- Red populations beyond Virgo's R_{200} imply **preprocessing** — quenching before cluster infall.

H I Gas Properties:

- Filament 2 hosts 20% H I-poor galaxies — most similar to Virgo cluster galaxies.
- Group 1 contains many red yet gas-rich galaxies, suggesting quenching not only due to gas loss.
- No strong radial gradient in H I fraction or star formation rate from Virgo to outskirts.

4. Environmental Effects

- **Preprocessing:** Interactions and slow encounters in filaments/groups affect gas and star formation.
- **Backsplashing:** Some galaxies may have passed through Virgo previously and been ejected outward.
- **Morphology:** Up to 60% of red galaxies in filaments are early types (ellipticals/lenticulars).

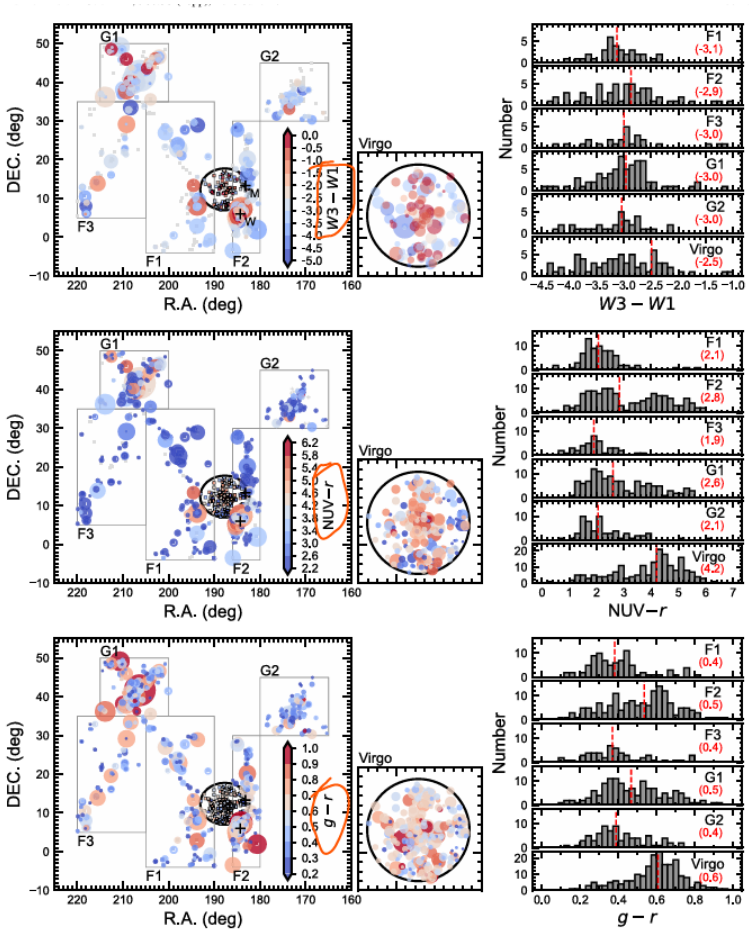

Figure 1: distribution of the galaxies mapped with three different colors

5. Main Conclusions

1. Quenching of star formation occurs well **outside Virgo**, mainly in Filament 2 and Group 1.
2. Gas depletion exists even in low-density environments and correlates more with stellar mass than with local density.
3. No large-scale gradient implies overlapping processes shaping galaxy evolution.
4. **Preprocessing** plays an important role before galaxies fall into clusters.

6. Broader Implications

Environmental effects begin earlier and in lower-density regions than previously assumed. Future high-resolution H I imaging will refine our understanding of **preprocessing, quenching, and gas accretion** in evolving galaxies.

Reference: Yoon et al. (2025), *"Mapping the Star Formation and H I Gas Properties of Galaxies along Large-scale Structures around the Virgo Cluster"*, *ApJ*, 986:38.
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